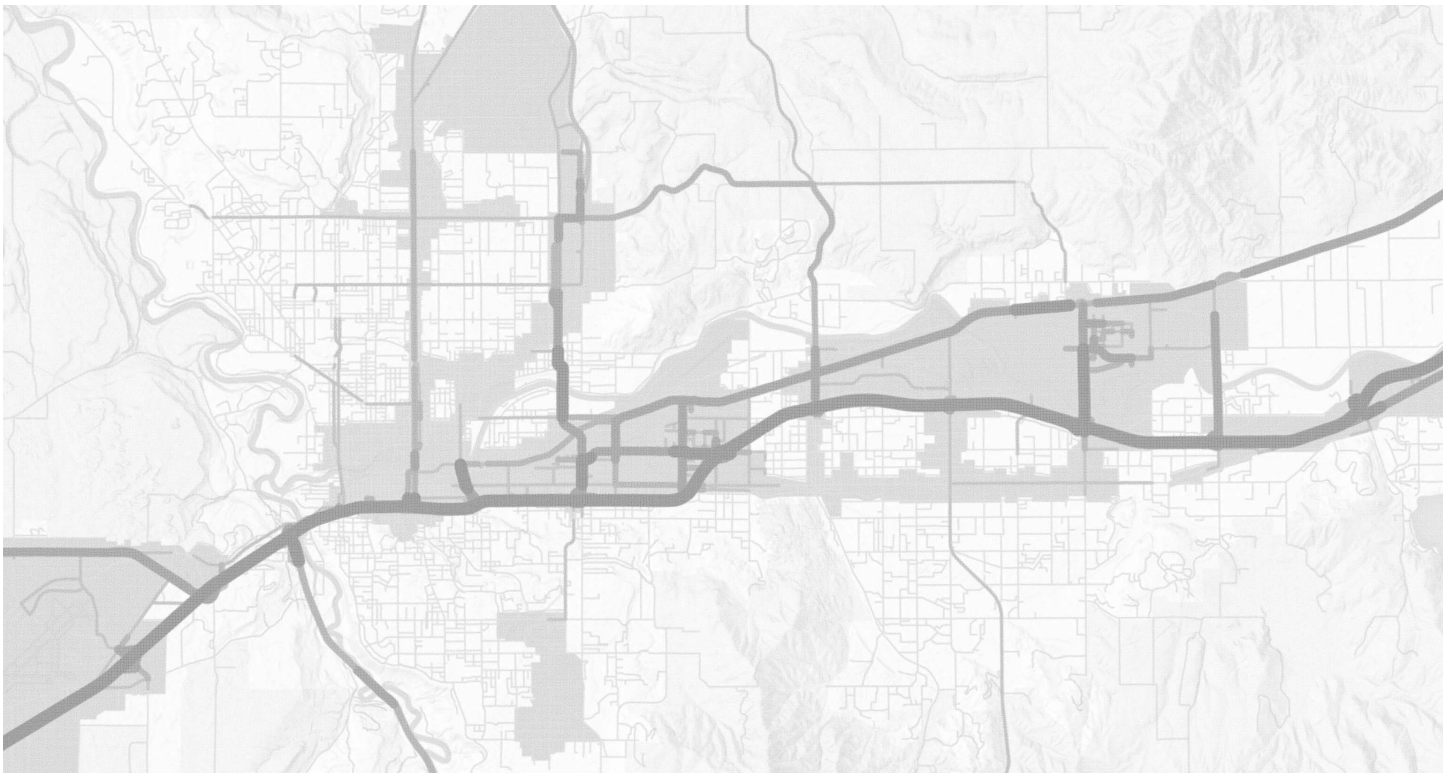

SPOKANE REGIONAL TRUCK FREIGHT PROFILE

Spokane Regional Transportation Council
October 2021

SRTC
SPOKANE REGIONAL TRANSPORTATION COUNCIL

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Profile Summary

The effective and efficient movement of goods supports a network of activity that helps create vibrant communities and thousands of jobs. Freight delivers food and many of life's other necessities. Economic activity often relies on "just-in-time" supply chain management; thus, any disruptions in freight systems can have an immediate ripple effect through the economy. Therefore, it is important to understand the unique transportation challenges related to the movement of goods in our region.

The majority of freight in the Spokane region, both by volume and value, is transported by truck. Given its significance to regional freight flows, the information provided in this profile is primarily focused on this mode. However, it should be noted that both rail and air freight also play important roles and warrant future study.

Previous Freight Efforts

This work builds upon several previous freight planning efforts undertaken by the Spokane Regional Transportation Council (SRTC). These include both the Inland Pacific Hub (IPH) and Bridging the Valley (BTV) studies. The former examined the feasibility of establishing the Inland Pacific region as a multi-modal global gateway to increase domestic and international commerce. It was completed in 2012. The BTV study was completed in 2006. It evaluated road-rail crossings along a 42 mile corridor between Spokane and Athol, Idaho. Both studies can be found on the SRTC website. The SRTC team involved in this profile's creation completed a thorough review of these studies, along with other state and local freight planning studies. Including the Washington State Department of Transportation's (WSDOT) Freight System Plan and the Joint Transportation Commission's Study of Road-Rail Conflicts.

Intent of this Profile

The Spokane Regional Truck Freight Profile represents SRTC's efforts to understand how truck freight utilizes the regional transportation network and identify challenges related to this. It is a first step to developing a freight specific modal plan. The analysis contained in the profile should provide decision makers with a more complete understanding of a number of different topics, including:

- Freight's relationship with land use
- The region's freight activity centers
- Truck parking
- Regional freight activity flows
- Freight-related equity concerns
- Stakeholder feedback

Freight, as a mode of transportation, is important to study because of its interconnectedness with economic vitality. A strong economy is dependent on the effective and efficient movement of goods. Just like walking or transit, freight must be planned for to support economic growth. Accordingly, Horizon 2045, the region's Metropolitan Transportation Plan (MTP), includes this profile to begin to understand the unique challenges and opportunities related to truck freight in the region.

Ultimately, this profile is intended to function as a foundation to support future freight planning work. Continued effort is necessary to evolve and expand upon the freight specific goals and objectives contained in this document. Doing so will provide a guide for future investments in the freight net-

work that serve to achieve goals defined by the SRTC Board of Directors.

