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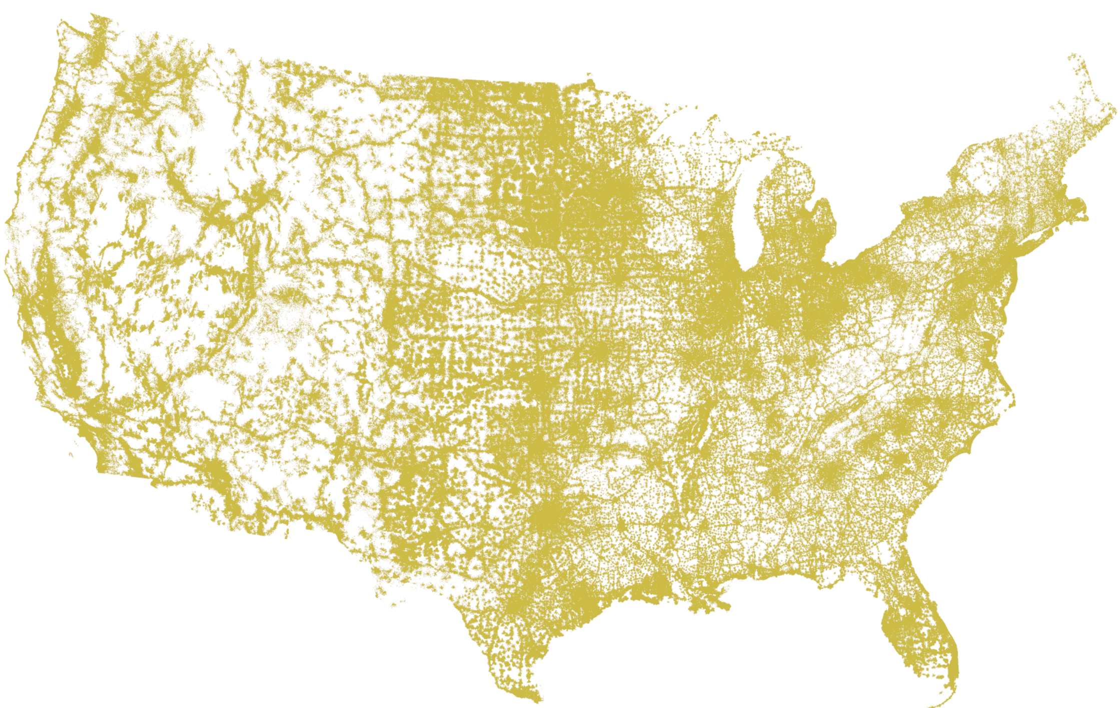
Mobile Broadband Coverage for Hazardous Waste Tracking and Transport

An Analysis of In-Vehicle Mobile Broadband Availability from Major Service Providers



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Arielle Herman (0009-0000-4902-2591), Kirby Ledvina (0000-0003-1025-2212), David Lamb (0000-0002-6799-8368), Andrew Breck (0000-0001-6617-2161), Amity Wilczek (0009-0000-0189-0090), Mark Raney (0009-0008-9285-2804), Erika Sudderth (0000-0002-8498-4777)

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John A. Volpe National Transportation Systems Center
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14. ABSTRACT

This report presents the extent of in-vehicle mobile broadband coverage along national highways and around hazardous waste generator locations with results summarized by U.S. Environmental Protection Agency (EPA) region. Mobile broadband coverage is based on data for three main service providers (AT&T, Verizon, and T-Mobile) as published by the Federal Communications Commission National Broadband Map. Nationally, coverage is widespread, with mobile broadband accessible along 92% of road miles in the National Highway System and for 99% of hazardous waste generators. For most generator locations outside of coverage areas, mobile broadband access is less than a minute drive away. Still, small disparities exist between EPA regions, and the on-the-ground experience at individual sites will vary.

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The authors also appreciate the FCC Broadband Data Task Force for their early consultation on the available FCC broadband datasets.

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Executive Summary

This report presents the extent of in-vehicle mobile broadband coverage along national highways and at hazardous waste handler locations. Researchers from the United States (U.S.) Department of Transportation (DOT) Volpe Center (Volpe) conducted this study in support of the Environmental Protection Agency (EPA) Office of Resource Conservation and Recovery (ORCR).

In 2018, the EPA launched the Hazardous Waste Electronic Manifest System (e-Manifest) to enable the use of electronic manifests in place of paper manifests for cradle-to-grave tracking of hazardous waste shipments.[1] To mitigate internet access limitations, in 2023 the EPA enacted a Remote Signer Policy to allow a registered user at an off-site location to execute signatures on behalf of generators, transporters, or designated receiving facilities without network access at the time of exchange, until the earlier of 24 hours from the time that (a) their field personnel receive the waste from the preceding waste handler or (b) waste is transferred to another handler.[2] In March 2026 the EPA issued a proposed rule requiring the use of electronic manifests for all shipments.[3] In anticipation of a large shift to electronic signatures on manifests, this Volpe study investigates mobile broadband coverage on the national highway network and at the sites of hazardous waste generators. It also estimates the drive time from generators in “dead zones” without coverage to the nearest covered road. Results are summarized by EPA region.

For this analysis, the Volpe team considers “mobile broadband coverage” areas as the geographic areas with 4G LTE in-vehicle mobile broadband coverage by at least one of three main service providers (AT&T, Verizon, and T-Mobile) based on the Federal Communication Commission (FCC) National Broadband Map datasets.[4] The analysis also uses National Highway System (NHS) spatial data as maintained by the Bureau of Transportation Statistics (BTS)[5] to assess coverage along major travel corridors as well as a detailed OpenStreetMap (OSM)[6] road network with local roads to assess coverage in the vicinity of hazardous waste generators. The Volpe team obtains locations of hazardous waste generators based on manifest activity in 2025 as recorded in the EPA Resource Conservation and Recovery Act Information (RCRAInfo) system.[7]

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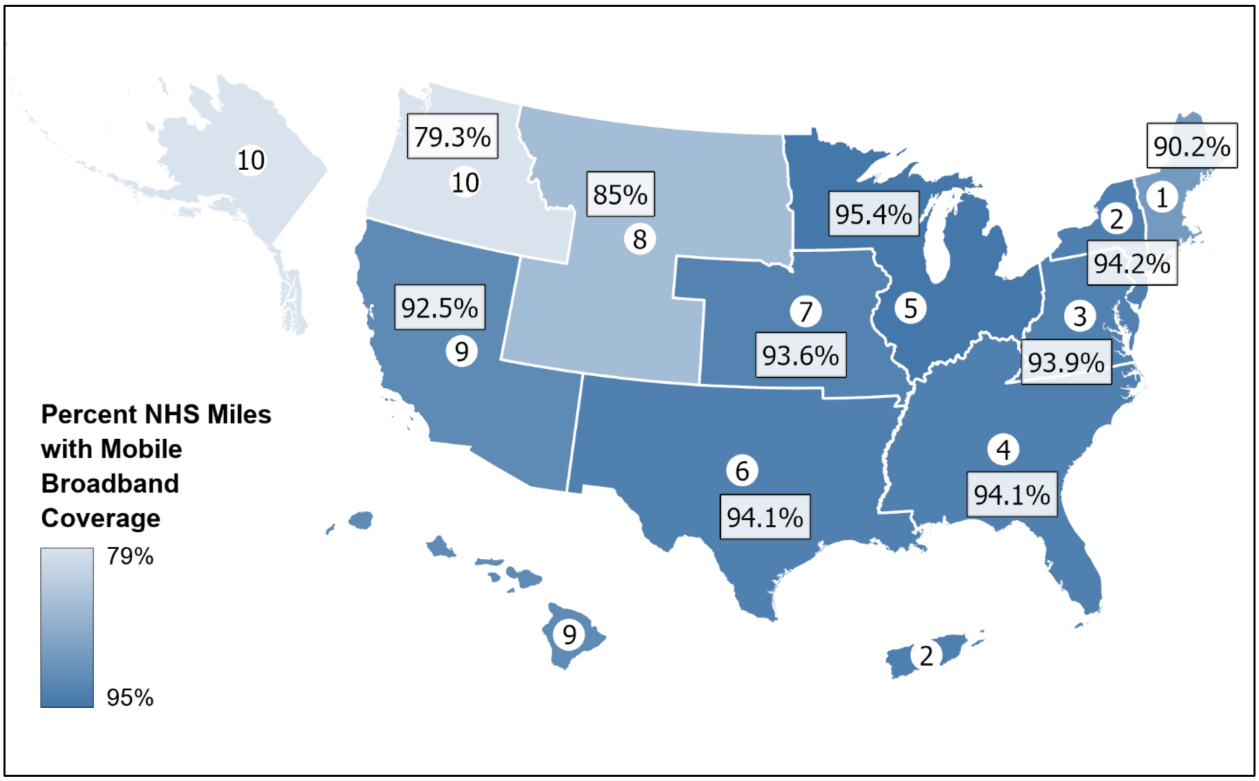
[1] https://www.epa.gov/e-manifest/learn-about-hazardous-waste-electronic-manifest-system-e-manifest
[2] https://www.epa.gov/e-manifest/frequent-questions-about-e-manifest; https://rcrapublic.epa.gov/files/14956.pdf
[3] https://www.epa.gov/e-manifest/e-manifest-rulemakings-and-policies; https://www.federalregister.gov/documents/2026/03/05/2026-04366/paper-manifest-sunset-rule-modification-of-the-hazardous-waste-manifest-regulations
[4] https://broadbandmap.fcc.gov/home
[5] https://geodata.bts.gov/datasets/usdot::national-highway-system-nhs/about
[6] https://www.openstreetmap.org/about
[7] https://www.epa.gov/enviro/rcrainfo-overview

This study will assist ORCR in identifying gaps in mobile broadband coverage that may impact their stakeholders during widespread electronic manifest adoption. Findings may help inform future policy and technology changes and technical assistance. Ensuring hazardous waste handlers can reliably sign electronic manifests enables a smooth transition to and continued use of fully electronic manifests, with the overarching goal of reducing costs and complexity for regulated industry. Altogether, the analyses detailed below find that coverage is widespread. Nationally, mobile broadband is accessible along 92% of the nation's highways and at 99% of hazardous waste generator locations. For most generator locations outside of coverage areas, mobile broadband access is less than a minute drive away. Still, small disparities exist between EPA regions, and the on-the-ground experience at individual sites will vary.

The Volpe team first assesses overall mobile broadband coverage at a high level on major roadways for within-state and interstate transport, based on the NHS system. Of the 222,052 miles of NHS road network nationwide, 204,567 miles (92%) have mobile broadband coverage. Summarized in Figure ES-1, coverage in individual EPA regions ranges from 79% of miles in Region 10 (the Pacific Northwest) to 95% of miles in Region 5 (the Upper Midwest). The median state has 93% coverage.