Developing the Profile

The profile was developed between January 2020 and May 2021. Outcomes of its analyses include:

- The development of freight-related goals and objectives
- A detailed truck freight origin-destination analysis
- The identification of key freight activity and employment centers, along with the categorization of these centers into four freight industry sector focus areas
- The identification of areas of potential disadvantage where residents may be more vulnerable to negative freight impacts

SRTC sought to accomplish two main objectives with these analyses. The first was to analyze how truck freight moves through the region, to provide a basis for furthering our understanding of the region's freight-related transportation needs. This was done by reviewing the spatial distribution of freight-related land uses to examine their relationship to regional freight flows, existing freight routes, and freight trip origins and destinations in the region. The second was to consider truck freight's place in the regional economy and gain a better understanding of how it impacts the region. To support this objective, the SRTC team mapped out freight-related employment and used it, in conjunction with the freight origins-destinations analysis outputs, to identify and evaluate freight activity centers in the region. The region's external freight connections were also examined to further this understanding.

The work was informed by a freight subject matter expert (SME) team, comprised of public and private sector freight stakeholders from SRTC's planning area. The SME team included Individuals from local public development authorities, freight logistics companies, state and local freight planning staff, and regional railroad staff.

To support the previously mentioned truck freight origin-destination analysis, the SRTC contracted with Eastern Washington University (EWU) to process an extensive truck freight trip dataset, acquired from the American Transportation Research Institute (ATRI). The SRTC team then mapped the distribution of origins and destinations for those trips and used the information to make inferences about the individual freight trips.

Profile Structure & Findings

The profile is organized into four main sections: 1) Freight and Land Use, 2) Freight Connections, 3) Freight and Equity, and 4) Stakeholder Engagement. Additionally, a summary of EWU's ATRI data processing methods is provided at the end of the document.

The first section, Freight and Land Use, is centered around a regional freight activity centers analysis. Using both freight trip origins and destinations, as well as employment data, the SRTC team identified activity centers and classed them into four freight industry sectors, relating to the different types of economic activities connected to a product's life cycle. These are: 1) Extraction, 2) Production, 3) Distribution, and 4) Consumption.1 Each of these sectors contributes to the regional economy and informs the movement of goods and associated impacts on the regional transportation network. Likewise, each of the four sectors has unique challenges and needs related to transportation. This section also includes a brief overview of overnight truck parking, which is a significant safety concern specific to truck freight.

Section two, Freight Connections, focuses on regional freight movements. It includes an overview of the region's freight routes and networks, a summary of overall freight flows and volumes in the region, and a more detailed look at freight flows by activity. These activity flows correlate with the four freight industry sectors mentioned in the previous paragraph and can be though of as a proxy for commodity flows. Ultimately, Identifying and understating the characteristics of key transportation routes relied on by the various types of truck freight is an essential step in effective regional freight planning.

The third section, Freight and Equity, looks at the connection between these two topics in our region. It considers how freight movements, while critical to our economy, can lead to equity and environmental justice concerns. To analyze potential freight impacts, SRTC pursued a methodology based on the procedure followed by Delaware Valley Regional Planning Commission (DVRPC), the metropolitan planning organization (MPO) for the greater Philadelphia region.[2] SRTC's freight environmental justice analysis focused on environmental justice populations as defined through six key indicators of potential disadvantage (IPD). Tracts in the region that scored above average or well above average were categorized as areas of potential disadvantage (APD). As part of this analysis, the SRTC team identified and mapped the region's APDs. The analysis found that these areas are distributed throughout the region's urban areas, with the exception of Deer Park and Liberty Lake.

Section four, Stakeholder Engagement, highlights the SME teams role in the profile development and its analyses. It also details the freight-related goals and objectives developed as part of this process. These goals and objectives are critical pieces to the freight element of Horizon 2045 and provide the missing links between the SRTC's existing guiding principles and policies and the region's freight needs.

1 DVRPC. 2021. "Philly Freight Finder." dvrpc.org. Accessed July 29, 2021. https://www.dvrpc.org/webmaps/phillyfreightfinder/freight-center-story.html

2 DVRPC. 2020. "Equity Analysis for the Greater Philadelphia Region." dvrpc.org. Accessed July 29, 2021. https://www.dvrpc.org/webmaps/IPD/#map.

Freight and Land Use

Land use patterns significantly impact demand on transportation networks. For this reason, it is important to consider the region's land use to understand it's freight needs. This includes identifying and evaluating significant freight land use clusters, or activity centers. The SRTC team utilized employment, freight trip origin-destination, and land use data to analyze freight-related land use and activity in the Spokane region.

Freight Trip Origins & Destinations

The SRTC team contracted with Eastern Washington University (EWU) to analyze over 10 million GPS pings from commercial truck transponders to identify over 150,000 freight related trips made in 2019. The distribution of freight trip origin and destinations throughout the SRTC planning area is shown in **Figure F.3**. The SRTC team used this information to make various inferences about the individual freight trips, which are detailed throughout this profile. More information about the methodology used and the analysis performed by EWU can be found in the final section of the document. These freight trip origins and destinations were used in conjunction with regional land use and employment data to evaluate freight-related land use in SRTC's planning area

Freight Industry Sectors

SRTC's planning area is home to over 16,000 employers employing nearly 230,000 individuals. These employers are the foundation of the freight activity centers identified in this profile. The SRTC team used the Washington State Employment Security Department's unemployment insurance data to separate the region's employment into four freight industry sectors, based on the two-digit North American Industry Classification System (NAICS) code associated with the employer, as shown in **Figure F.1**.

The four industry sectors relate to the different types of economic activities connected to a product's life cycle. They are: 1) Extraction, 2) Production, 3) Distribution, and 4) Consumption.[3] Total employment across these sectors in the Spokane region is nearly 95,000, which equates to over 42 percent of all regional employment. Each of them contributes to the regional economy. They all inform the movement of goods and associated impacts on the regional transportation network. Likewise, they all have unique challenges and needs related to transportation.

Figure F.1: Freight Industry Sectors by NAICS Code

Industry Type	Freight Industry Sector	Freight Industry Subsectors	2-Digit NAICS Code
Freight-Intensive Industries	Extraction	Agriculture, Forestry, Fishing, Hunting	11
		Mining, Quarrying, Oil/Gas	21
	Production	Construction	23
		Manufacturing	31
			32
			33
	Distribution	Utilities	22
		Wholesale Trade	42
		Transportation and Warehousing	48
			49
Freight-Related Industries	Consumption	Retail Trade	44
			45
		Accommodation and Food Services	72

Extraction

This sector includes jobs that are involved in the extraction of raw materials from the earth and/or raising of animals and crops. In terms of total employment, it represent a small but important part of the regional economy.

Production

This sector involves the making of finished goods and consumer products. It is responsible for the production of goods and its operations have a critical reliance on the freight transportation system to deliver the necessary inputs and get outputs, or final products to the market.