Figure ES-1. Share of NHS miles with coverage by EPA region



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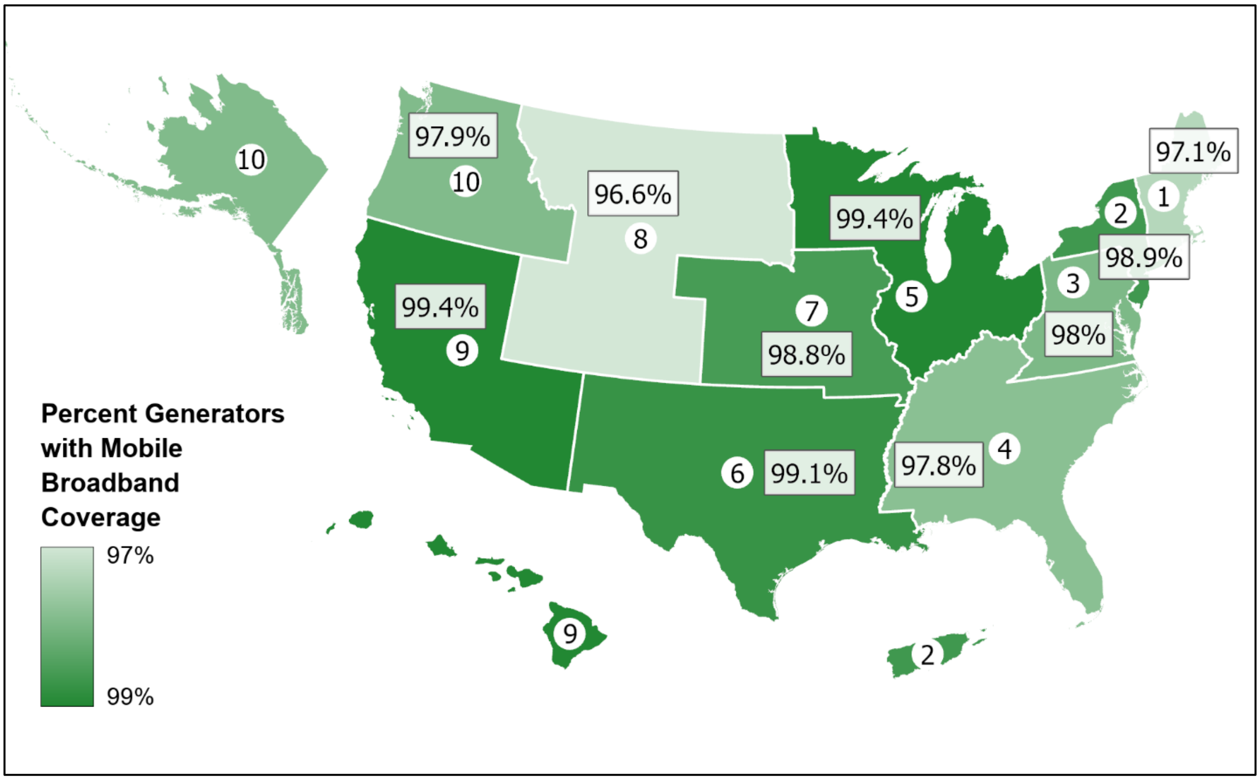
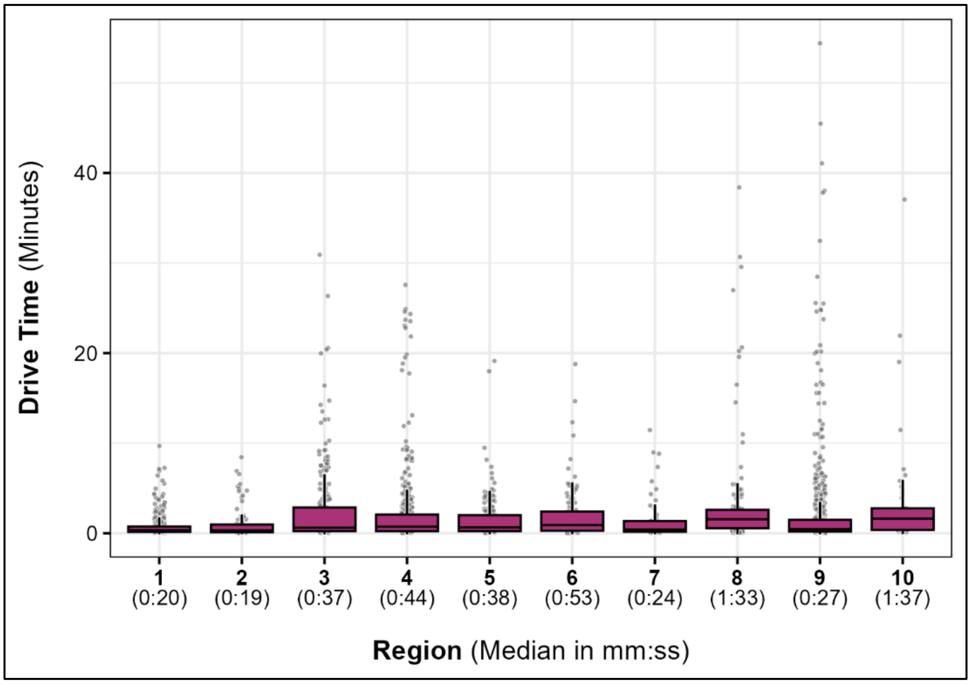
Narrowing focus to cover the specific locations of hazardous waste generators who may initiate hazardous waste manifests, the Volpe team finds that 98.8% of the 203,342 hazardous waste generators analyzed are in an area with mobile broadband coverage from at least one of the three main service providers. These generators produced 97.8% of waste tonnage and 98.7% of manifests in 2025. By region, the percent of generators with coverage ranged from 96.6% to 99.4%. Figure ES-2 presents the share of generators within coverage by EPA region.

Figure ES-2. Share of generators with coverage by EPA region



Finally, the Volpe team estimates drive time from hazardous waste generators outside of mobile broadband coverage to the nearest point of coverage using the detailed OSM road network. For half of the generators analyzed, mobile broadband can be reached within 0.3 miles, and for about three quarters of the generators, mobile broadband can be reached within 0.8 miles. Focusing on drive time, mobile broadband can be reached in an estimated 32 seconds for half of generators and in one minute and 43 seconds for three quarters of generators. Figure ES-3 displays the distribution of drive times by region— Regions 1 and 2 (covering New England, New York, New Jersey, and Puerto Rico) have the lowest median drive times (20 and 19 seconds) while Regions 8 and 10 (the Mountains and Plains and the Pacific Northwest) have the highest median drive times (1:33 and 1:37, in minutes and seconds).

Figure ES-3. Distribution of drive time from uncovered generators to nearest point of coverage by EPA region



All analyses in this report reflect static snapshots of broadband coverage as reported by mobile providers and may not reflect the on-the-ground experience. In addition, the current study focuses on the combined coverage areas from three major providers—if at least one of the three providers reports coverage at a location, this analysis considers that location to be covered. As individual waste handlers typically have service with a single provider, the analysis may overestimate access where the major providers' coverage areas do not overlap. However, the analysis may underestimate access where roaming agreements are in place. Additionally, for the drive time estimates, the Volpe team implemented several modeling decisions, including limiting the study areas to points reachable within a 100-mile radius or a 60-minute drive; as a result, summary statistics exclude the most remote generators, such as generators in northern and western Alaska. However, for many of the excluded generators, an estimated drive time to the nearest point of service from a major provider is less relevant given the geography and road infrastructure, the reliance on backhaul programs, and the availability of smaller, regional mobile providers.

Table ES-1 presents a combined summary with key findings from the completed analyses by EPA region. Nationally and by EPA region, a majority of considered roadway miles and generators fall within mobile broadband coverage though some regions see lower shares of coverage. More tailored geographic analysis could be the focus of future work as EPA rolls out policies and resources supporting the adoption of fully electronic hazardous waste manifests.

Table ES-1. Summary of mobile broadband coverage by EPA region

Region	Percent Covered Miles of Highway Network	Percent Covered Generators	Median Drive Time to Point of Coverage (Minutes:Seconds)*	Average Drive Time to Point of Coverage (Minutes:Seconds)*
1	90.2%	97.1%	0:20	0:42
2	94.2%	98.9%	0:19	1:04
3	93.9%	98.0%	0:37	2:34
4	94.1%	97.8%	0:44	2:11
5	95.4%	99.4%	0:38	1:36
6	94.1%	99.1%	0:53	2:05
7	93.6%	98.8%	0:24	1:28
8	85.0%	96.6%	1:33	3:22
9	92.5%	99.4%	0:27	2:23
10	79.3%	97.9%	1:37	3:33
Total	**92.1%**	**98.8%**	**0:32**	**1:58**

* From generators in locations without coverage

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1. Introduction

This report presents analysis of the extent of mobile broadband coverage, or wireless internet access via cellular networks, at hazardous waste handler locations and along the transport network. Researchers from the United States (U.S.) Department of Transportation (DOT) Volpe Center (Volpe) conducted this study in partnership with the Environmental Protection Agency (EPA) Office of Resource Conservation and Recovery (ORCR). Volpe is providing policy and regulatory research, technology research, and data analysis and visualization support for ORCR's electronic manifest system (e-Manifest) program.

The remainder of this section introduces EPA's hazardous waste cradle-to-grave tracking processes, the use of electronic manifests, and the motivation and focus areas for the Volpe team's study. The subsequent sections of the report present the analyses, datasets, methodologies, findings, and conclusions of the study:

- Section 2 describes the datasets and preprocessing steps.
- Sections 3, 4, and 5 present methods and findings from analyses focusing on the extent of mobile broadband coverage.
- Section 6 documents limitations in the analyses and opportunities for expansion.
- Section 7 provides a summary and study conclusion.

1.1 Background

Hazardous waste is waste capable of having a harmful effect on human health or the environment and is generated from manufacturing and industrial processes, among other sources.[8] Authorized by the Resource Conservation and Recovery Act (RCRA) in 1976, the EPA oversees a national cradle-to-grave hazardous waste management program to track and ensure the safe management of hazardous waste from its point-of-origin at a generator facility to its ultimate destination at a designated waste management facility that will store, treat, or dispose of the hazardous waste. [9] Hazardous waste generators must prepare a manifest with information on the type and quantity of hazardous waste being transported, handling instructions, and signature lines for all handlers involved in the transportation and disposal process.[10] Hazardous waste handlers—i.e., the generator, brokers, all transporters, and the designated receiving facility—must sign and date the

[8] https://www.epa.gov/hw/learn-basics-hazardous-waste
[9] https://www.epa.gov/hw/learn-basics-hazardous-waste
[10] https://www.epa.gov/hwgenerators/hazardous-waste-manifest-system

manifest with each successive hand-off (transfer). [11] All handler organizations, except for very small quantity generators under limited circumstances, must obtain an EPA Identification Number for tracking and reporting purposes.[12]

In 2018 the EPA launched the Hazardous Waste Electronic Manifest System (e-Manifest) as part of the Resource Conservation and Recovery Act Information (RCRAInfo) system to enable the use of electronic manifests in place of paper manifests with a goal of reducing costs to handlers and improving the accuracy and timeliness of reporting on waste shipments. Under the Hazardous Waste Electronic Manifest Establishment Act (2012), the EPA can encourage the use of electronic submittals, though the use of paper manifests is still permitted.[13] Ultimately, information from all manifests, whether electronic or paper, are uploaded into e-Manifest. Currently, rules of record retention for copies of paper manifests may still apply.

In March 2026 the EPA issued a proposed rule to sunset the use of paper manifests, ending the acceptance of paper manifests and requiring waste handlers to use electronic manifests, including fully electronic or hybrid manifests, for all shipments.[14] Since the inception of e-Manifest, the EPA has responded to questions on expectations for handlers who do not have internet access to sign and date electronic manifests upon handoff. To mitigate internet access limitations, in 2023 the EPA enacted a Remote Signer Policy to allow a registered user at an off-site location to execute signatures on behalf of generators, transporters, or designated receiving facilities without network access at the time of exchange, until the earlier of 24 hours from the time that (a) their field personnel receive the waste from the preceding waste handler or (b) waste is transferred to another handler. However, adoption rates of electronic manifests remain low, with 99.5% of submissions still relying on paper.[15] The proposed rule will require a large shift to electronic signatures, and questions around internet access and e-Manifest policies remain applicable to the majority of handlers, manifests, and hazardous waste tracked within e-Manifest.