3 DVRPC. 2021. "Philly Freight Finder." dvrpc.org. Accessed July 29, 2021. https://www.dvrpc.org/webmaps/phillyfreightfinder/freight-center-story.html

Distribution
This sector serves as the vital link between the various components of the supply chain. It includes businesses involved in the conveyance and storage of freight.

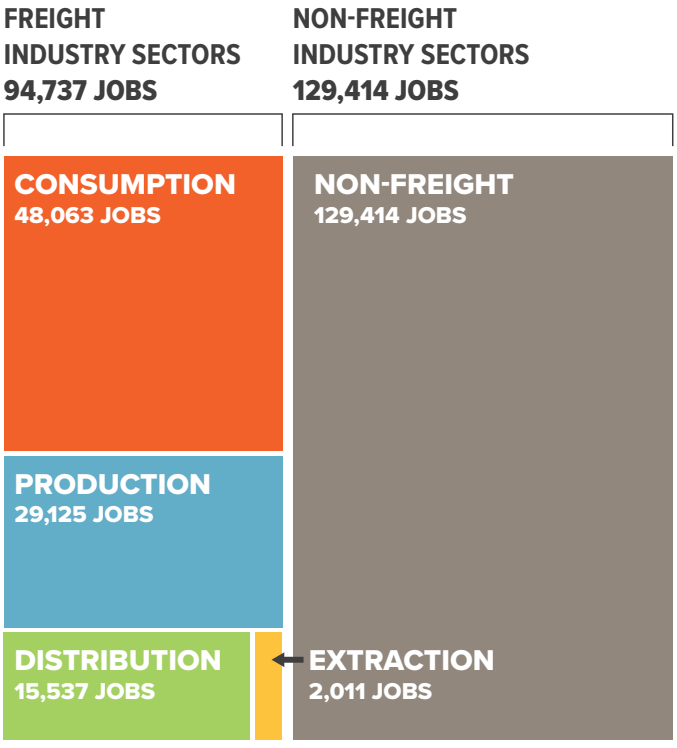
Consumption
This sector primarily consists of consumers of finished goods. While it includes major freight attractors, it is not considered core to the development of freight centers. It relies on goods and services provided by the other three groups. Its needs are addressed through urban freight planning in commercial corridors and towns, as it relies heavily on goods and services provided by the other three freight industry sectors.

Freight Activity Centers

Each freight industry sector has unique challenges and needs related to transportation. For example, the needs of a retail consumer are very different than a manufacturing producer. Consumers often make single occupancy vehicle trips, while producers make less frequent trips with commercial freight vehicles. Roadway design, user conflict, and reliability are all considerations that must be accounted for differently depending on category.

To identify freight activity centers, the SRTC team overlayed freight industry sector employment with freight trip origins and destinations. This allowed the team to focus in on areas with significant amounts of freight activity. Hot spots (shown in **Figures F.3 and F.4**) were used to identify activity centers and determine the magnitude of their freight-related activity relative to other centers. The team also mapped out freight-related employment by individual sector, as shown in **Figure F.5**, which provided further information regarding the type of freight activity at a given center. Additionally, the underlying parcel-level land use map, shown in **Figure F.6** were used to guide to process of delineating activity center boundaries. **Figure F.7** shows the activity centers in the SRTC planning area, by level of freight activity. Continued analysis will be necessary to inform specific transportation needs based on category.

Figure F.2: Jobs by Industry Sector in the Spokane Region



ESD UI Data, Quarter 2 of 2019

While freight employment is a key factor in identifying freight activity, understanding the regional freight economy's distribution requires additional metrics to help identify key clusters of activity.

The distribution of freight employment using number of employees helps us to better understand the relative intensity of freight activity in each zone. More employees working in freight industries would indicate a higher probability for freight generating activities.

West Plains, which has a distribution focus, has a strong connection with the region's production focused centers. The connections to/from consumption focused centers are much less significant.

There is a lot of travel between production centers and I-90—this shows up in the region's largest truck stop, which has a lot more traffic to/from production centers than consumption centers.

Both consumption centers—Central Spokane and the East Sprague Corridor—have a significant number of trips to and from the East Spokane Industrial Area. **Figure F.8** shows origins and destinations of freight trips starting or ending in an activity center, for centers with the most freight activity in the region.

Activity centers are intended as a planning tool to help SRTC and regional partners better understand the priorities, challenges, and opportunities created by these important regional centers. Activity centers will be utilized in a variety of SRTC activities and continually updated to provide a clear picture of the regional freight economy.

Freight activity is not exclusive to trips to and from origins and destinations. Another growing challenge in freight planning is the need to provide for adequate facilities between freight trips.