1.2 Research Objectives

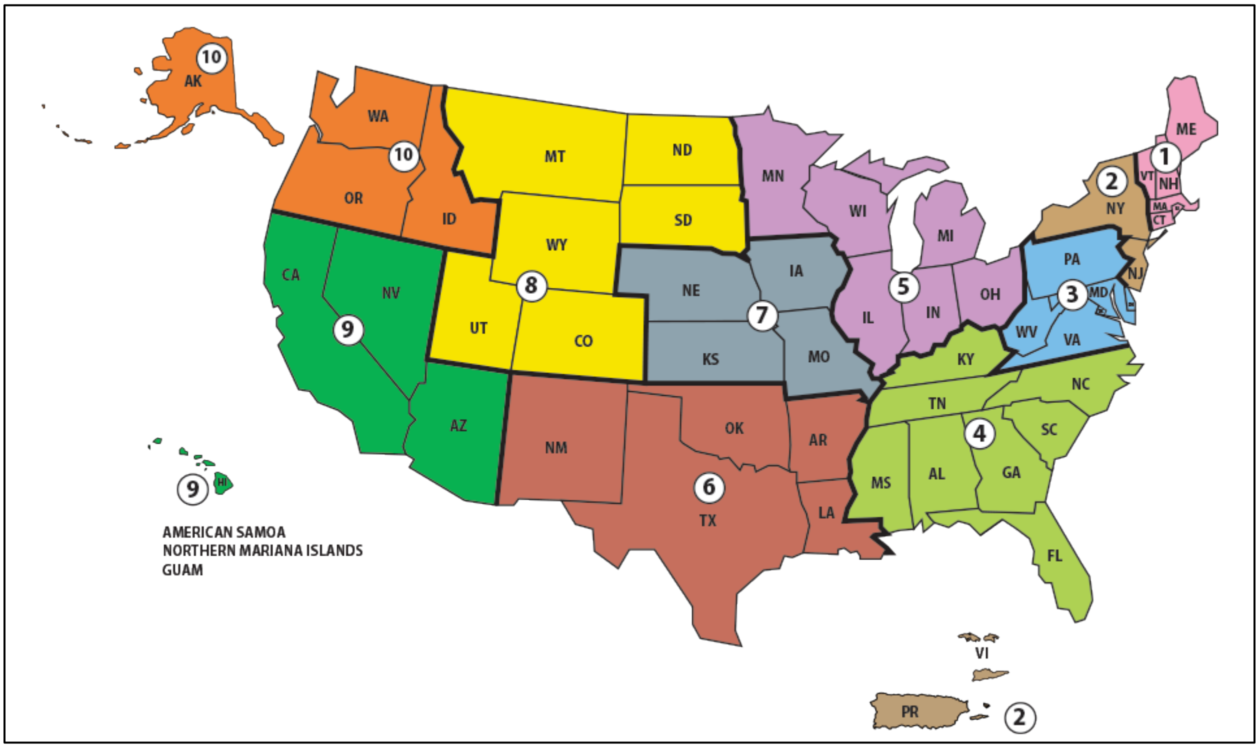
This study investigates in-vehicle mobile broadband coverage on the national highway network and at the sites of hazardous waste generators. It also explores the practical implications of fully

[11] Specifically for transport by road. Requirements differ for transport by rail and water.
[12] https://www.epa.gov/e-manifest/frequent-questions-about-e-manifest; https://www.epa.gov/hw/hazardous-waste-transportation
[13] https://www.epa.gov/e-manifest/learn-about-hazardous-waste-electronic-manifest-system-e-manifest
[14] https://www.epa.gov/e-manifest/e-manifest-rulemakings-and-policies; https://www.federalregister.gov/documents/2026/03/05/2026-04366/paper-manifest-sunset-rule-modification-of-the-hazardous-waste-manifest-regulations
[15] https://www.regulations.gov/document/EPA-HQ-OLEM-2025-0391-0003

electronic manifests by estimating and summarizing the drive time from generators in uncovered areas ("dead zones" or locations outside of mobile broadband coverage areas) to the nearest area of coverage. Results are summarized by EPA region. Figure 1 maps the EPA regions, and Appendix A lists each region's constituent states.

This study will assist ORCR in identifying gaps in mobile broadband coverage that may impact their stakeholders during widespread electronic manifest adoption. Findings may help inform future policy and technology changes and technical assistance. Ensuring hazardous waste handlers can reliably sign electronic manifests enables a smooth transition to and continued use of fully electronic manifests, with the overarching goal of reducing costs and complexity for regulated industry.

Figure 1. EPA region map



Source: EPA

2. Dataset Description

The sections below describe the mobile broadband, roadway, and hazardous waste generator datasets used in these analyses.

2.1 FCC Mobile Broadband Data

The Federal Communication Commission (FCC) collects, validates, and publishes highly detailed propagation-modeled footprints for mobile broadband coverage, i.e., wireless internet access, from mobile providers across the U.S. states and territories. In modeling coverage areas for submission to the FCC, mobile providers adhere to specific technical parameters including minimum download and upload speeds, which EPA anticipates to be sufficient for signature actions in the e-Manifest system.[16] Providers must also indicate whether service can be accessed if (i) moving in a vehicle or (ii) standing still outdoors.[17] FCC publishes both the raw provider datasets[18] as well as spatial aggregations over a network of hexagonal polygons (at H3 Resolution 9, or about 0.1 square kilometers),[19] where a polygon is considered covered if its center falls within the provider's coverage data.[20] Analyses are performed using the WGS 1984 projection, and visualized using the USA Contiguous Albers Equal Area Conic projection.

For this analysis, the Volpe team considers "mobile broadband coverage" areas as the geographic areas with 4G LTE in-vehicle mobile broadband coverage by at least one of three main providers (AT&T, Verizon, T-Mobile). The study focuses on these three large providers since service through roaming agreements with regional providers may vary. The Volpe team uses the National Broadband Map's hexagonal datasets, reflecting coverage data as of June 30, 2025 and any subsequent corrections prior to December 31, 2025. Figure 2 depicts the extent of mobile broadband data used in this study, i.e., 4G LTE in-vehicle mobile broadband service from at least one of the three included providers. Coverage spans the U.S. states, Puerto Rico, and the Virgin Islands.

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[16] For 4G LTE technology, service must provide a download speed of at least 5 megabits per second (Mbps) and an upload speed of at least 1 Mbps, with sufficient probability under realistic network congestion. https://help.bdc.fcc.gov/hc/en-us/articles/6047425308187-Formatting-Mobile-Broadband-Availability-Coverage-Maps

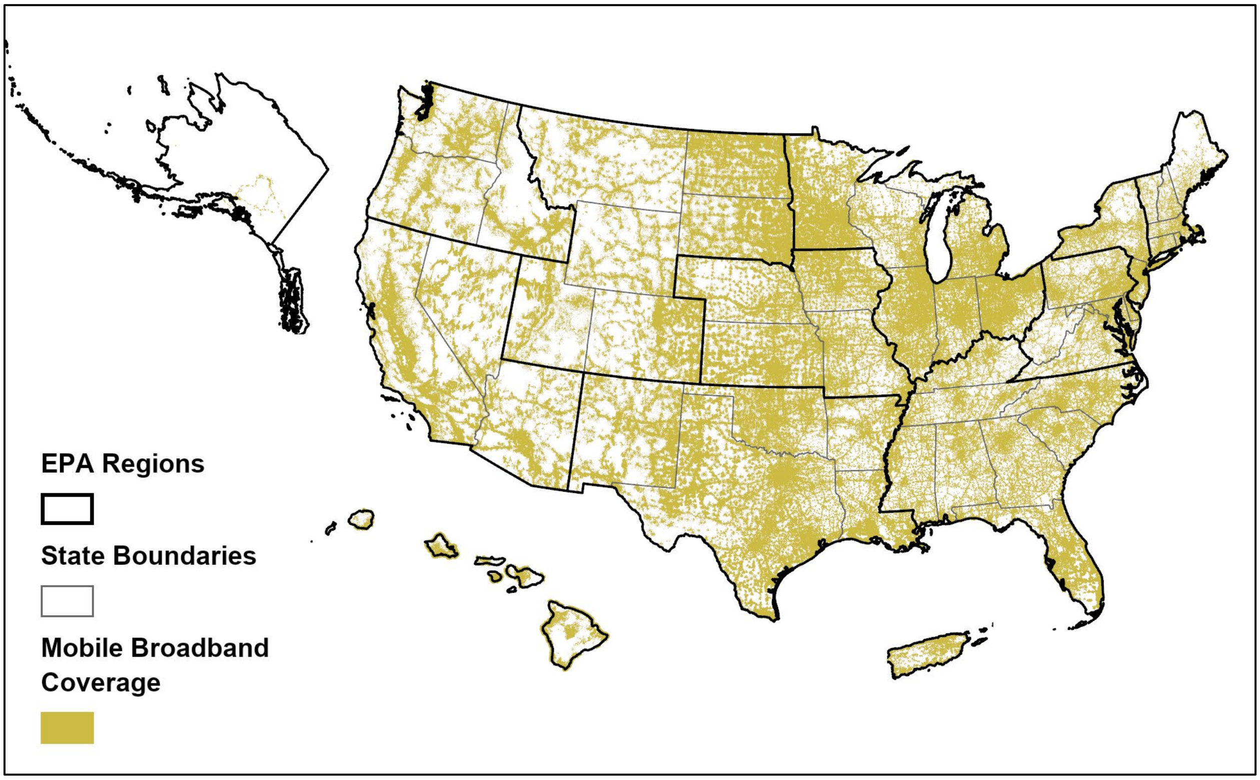
[17] In-vehicle mobile coverage areas are strictly within outdoor stationary coverage areas per FCC requirements. https://help.bdc.fcc.gov/hc/en-us/articles/6047425308187-Formatting-Mobile-Broadband-Availability-Coverage-Maps