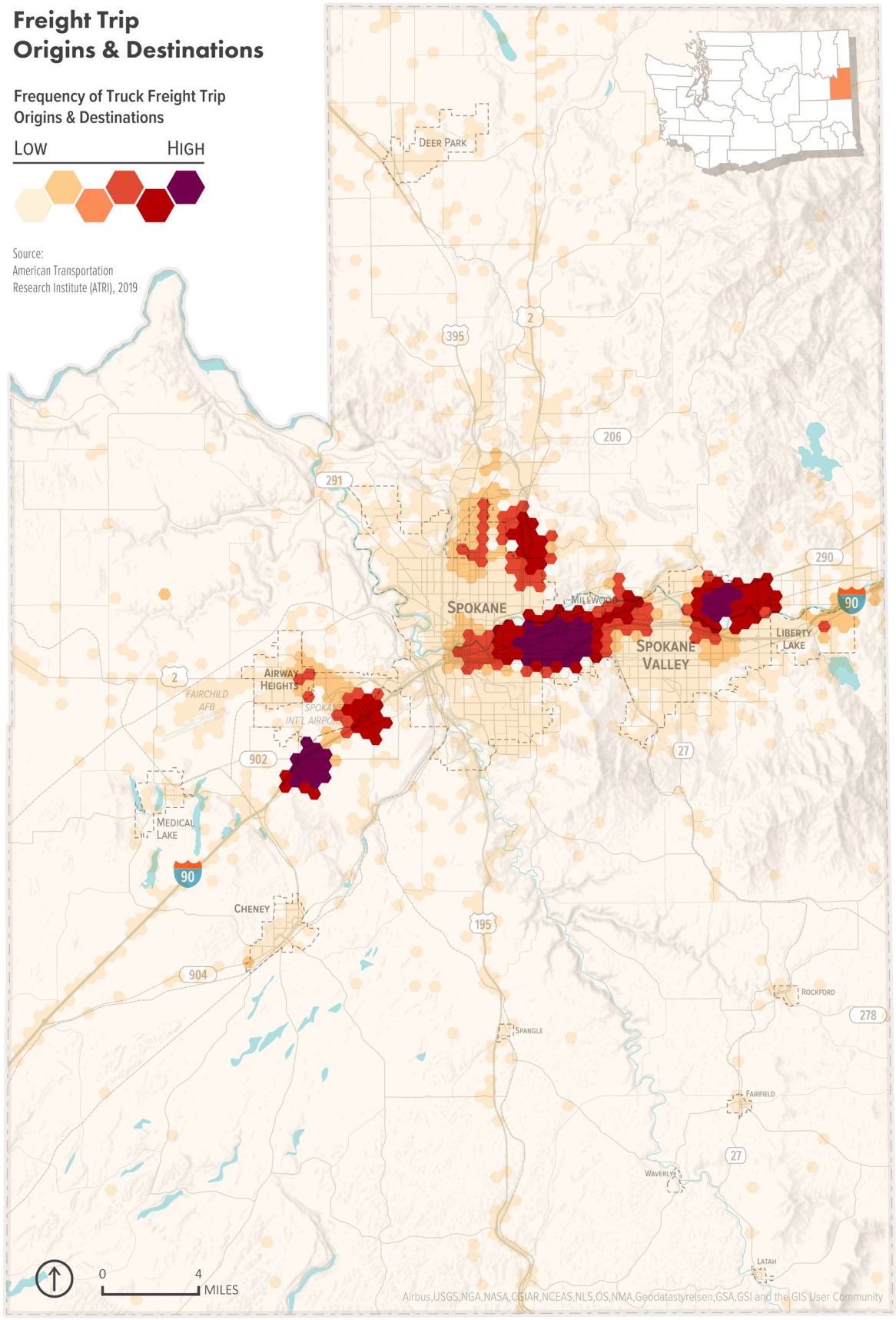


Figure F.3: Freight Trip Origins and Destinations

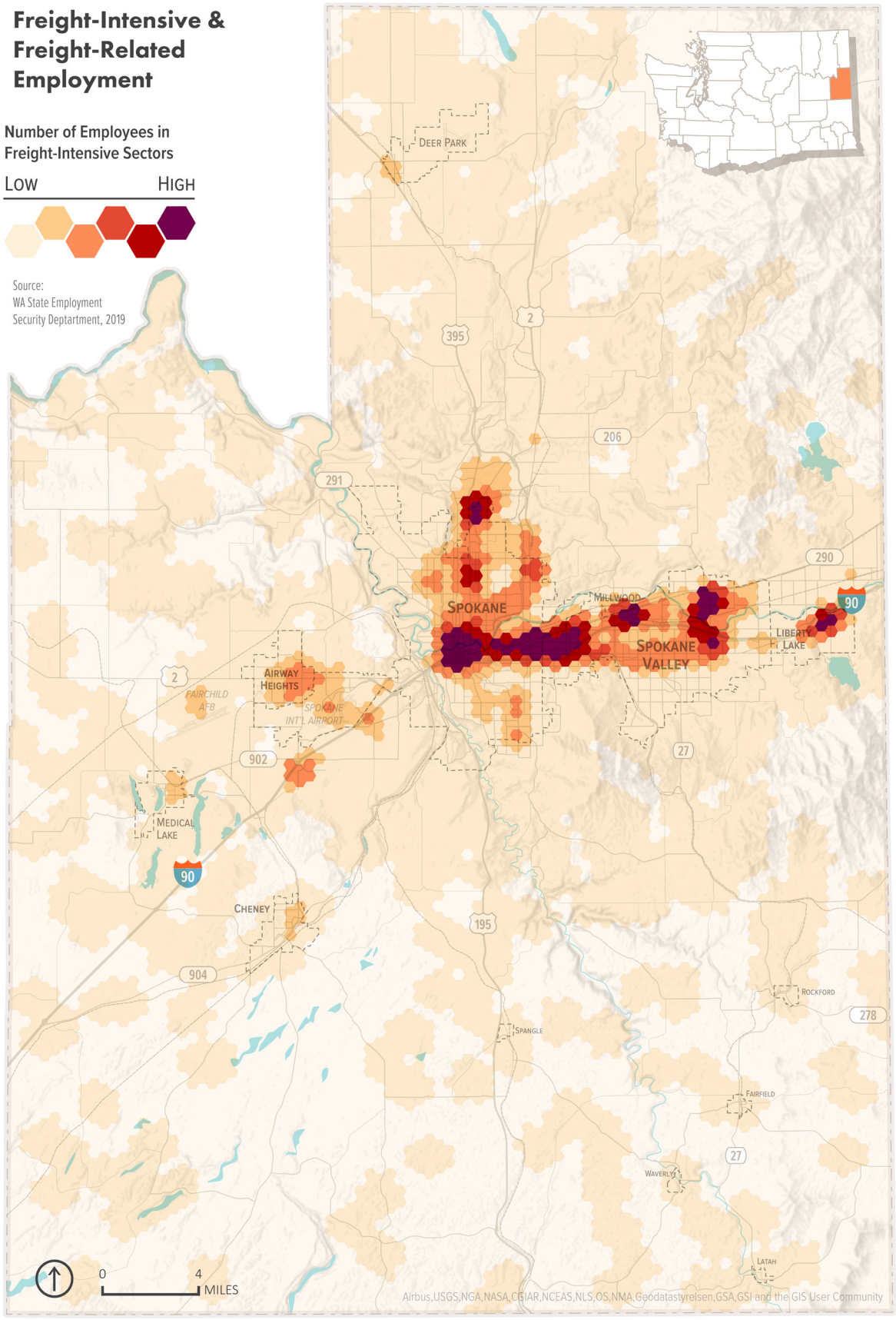


Figure F.4: Total Freight Industry Sector Employment