[18] https://www.fcc.gov/sites/default/files/bdc-data-downloads-output.pdf

[19] https://h3geo.org/docs/3.x/core-library/restable/

[20] https://www.fcc.gov/sites/default/files/bdc-data-downloads-output.pdf

Figure 2. Combined mobile broadband coverage from AT&T, Verizon, and T-Mobile

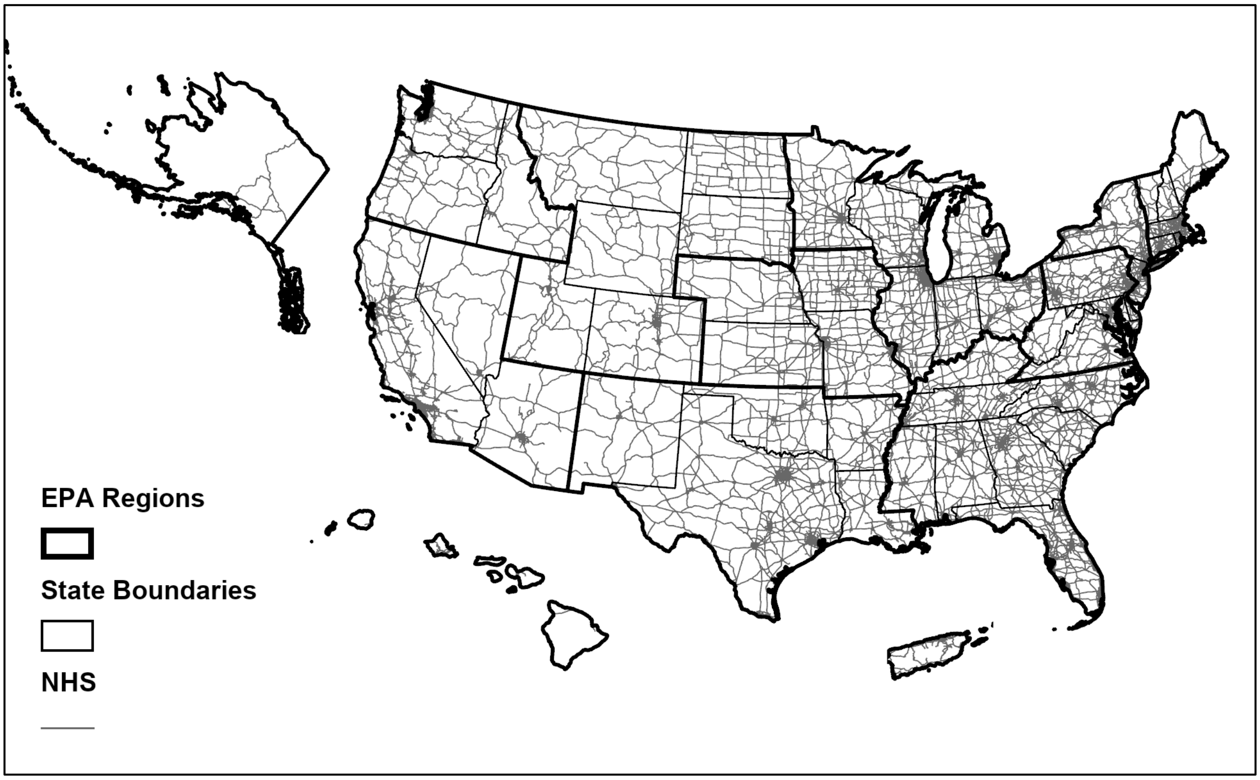


2.2 BTS National Highway System

The National Highway System (NHS) is used to assess overall mobile broadband coverage at a high level on major roadways. The NHS consists of roadways important to the nation's economy, defense, and mobility and comprises over 44% of the nation’s road travel.[21, 22] The acquired NHS dataset—updated August 08, 2025 and covering all 50 states, D.C., and Puerto Rico—is maintained by the Bureau of Transportation Statistics (BTS) as part of their National Transportation Atlas Database (NTAD) to serve the Federal Highway Administration (FHWA) in highway planning and policy analysis.[23] The Volpe team also considered the U.S. Census Bureau Primary and Secondary Roads and the BTS Freight Analysis Framework Version 5 road network but selected the NHS for its appropriate level of detail. While the NHS is not specific to routes where hazardous waste is transported, it is useful for a nationwide assessment of mobile broadband coverage on critical roadways. Figure 3 depicts the NHS along with state and EPA region borders.

[21] https://geodata.bts.gov/datasets/usdot::national-highway-system-nhs/about
[22] https://www.fhwa.dot.gov/ohim/onh00/onh2p6.htm
[23] https://geodata.bts.gov/datasets/usdot::national-highway-system-nhs/about

Figure 3. National Highway System (NHS)



2.3 Hazardous Waste Generators

The Volpe team considered hazardous waste generators active in 2025, based on recorded generators with valid EPA identification numbers and their associated manifests in the EPA RCRAInfo system as of January 2026. The analysis retained information on the federal generator category, short-term generator status, generator coordinates, and the number of manifests with a shipped date in 2025 and the associated total tonnage. After querying the RCRAInfo system, the analysis excluded generators that fell outside of U.S. land boundaries based on the Census Bureau's 2018 county-level cartographic boundary files (1:500,000 resolution),[24] reducing the sample size from 203,571 to 203,342 generators.

Table 1 summarizes by EPA region the number of hazardous waste generators in the final study sample. Region 9 includes almost half of the study generators, with California in Region 9 alone accounting for 46% of the generators nationwide.

[24] https://www.census.gov/geographies/mapping-files/time-series/geo/carto-boundary-file.html

Table 1. Generators per EPA region

Region	Count Generators	Percent Generators
1	15,828	7.8%
2	8,888	4.4%
3	11,673	5.7%
4	19,921	9.8%
5	26,361	13.0%
6	10,515	5.2%
7	5,041	2.5%
8	3,828	1.9%
9	96,778	47.6%
10	4,509	2.2%
Total	**203,342**	**100.0%**

Of the 203,342 generators included in the study, about 9% are Large Quantity Generators (LQGs), 19% are Small Quantity Generators (SQGs), and 29% are Very Small Quantity Generators (VSQGs).[25] The remaining 43% are generators of non-federally regulated waste, although they may still be subject to manifest requirements if they generate state-regulated waste.

2.4 OpenStreetMap

For hazardous waste generators without mobile broadband coverage at their physical location, the Volpe team used OpenStreetMap (OSM)[26], accessed in 2024, to estimate drive time to the nearest area of coverage. OSM data are open source and were downloaded as a 24-hour snapshot from Geofrabik[27] for all 50 states and D.C. but excluding U.S. territories. The raw data were processed using the open-source tool OSMOSIS[28] to generate a road network for all highway types down to residential classified segments[29] (excluding service routes). Supplementary information for the segment such as one-way directions or speed limits was taken from the OSM tags. When the speed limit tag was not available, speed limits were estimated based on the road's Census Feature Class Code (CFCC)[30] as: Arterials (70 mph), Collectors (50 mph), and Local Roadways (25 mph).

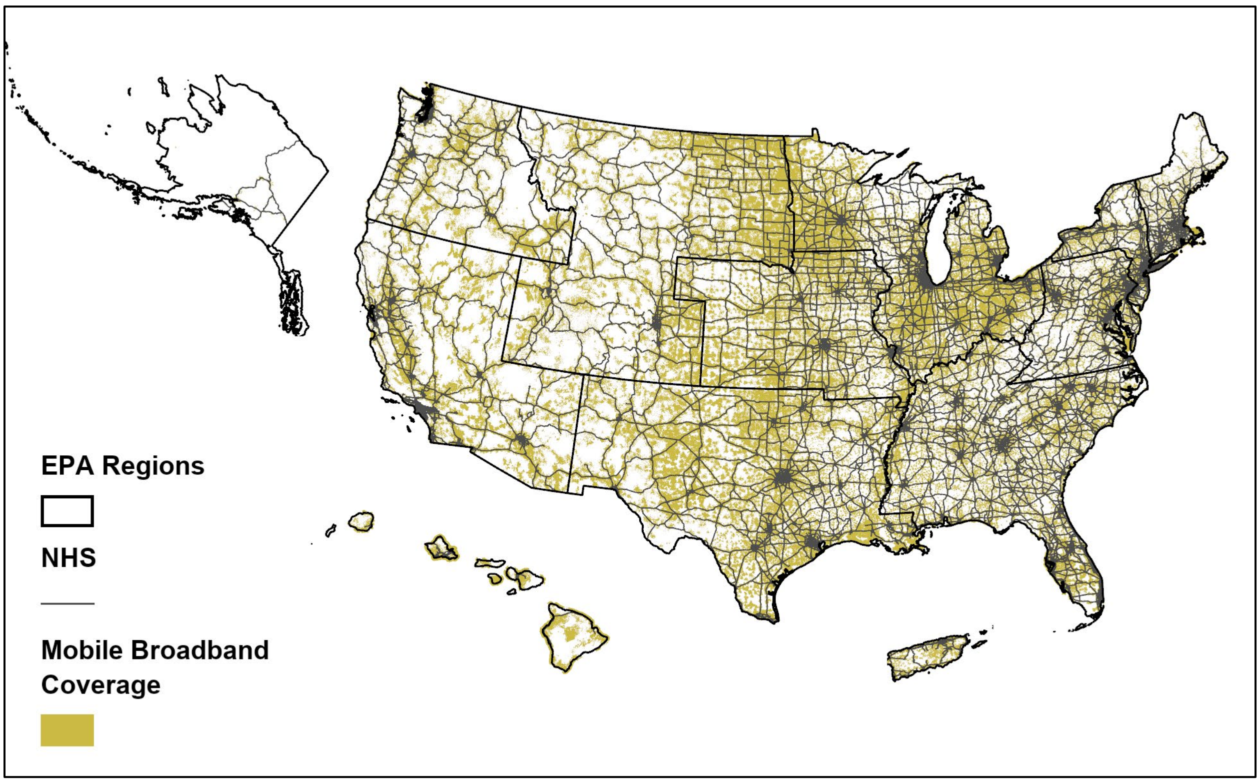
[25] https://www.epa.gov/hwgenerators/categories-hazardous-waste-generators
[26] https://www.openstreetmap.org/about
[27] https://www.geofabrik.de/data/download.html
[28] https://wiki.openstreetmap.org/wiki/Osmosis
[29] https://wiki.openstreetmap.org/wiki/Key:highway
[30] https://wiki.openstreetmap.org/wiki/TIGER_to_OSM_Attribute_Map

3. Coverage of the National Highway System

3.1 Methodology

The Volpe team overlayed spatial features representing the NHS road network with the derived mobile broadband coverage (see Figure 4) to estimate the geodesic length in miles of highway with mobile broadband coverage from at least one of the three main service providers. The analysis also calculated the percentage of NHS road miles with coverage in each EPA region. Generally, coverage areas appear to align with NHS roads, with both highways and coverage becoming visually sparser in the intermountain west.

Figure 4. Mobile broadband coverage along NHS network



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3.2 Findings

Of the 222,052 miles of NHS road network, 204,567 miles (92%) have mobile broadband coverage. Individual regions range from 8,000 to 40,000 NHS road miles in total, with percent covered miles ranging from 79% in Region 10 (the Pacific Northwest) to 95% in Region 5 (the Upper Midwest). Figure 5 illustrates the percentage of covered NHS miles by region while Table 2 provides additional detail on the number of total NHS miles and covered miles in each region.