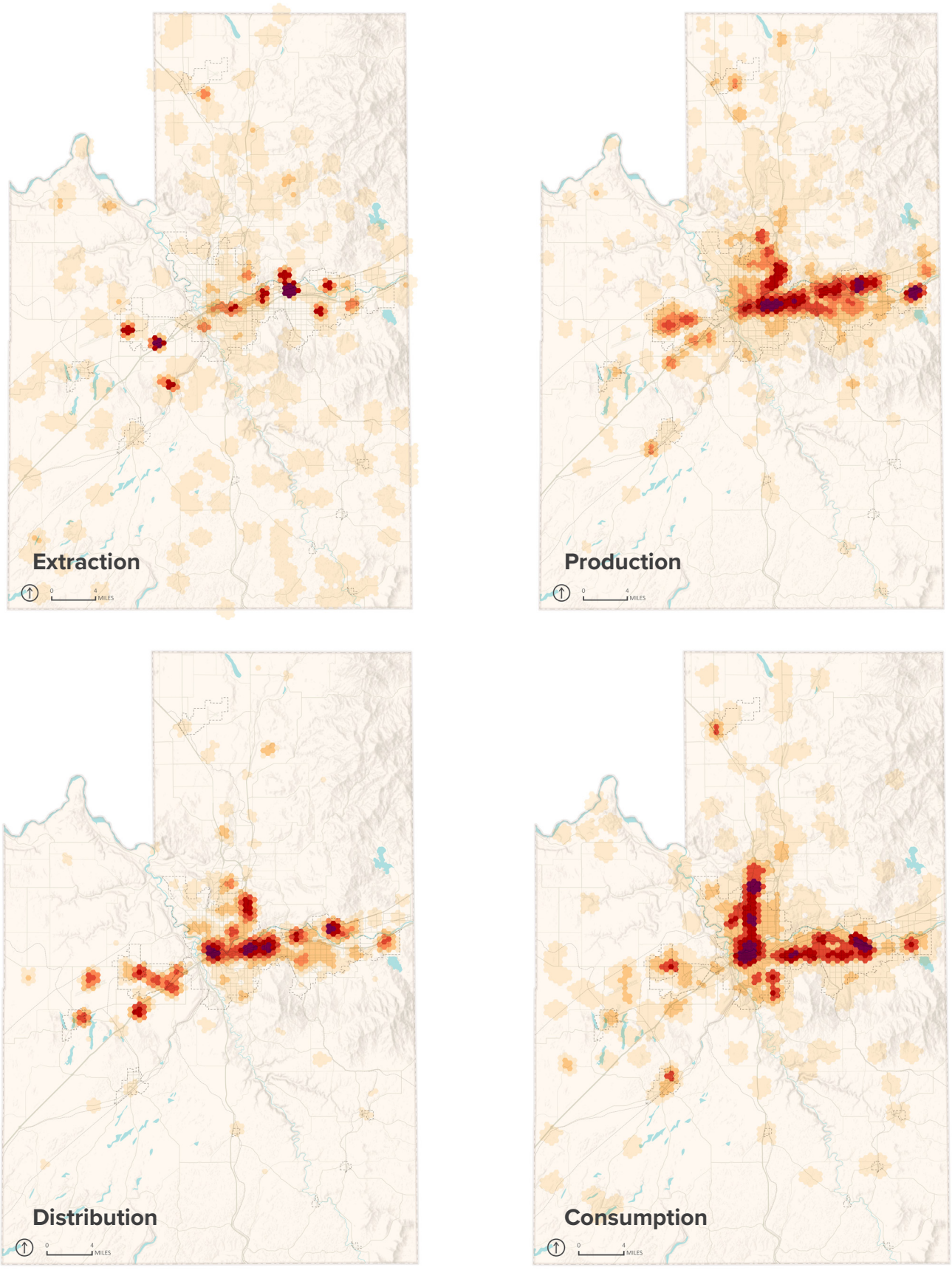


Figure F.5: Employment by Freight Industry Sector

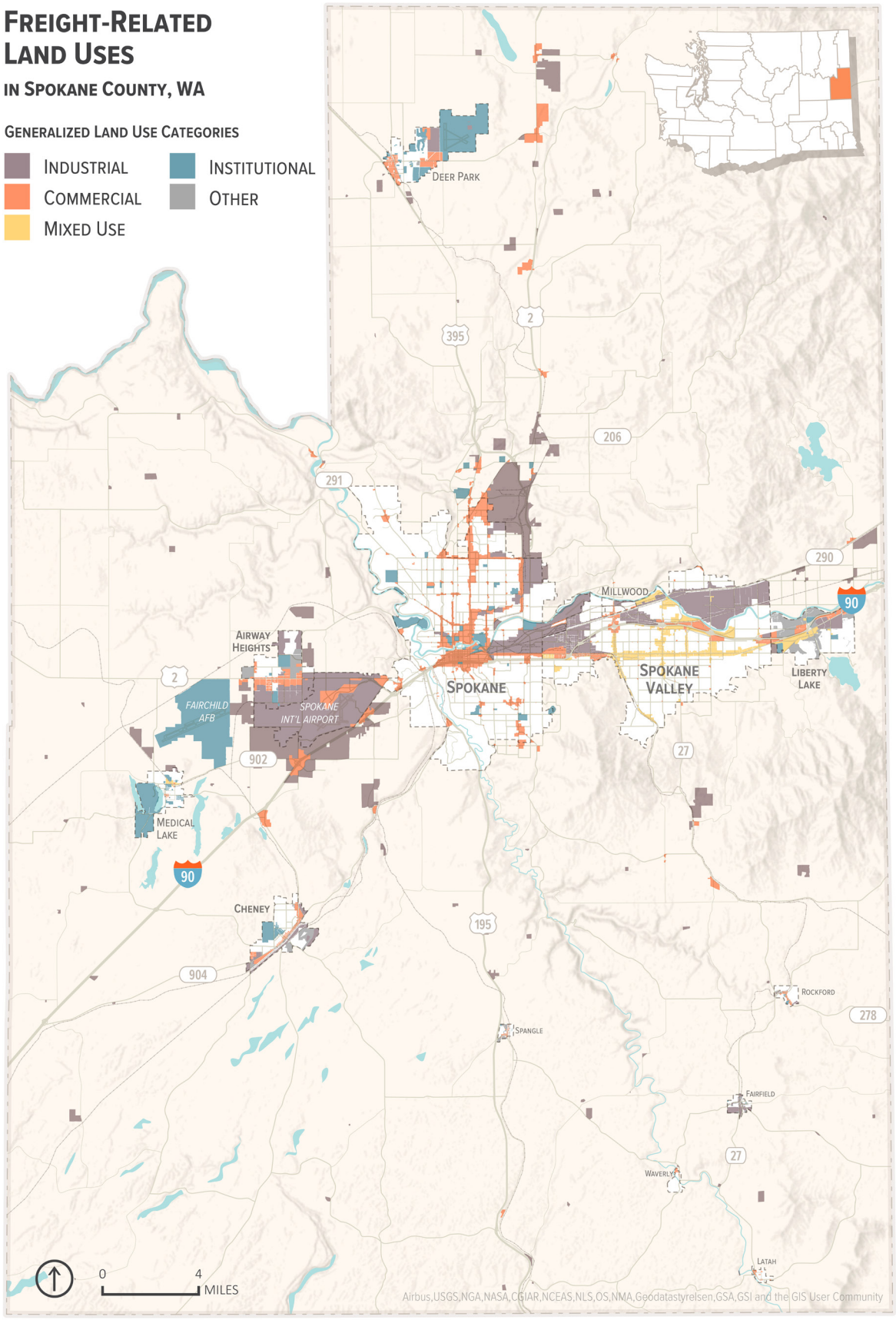


Figure F.6: Freight-Related Land Use

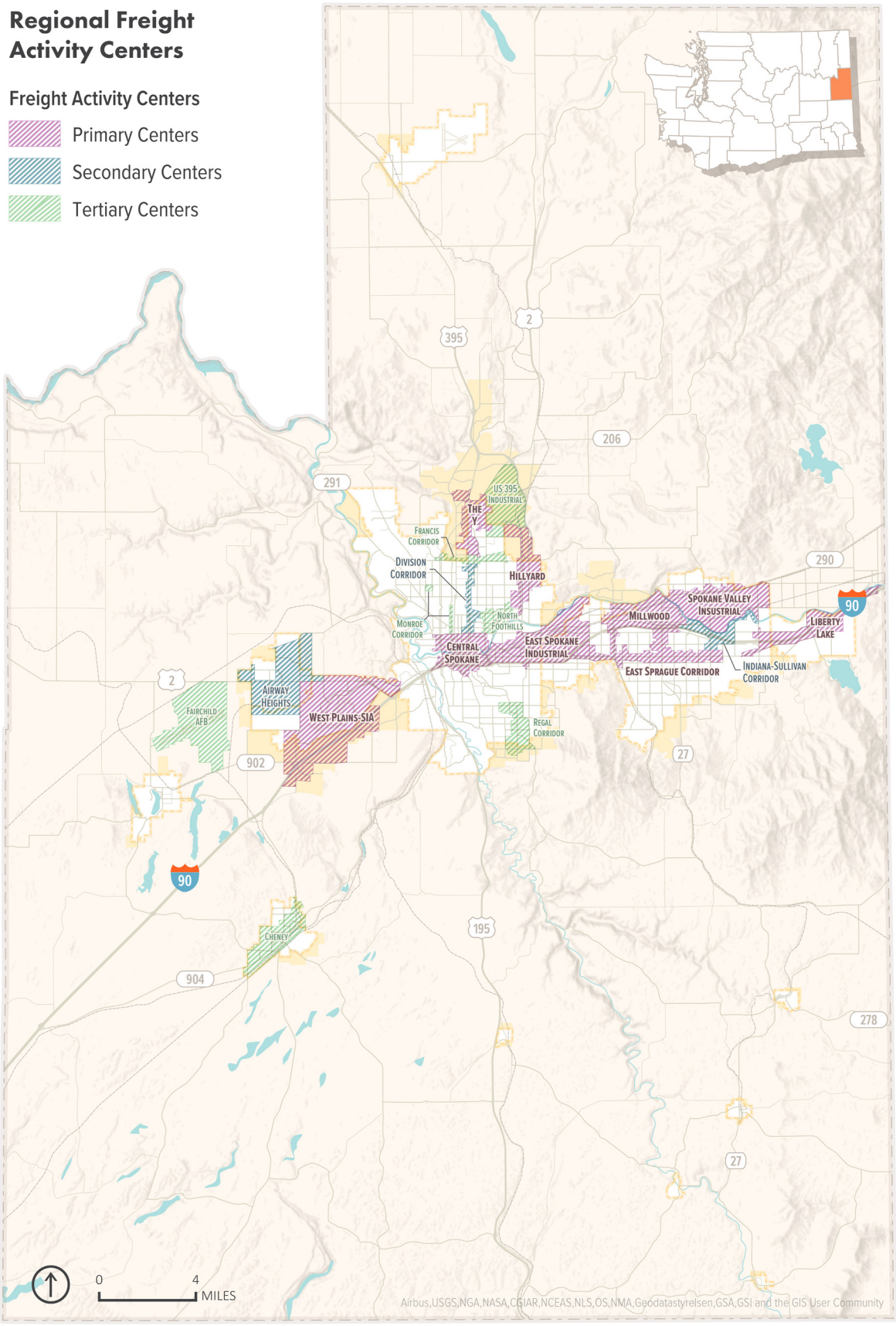
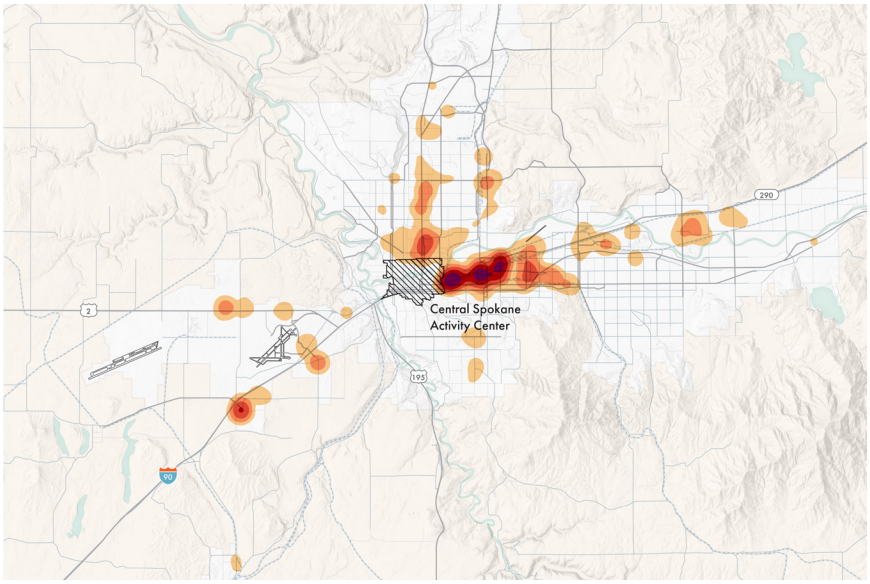
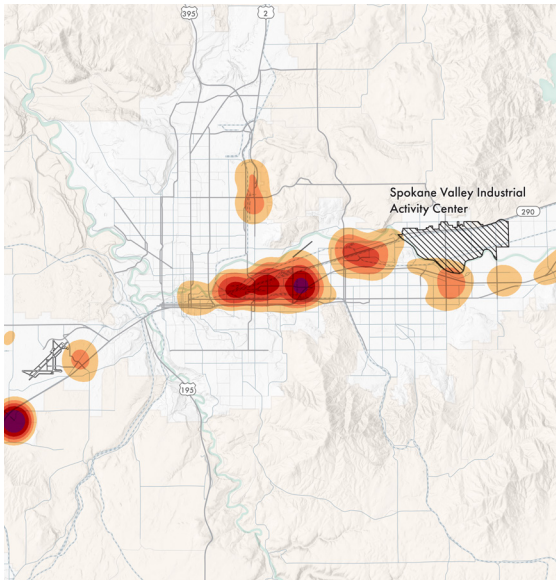
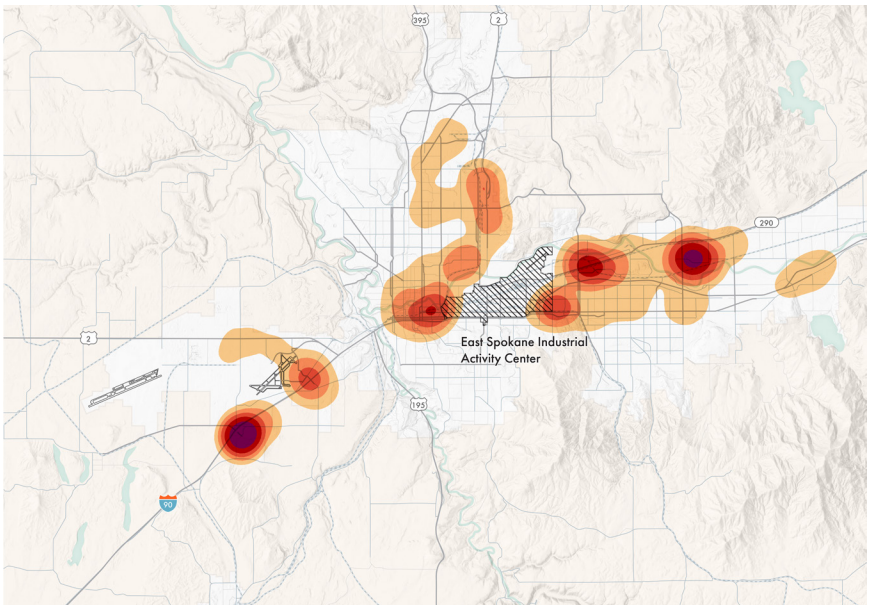
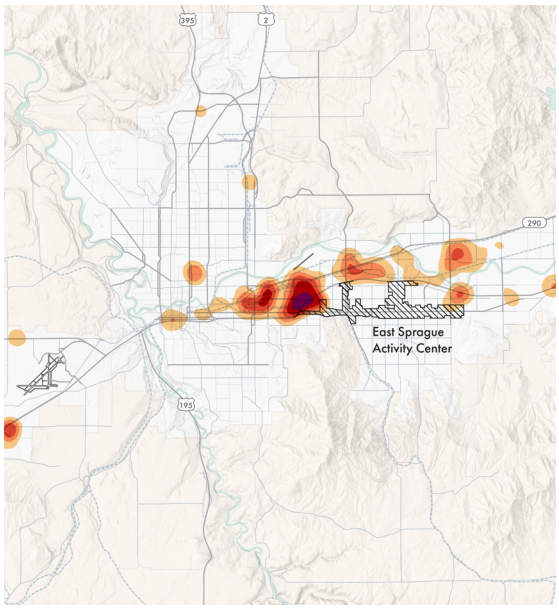