Figure 5. Share of NHS miles with coverage by EPA region

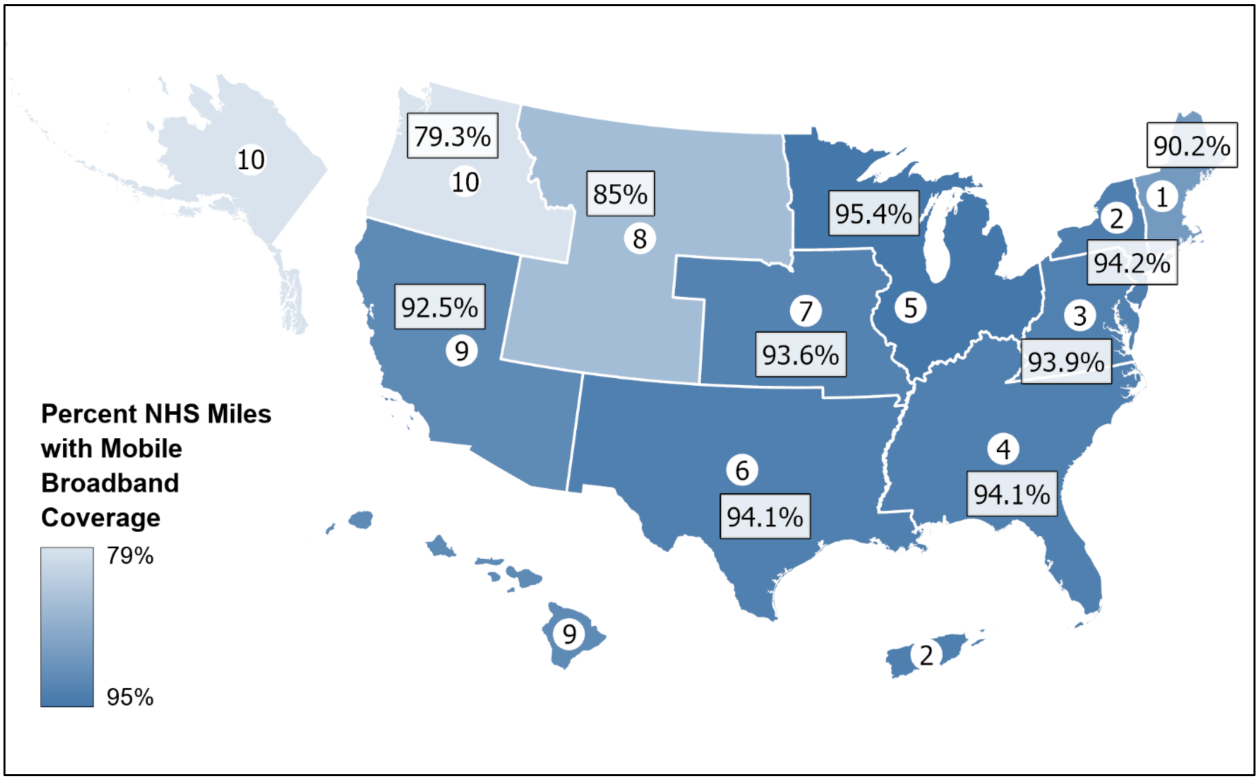


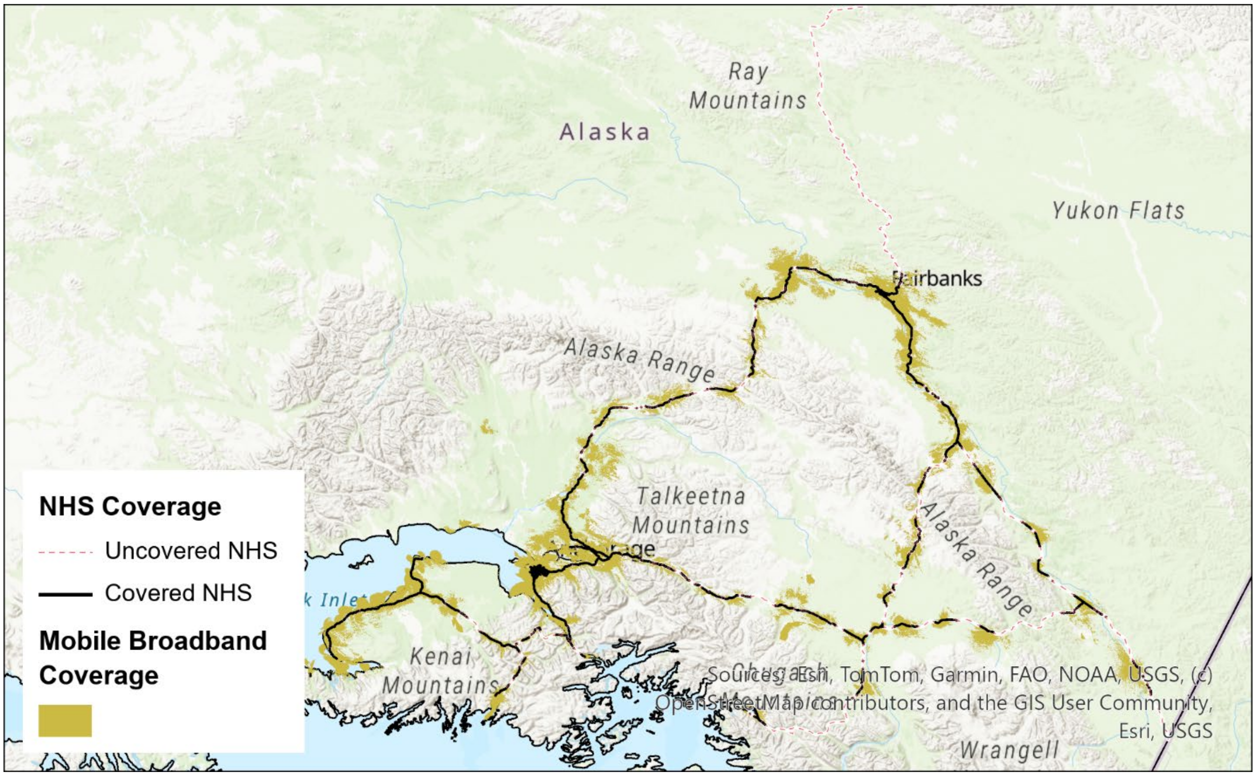
Table 2. Road network mileage with mobile broadband coverage by EPA region

Region	All Miles	Miles with Mobile Broadband Coverage	Percent Miles with Mobile Broadband Coverage
1	8,386	7,565	90.2%
2	11,848	11,157	94.2%
3	16,673	15,661	93.9%
4	42,374	39,866	94.1%
5	34,861	33,247	95.4%
6	32,238	30,339	94.1%
7	19,048	17,835	93.6%
8	22,425	19,068	85.0%
9	20,450	18,918	92.5%
10	13,751	10,908	79.3%
Total	**222,052**	**204,567**	**92.1%**

With just 47.9% of its NHS miles covered, Alaska is the state with the lowest share of coverage. Excluding Alaska from Region 10 increases the region's percent covered miles from 79.3% to 85.4%. Figure 6 maps the NHS network in Alaska, differentiating highway segments within and outside of mobile broadband coverage areas. Note, however, that generators in rural Alaska commonly backhaul hazardous waste via air and barge transport, so these findings on covered NHS miles do not capture the experiences and challenges of these most remote generators.[31] Otherwise, the state with the second lowest coverage is Wyoming with 75.8% of NHS miles covered. The median state has 93.5% coverage.

[31] https://www.epa.gov/r10-tribal/tribal-solid-waste-and-sustainable-materials-management-region-10

Figure 6. NHS network coverage (AT&T, Verizon, and T-Mobile) in Alaska

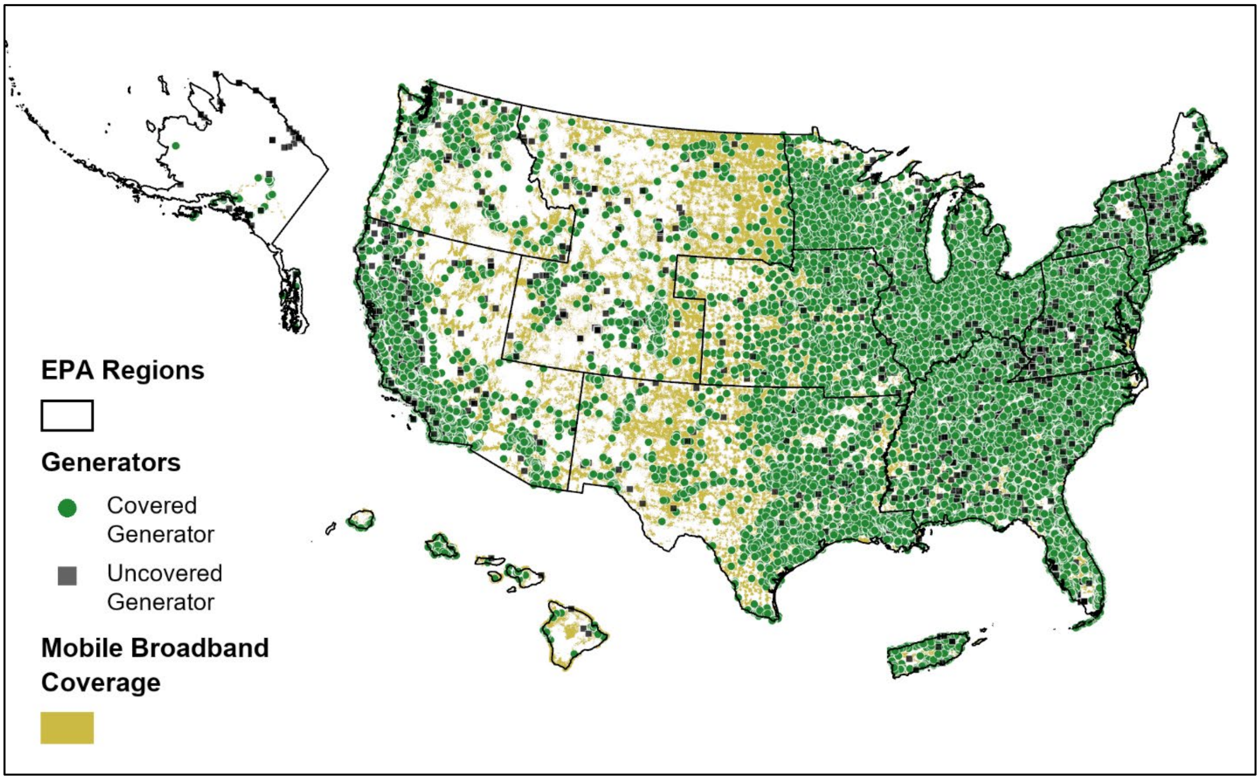


4. Coverage of Hazardous Waste Generators

4.1 Methodology

The Volpe team overlayed the filtered hazardous waste generator dataset with the derived mobile broadband coverage dataset (see Figure 7) to identify generators with and without mobile broadband coverage. The analysis identified the number and percent of generators, manifests, and tons produced within coverage areas for each region.

Figure 7. Generators with and without mobile broadband coverage

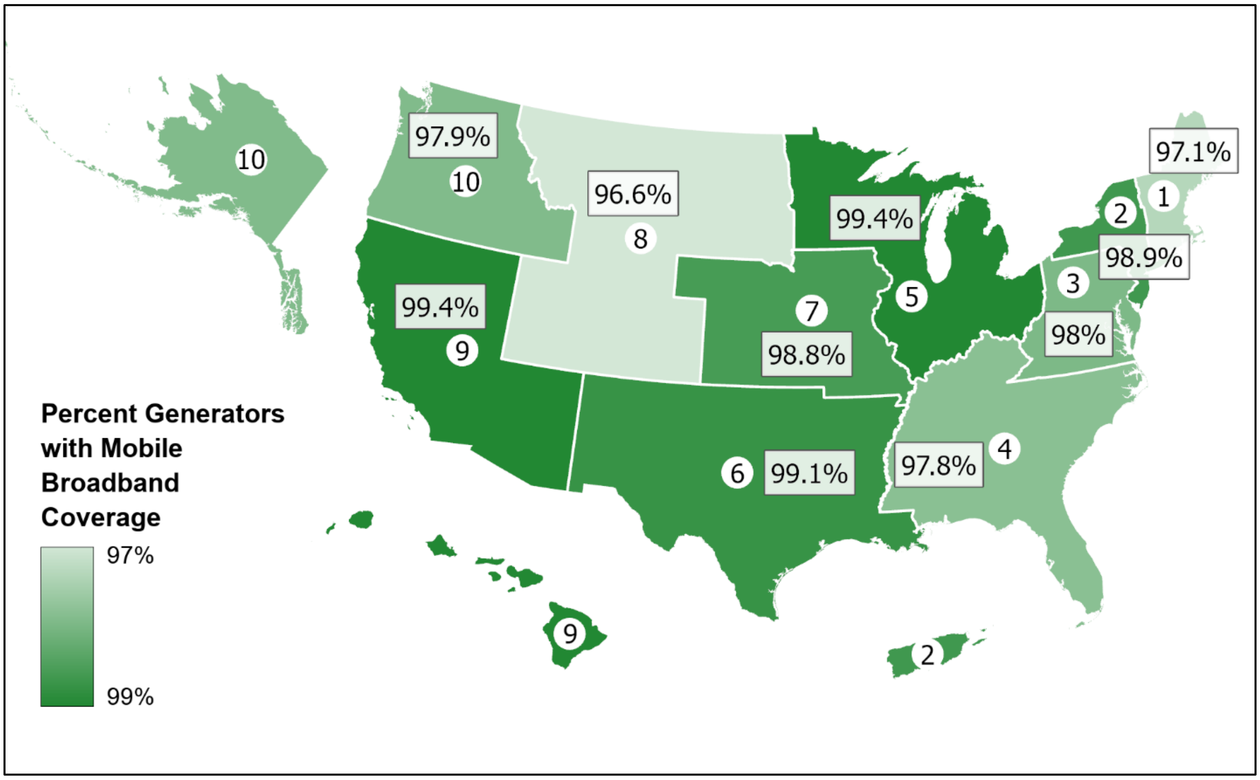


4.2 Findings

Of the 203,342 generators analyzed, 200,942 (98.8%) generators are covered by at least one of the three main service providers. These generators produced 97.8% of waste tonnage and 98.7% of manifests in 2025.