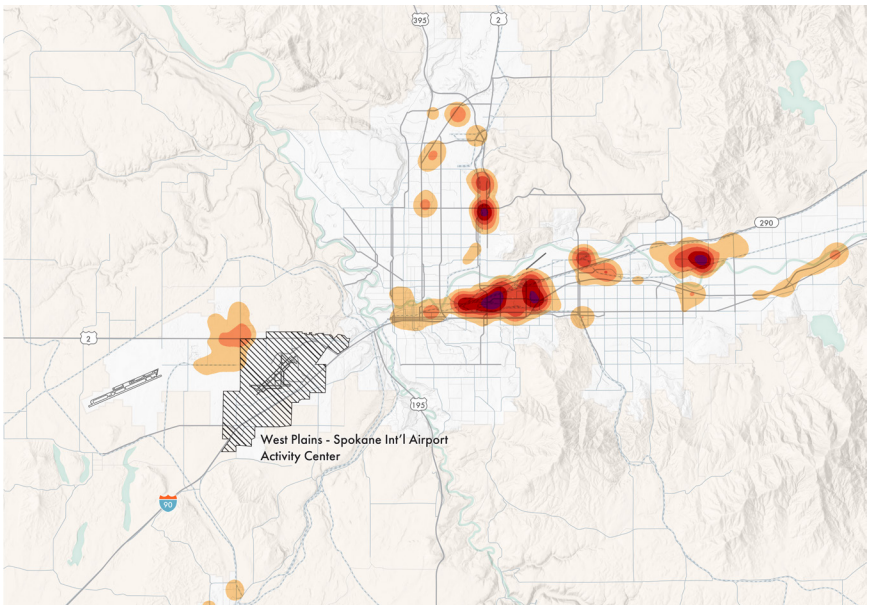
Figure F.7: Regional Activity Center Freight Designations











Density of Freight Trip Origins and Destinations to/from Activity Center

High Density of Trips

Low Density of Trips

Figure F.8: Origins and Destinations for Freight Trips Beginning or Ending in Activity Centers

Truck Parking

In 2009, days before his wife would give birth to twins, truck driver Jason Rivenburg, was shot and killed for the seven dollars in his wallet after being forced to park his truck in an abandoned gas station parking lot in South Carolina. In the wake of this tragedy, Jason's Law was included in the MAP-21 act, highlighting those areas most in need of additional overnight truck parking while providing a federal funding mechanism for states to increase truck parking availability. The Jason's Law study sought to investigate the availability of freight truck parking nationwide.

In the Jason's Law truck parking survey, 39 percent of drivers nationwide indicated that it often takes more than an hour to find parking when they decide to (or are mandated to) take a break. Additionally, 88 percent of respondents indicated they had felt unsafe while parked for rest or waiting. Regulations often require truck drivers to stop driving at a certain point regardless of whether or not they've found a safe and legal parking space.