By region, a vast majority of generators have access to mobile broadband, with the percent covered ranging from 96.6% to 99.4% of generators. At the state and territory level, the percent of generators with coverage ranges from 75% in the Virgin Islands to 100% in Washington, D.C. Figure 8 presents the share of generators within coverage by EPA region.

Figure 8. Share of generators with coverage by EPA region



As another perspective, Figure 9 presents the *share of manifests* initiated from generator locations with mobile broadband coverage. Compared to the share of covered generators, the share of manifests originating from covered generators is at least a percentage point higher in Regions 1 and 5. In contrast, Region 4 has 97.8% of generators in covered areas but only 95.8% of manifests originating from covered generators, suggesting the more active generators are disproportionately in areas with less mobile broadband coverage. Both the generator locations and the manifest counts are based on manifests with a shipped date in 2025.

Finally, Table 3 presents all calculated results for generators by EPA region. The percent of generators with mobile broadband coverage ranges from 97% to 99% in each region. Overall, exactly 2,400 (1.2%) of the studied generators fell outside of mobile broadband coverage areas. While generators of federally regulated waste—including LQGs, SQGs, and VSQGs—compose 57% of the generators studied, they represent 71% of the 2,400 uncovered generators.

Figure 9. Share of manifests from generators with coverage by EPA region

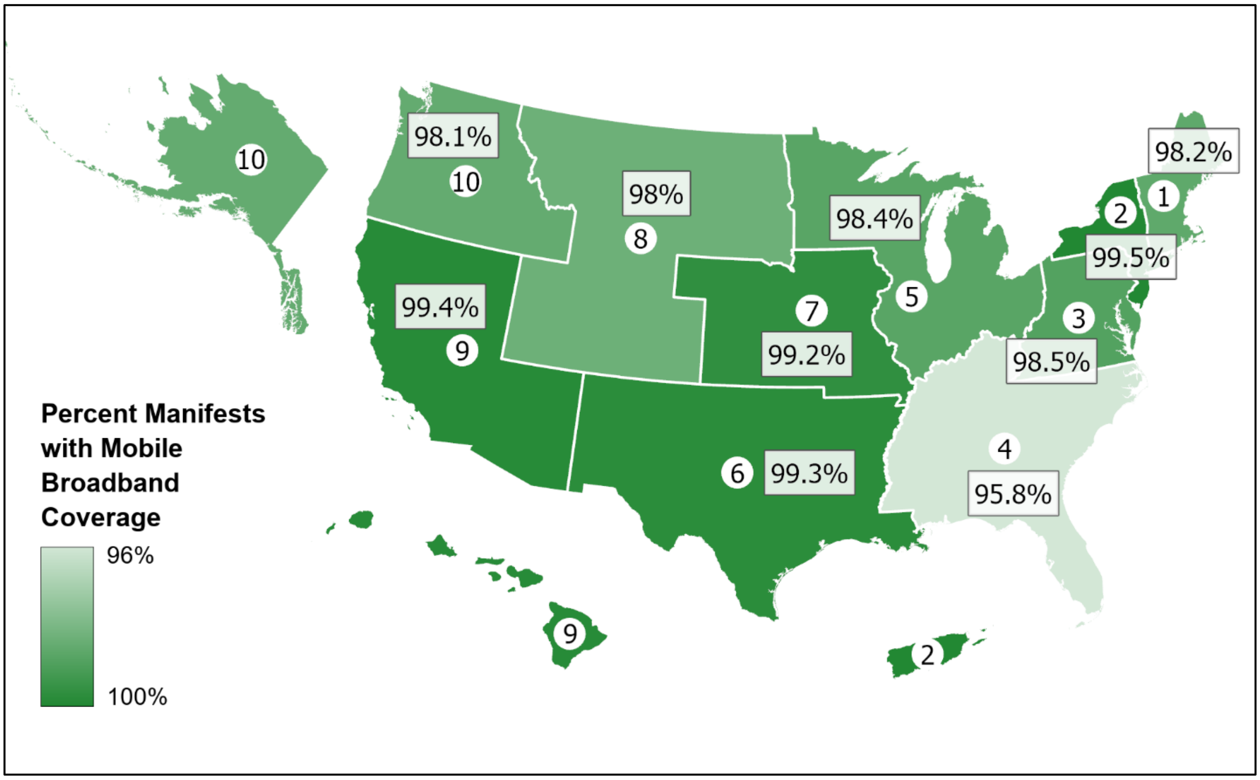


Table 3. Mobile broadband coverage of 2025 generators by EPA region

Reg	All Generators	Covered Generators	Covered Tons	Covered Manifests	Percent Covered Generators	Percent Covered Manifests	Percent Covered Tons
1	15,828	15,366	361,960	125,148	97.1%	98.2%	98.9%
2	8,888	8,790	616,624	108,117	98.9%	99.5%	99.9%
3	11,673	11,435	423,052	91,961	98.0%	98.5%	98.2%
4	19,921	19,475	1,140,699	177,575	97.8%	95.8%	89.9%
5	26,361	26,197	2,594,925	250,348	99.4%	98.4%	97.0%
6	10,515	10,416	6,532,870	233,778	99.1%	99.3%	99.4%
7	5,041	4,980	286,318	53,072	98.8%	99.2%	91.7%
8	3,828	3,698	259,189	37,273	96.6%	98.0%	99.1%
9	96,778	96,171	2,397,828	663,640	99.4%	99.4%	98.5%
10	4,509	4,414	165,774	49,025	97.9%	98.1%	95.6%
Total	**203,342**	**200,942**	**14,779,238**	**1,789,937**	**98.8%**	**98.7%**	**97.8%**

*Excluding 229 generators that fell outside of the census boundaries

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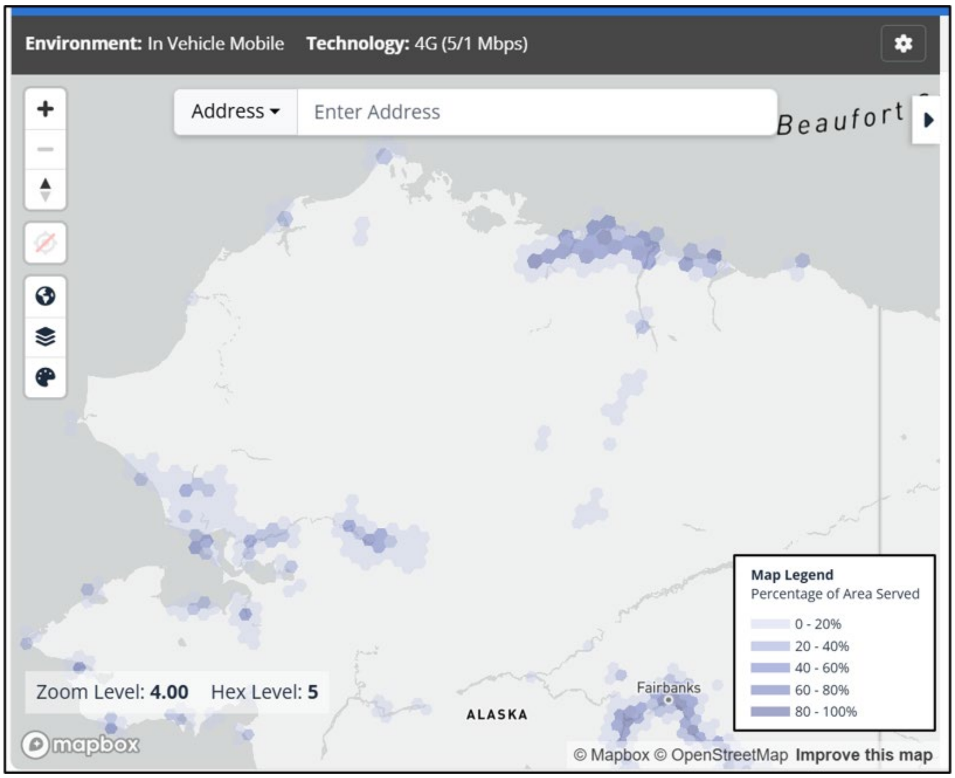
Note that generators outside of service areas for the top three mobile providers may still be served by regional providers. For example, Figure 7 in Section 4.1 above depicts uncovered generators in northwest Alaska. However, other regional mobile providers are active in those areas of Alaska. Figure 10 below shows in-vehicle mobile broadband coverage from all providers, not just the top three. To appropriately evaluate the feasibility of electronic manifests for these generators, future analysis should consider other providers, in addition to other modes of transport for hazardous waste removal, specific to these locations.

Figure 10. All-provider in-vehicle mobile broadband coverage in Northwest Alaska



Source: FCC National Broadband Map (Accessed August 2026)[32]

[32] https://broadbandmap.fcc.gov/location-summary/mobile?version=dec2025&zoom=4&env=1&tech=tech4g

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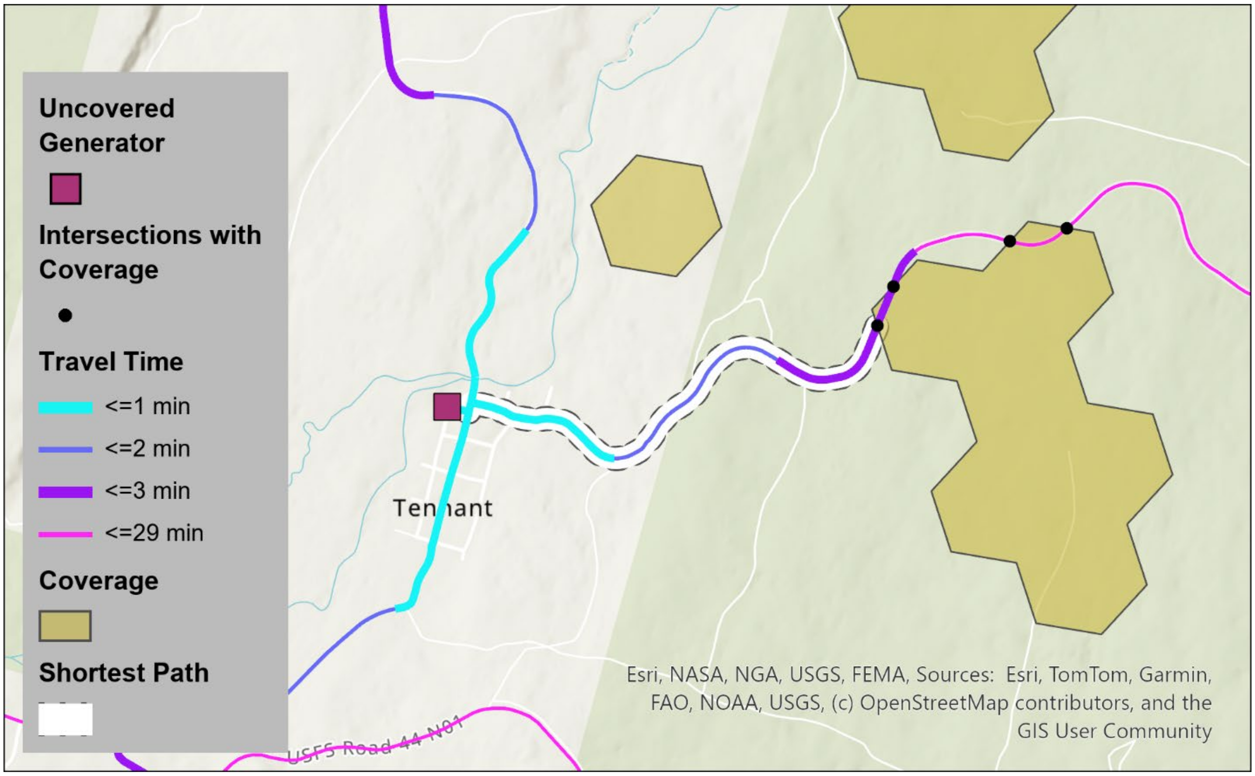
5. Drive Time Analysis

5.1 Methodology

This analysis focused on the hazardous waste generators located outside of mobile broadband coverage areas to estimate the drive distance and time to the nearest point of coverage on the road network. The Volpe team used the detailed OSM road network described in Section 2.4 and the tool ArcGIS Pro Network Analyst 3.4 for the network-based analysis. The analysis drew a straight line from each uncovered generator's coordinates to the nearest point on the OSM road network, creating an artificial link to connect the generator to an OSM road. The analysis then identified the 50 closest intersections (as the crow flies) of road network and coverage areas within a 100-mile radius of the generator and mapped routes along the artificial straight-line connector and road network to those intersections. It mapped to only the 50 closest intersections to reduce analysis time. Using Esri tools, the analysis estimated drive times from the uncovered generator to the intersection points based on the route distance and applied speeds. Drive times were limited to 60 minutes or less, and the artificial straight-line connectors were assigned the same speed limit as CFCC local roads (25 mph) when estimating total travel time (see Section 2.4). Finally, the analysis selected the route with the shortest drive time. Figure 11 demonstrates the analysis for one generator without coverage (pink square), where the shortest route to an intersection with coverage is highlighted in white.

Overall, the population of generators used in this analysis is reduced from 2,400 generators outside of mobile broadband coverage to 2,304 uncovered generators. Of the 96 excluded generators, 40 generators fall in state territories that are outside of the OSM network used in this analysis; 15 generators could not reach a covered area of road network because of incomplete road network information or because the top 50 closest intersections with coverage weren't within 60 minutes of drive time; and 41 generators, all in northern and western Alaska, simply lacked covered road network within 100 miles. However, as discussed in previous sections, an estimated drive time to the nearest point of network access from a major provider is less relevant given the geography and road infrastructure, the reliance on backhaul programs, and the availability of smaller, regional mobile providers.

Figure 11. Example output for a single generator



5.2 Findings

Figure 12 and Figure 13 show the distribution of drive distance and drive time to in-vehicle mobile broadband coverage for the 2,304 uncovered generators nationally. Drive distance and time show a similar distribution across generators. For half of the generators analyzed, mobile broadband can be reached within 0.3 miles, and for about three quarters of the generators, mobile broadband can be reached within 0.8 miles. Focusing on drive time, mobile broadband can be reached in an estimated 32 seconds for half of generators and in one minute and 43 seconds for three quarters of generators. For both drive distance and time, there are some outliers—the greatest drive distance of 36 miles also has the greatest drive time of 54 minutes and 24 seconds (indicating an average speed of 39 miles per hour). Note these results exclude the 96 generators discussed in the methods section above.

Figure 12. Distribution of drive distance nationally

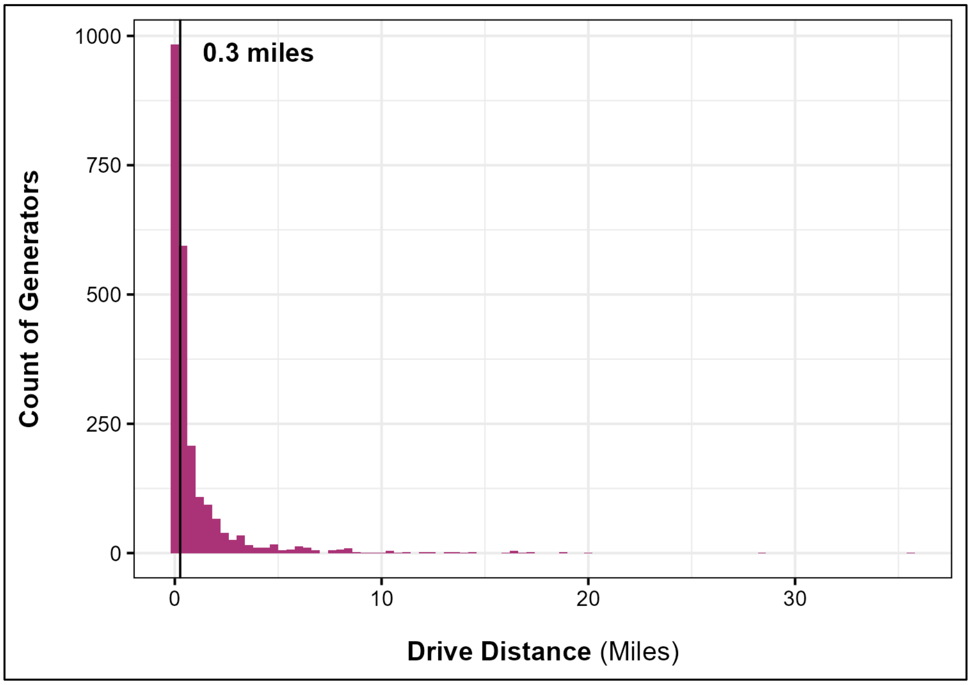


Figure 13. Distribution of drive time nationally

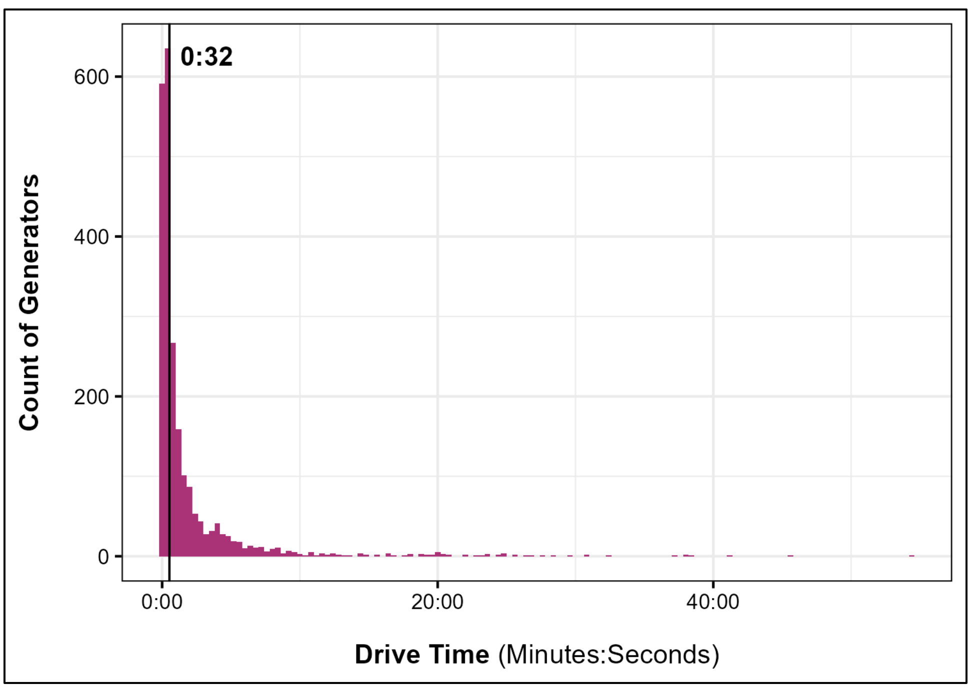


Figure 14 presents the distribution of drive distances by EPA region. The median drive distances by region are all less than 1 mile, with several regions tied for the lowest median drive distance of 0.2 miles. The longest median drive distance is in Regions 8 and 10 (the Rocky Mountains region and Pacific Northwest) at 0.8 miles. In all EPA regions, three quarters of the uncovered generators can drive to a covered area of road network within 2 miles.

Figure 14. Distribution of drive distance from uncovered generators to nearest point of coverage by EPA region

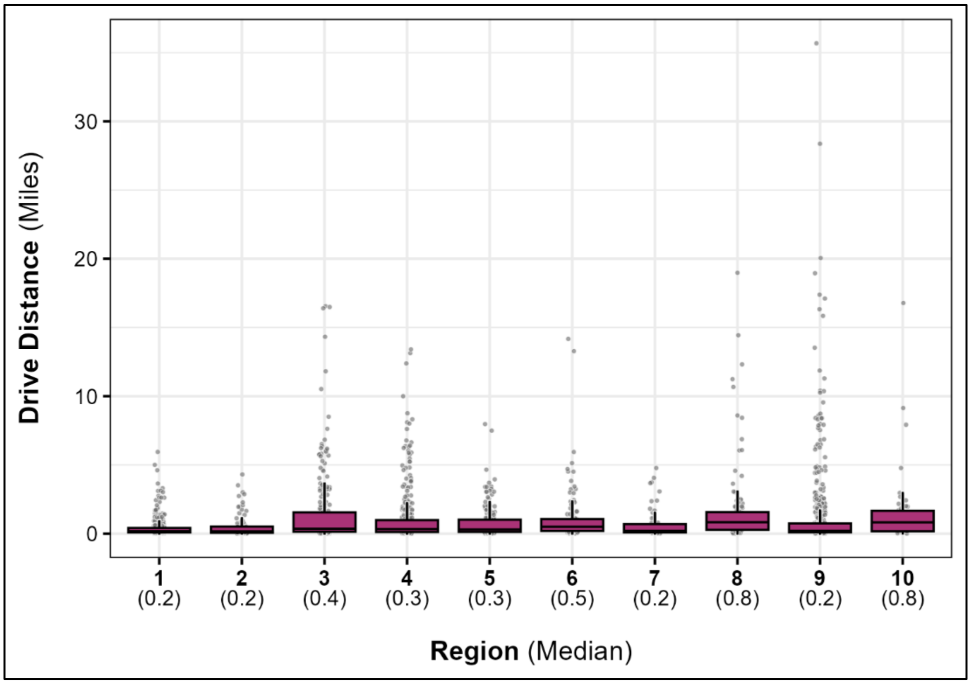


Figure 15 presents the distribution of drive times by region. Regions 1 and 2 (covering New England, New York, and New Jersey, and Puerto Rico) have the lowest median drive times (20 and 19 seconds) while Regions 8 and 10 (the Mountains and Plains and the Pacific Northwest) have the highest median drive times (1:33 and 1:37, in minutes and seconds). Region 9 (Pacific Southwest covering California, Nevada, Arizona, and Hawaii) has both the greatest variance in drive time and drive distance, in addition to the greatest density of uncovered generators.

Finally, Table 4 consolidates summary values, with the median and average drive distances and times by EPA region.

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Figure 15. Distribution of drive time from uncovered generators to nearest point of coverage by EPA region

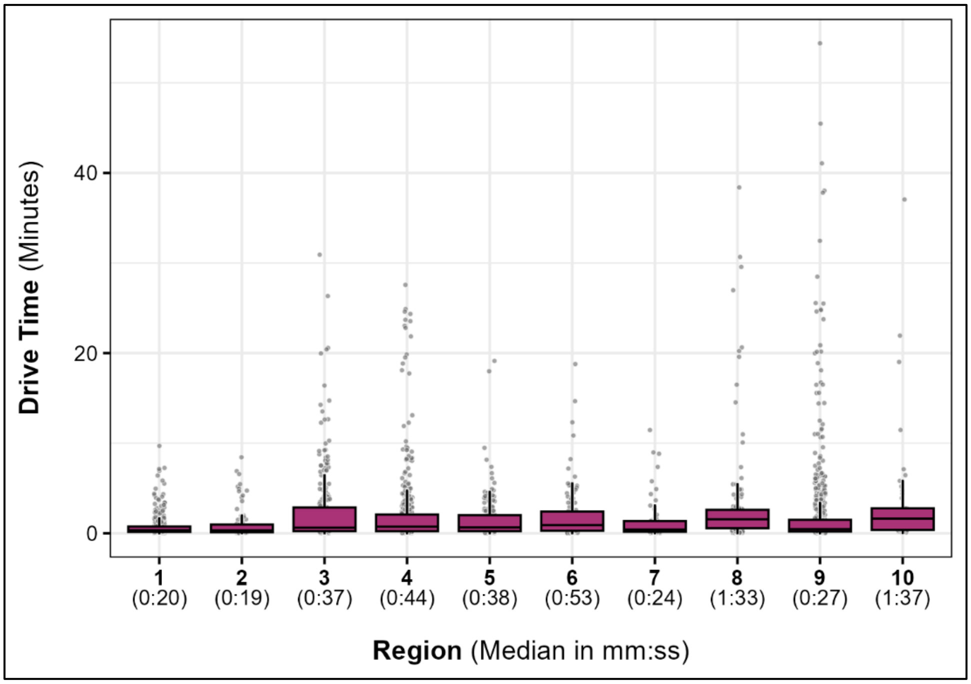

Table 4. Drive time results by EPA region

Region	Uncovered Generators	Median Drive Distance (Miles)	Median Drive Time (Minutes:Seconds)	Average Drive Distance (Miles)	Average Drive Time (Minutes:Seconds)
1	462	0.18	0:20	0.39	0:42
2	87	0.17	0:19	0.54	1:04
3	238	0.36	0:37	1.49	2:34
4	445	0.33	0:44	1.00	2:11
5	164	0.30	0:38	0.82	1:36
6	99	0.50	0:53	1.22	2:05
7	60	0.20	0:24	0.72	1:28
8	126	0.83	1:33	1.71	3:22
9	575	0.20	0:27	1.21	2:23
10	48	0.82	1:37	1.60	3:33
Total	**2,304**	**0.26**	**0:32**	**1.00**	**1:58**

6. Limitations and Potential Expansions

This section documents limitations in the study's datasets and methodologies and notes opportunities for expanded analysis. Across study areas, there is opportunity to investigate the variations within EPA regions and explore results at a higher level of geographic detail—for example, creating an index to describe areas where there is hazardous waste activity but a disproportionate lack of coverage—or focus datasets and analysis on a specific area or set of generators such as the most remote generators or those more likely served by smaller, regional mobile providers.

6.1 Mobile Broadband Coverage

The FCC National Broadband Map data represents mobile providers' expected network access areas based on propagation modeling, using certain common settings. An individual's actual on-the-ground experience accessing mobile broadband may vary with factors such as cell site capacity, terrain, and the user's device. To continuously improve published data, the FCC welcomes map users to dispute published coverage areas by submitting mobile speed test results (using the FCC Speed Test App or an approved third-party speed test app); FCC then aggregates tests into mobile challenges requiring a response from mobile providers to improve their maps. Corrections are published on a rolling basis throughout the year.

The current analysis focuses on internet access while moving in a vehicle, which is less available than internet access while outdoors and stationary; however, in some settings, users may additionally have outdoor, stationary connection, in which case, coverage areas are underrepresented. Additionally, the current analysis defines mobile broadband coverage as the combined coverage areas of three main service providers—AT&T, Verizon, and T-Mobile—in the United States. Individual waste handlers typically have service with a single provider and may not have access to mobile broadband outside of that specific provider's reported availability. However, this analysis may also underestimate coverage, given that these providers may utilize agreements with smaller local carriers to fill out coverage in areas that would otherwise be spotty or lack coverage entirely, or that the regional carriers may be the selected provider for certain handlers and locations. Further analysis could review the extent of overlap across the providers, focus on the most common provider for hazardous waste handlers, and the standard agreements with small providers to determine their relevance in assessing mobile broadband coverage.

6.2 National Transport Network

This study investigates mobile broadband coverage along the National Highway System, which is applicable to general transport. Further analysis could incorporate information on roads that are designated for or restricted from transporting hazardous materials specifically. The Federal Motor Carrier Safety Administration (FMCSA) National Hazardous Materials Route Registry (NHMRR) lists state-reported routes relevant to hazardous material transport. Future work could also explore mobile broadband coverage along non-road networks, such as rail or waterway routes, and consider any unique manifest and reporting rules for generators and transporters of those modes.

6.3 Generator Location

The analysis excludes 229 generators with geographic coordinates outside the U.S. Census Bureau's 2018 county-level cartographic boundary files (1:500,000 resolution). While some generators are truly located offshore (where FCC Mobile Broadband data does not extend), other generators may have been inadvertently excluded due to imprecisions in the boundary file. Since these 229 generators only compose 0.1% of the generators active in 2025, they are excluded from the analysis. Small changes in generator location might have greater impact in areas with spotty internet access, so future research, particularly if focused on a specific geography or a subset of generators, could validate generator locations before assessing coverage.

6.4 Drive Time Analysis

The drive time analysis utilizes a detailed road network from OpenStreetMap. However, the network dataset excludes service roads, which in some cases, may be the most relevant routes for generators in more remote areas. Artificial straight-line connectors used to connect the generators to the OSM network as proxy roads may pass through geographic obstacles or bypass nearer areas of cell coverage that would have otherwise been accessible via service roads. Additionally, as OSM data are created through a community of supporters, the network may lack data or be out of date. There may be less data available in rural or remote areas or instances where drive times may not be relevant (e.g., along Alaska coastlines), and the supplementary tagging information from OSM for one-way directions or speeds may be inaccurate. In addition, modeling decisions to ensure reasonable runtime—specifically imposing a 100-mile radius and 60-minute drive time limit and considering only the 50 closest points of cell coverage along the OSM network – caused some generators and, in one case, a closer point of cell coverage to be excluded from the analysis.

Further research could investigate the completeness or spottiness of coverage around uncovered generators, for example, by using drive time along the OSM network to estimate the share of road miles with mobile broadband coverage within a 5-minute drive, 10-minute drive, or 20-minute drive. An exploration within defined drive times of the origin generator is highly relevant as transporters may travel in different directions and likely will not know the nearest point of coverage.

7. Conclusion

In this study, the Volpe team analyzed the extent of mobile broadband coverage from three major providers and investigated where coverage may be lacking for handlers of hazardous waste. The study considered how the locations of national highways and hazardous waste generators intersect with mobile broadband coverage areas and explored the practical implications of that coverage by estimating the drive time for transporters traveling from uncovered generator locations to the nearest point of coverage along roadways.

Table 5 presents a combined summary with key findings from the various analyses by EPA region. Nationally, mobile broadband is accessible along 92% of the nation's highways and at 99% of hazardous waste generator locations. By EPA region, a majority of highway miles and generators fall within mobile broadband coverage though some regions see lower shares of coverage. Region 10, which includes Alaska, saw the lowest coverage along the highway network though ranked in the middle of the EPA regions for coverage of hazardous waste generators, which tend to cluster near road segments that do have mobile broadband coverage. Region 8 – the Mountains and Plains region with Wyoming, Idaho, and the Dakotas – also includes many remote areas and has the second lowest share of covered highways. However, for most generator locations outside of coverage areas, mobile broadband access is less than a minute drive away. Though not the focus of the current analysis, the study also observed variation in coverage within individual regions. More tailored or granular geographic analysis could be the focus of future work.

Altogether, these findings and any subsequent analysis will assist ORCR in identifying gaps in mobile broadband coverage that may impact their stakeholders during widespread electronic manifest adoption. Findings may help inform future policy and technology changes and technical assistance. Ensuring hazardous waste handlers can reliably sign electronic manifests enables a smooth transition to and continued use of fully electronic manifests, with the overarching goal of reducing costs and complexity for regulated industry.

Table 5. Summary of mobile broadband coverage by EPA region

Region	Percent Covered Miles of Highway Network	Percent Covered Generators	Median Drive Time (Minutes) to Point of Coverage*	Average Drive Time (Minutes) to Point of Coverage*
1	90.2%	97.1%	0:20	0:42
2	94.2%	98.9%	0:19	1:04
3	93.9%	98.0%	0:37	2:34
4	94.1%	97.8%	0:44	2:11
5	95.4%	99.4%	0:38	1:36
6	94.1%	99.1%	0:53	2:05
7	93.6%	98.8%	0:24	1:28
8	85.0%	96.6%	1:33	3:22
9	92.5%	99.4%	0:27	2:23
10	79.3%	97.9%	1:37	3:33
Total	**92.1%**	**98.8%**	**0:32**	**1:58**

* From generators in locations without coverage

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Appendix: EPA Regions

EPA includes ten regional offices responsible for the execution of EPA programs within U.S. states and territories.[33] The analysis summarizes results at both the national and EPA region level. Note than in the Volpe team's analysis, tribal lands are reported as parts of the region in which they geographically reside rather than separated into the administrative regions below.

- **Region 1** – Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
- **Region 2** – New Jersey, New York, Puerto Rico, the U.S. Virgin Islands, and 8 federally recognized Indian Nations
- **Region 3** – Delaware, District of Columbia, Maryland, Pennsylvania, Virigina, West Virigina, and 7 federally recognized tribes
- **Region 4** – Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee
- **Region 5** – Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin
- **Region 6** – Arkansas, Louisiana, New Mexico, Oklahoma, and Texas
- **Region 7** – Iowa, Kansas, Missouri, and Nevada
- **Region 8** – Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming
- **Region 9** – Arizona, California, Hawaii, Nevada, American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, and Republic of Palau
- **Region 10** – Alaska, Idaho, Oregan, Washington, and 271 native tribes.

[33] "Regional Offices", accessed June 29, 2026, https://www.epa.gov/aboutepa/regional-and-geographic-offices