Washington is the most trade-dependent state per capita in the United States. According to WSDOT, over 64 percent of freight in the state in carried by truck. The availability of freight truck parking is, as highlighted by Jason's Law, a safety concern. Even when there is some availability, a dearth of freight truck parking is still an economic concern, as it prevents healthy competition—driving up the price of safe parking and making it more likely that drivers will seek an alternative. Considering this, it is important to plan for both current and future overnight truck parking capacity. **Figure F.9** shows overnight truck parking locations in SRTC's planning area.

The 2016 WSDOT Truck Parking study emphasizes that the Jason's Law survey "found Washington has some of the most severe truck parking challenges in the nation." That study was a statewide effort and its findings specific to Eastern Washington were limited. However, since 2009, truck parking has become an issue of national interest.

As of 2014, Washington State ranked near the bottom nationally in truck parking spaces per 100 miles of NHS.4 However, many of the challenges related to truck parking in Washington state are concentrated around the ports in the Puget Sound region. When the freight SME team was polled regarding freight-related issues facing the Spokane region, truck parking ranked last amongst the most pressing concerns. However, that response may be attributed to the lack of representation from freight operators amongst the team. Only one of the respondents was a private freight operator who relies in part on truck parking as part of their operations. With this in mind, SRTC's understanding of this issue would benefit from more direct focus groups with freight operators in the region. Doing so would help the organization develop a more complete understanding of the extent to which truck parking issues are relevant in the region.

As SRTC works to fulfill the Horizon 2045 Guiding Principle of Economic Vitality, it is worth noting that freight truck volumes will likely increase through the plan's 2045 horizon year. It is important that the region continue building facilities to support increased volumes. It must also plan for the ancillary impacts of additional freight volumes. SRTC will continue to monitor key performance indicators related to truck parking and make recommendations to the SRTC Board accordingly.

Recently, WSDOT has committed significant resources to help understand the issue statewide. In 2021, it hosted a series of truck parking workshops, aimed at achieving the following goals:

- Identifying primary truck parking challenges specific to Washington
- Identifying effective public and private sector practices for managing truck parking challenges
- Assessing feasibility and effectiveness of truck parking response strategies
- Building a collective set of potential truck parking strategies and funding options for Washington
- Identifying data and tools needed to inform and assess feasibility and performance of truck parking strategies

4 Bureau of Transportation Statistics. 2017. "Freight Facts and Figures, 2017." Accessd October 25, 2021. https://rosap.ntl.bts.gov/view/dot/34923.

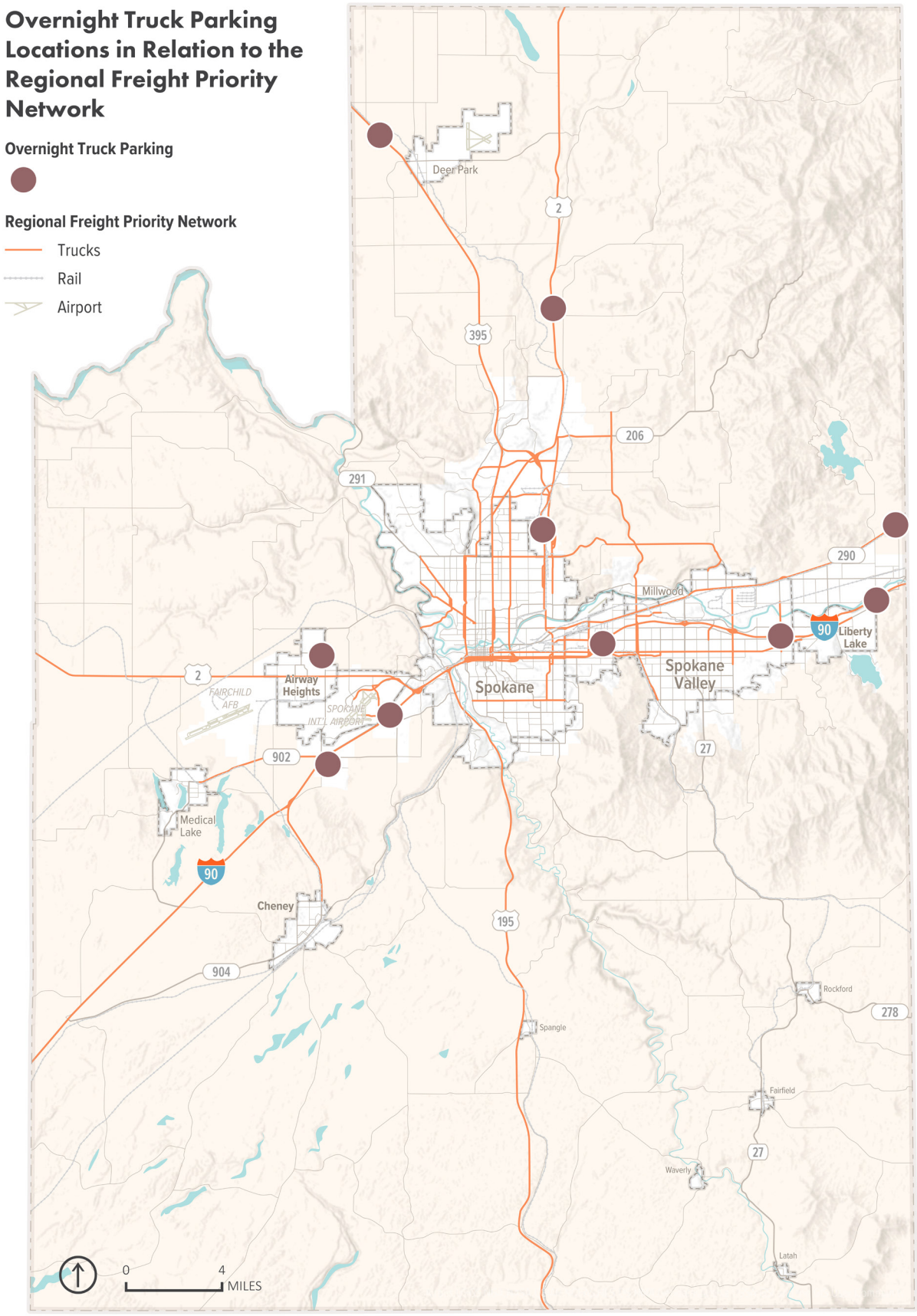


Figure F.9: Overnight Truck Parking Locations

Freight Connections

Trucking is the primary mode of freight in the SRTC planning area. It transports roughly 54 percent of all freight, by volume, and nearly 80 percent by value.[5] These trips rely on the region's transportation network to connect to their destinations. Key components of the network are identified as regional freight routes, which are described in the section below.

Regional Freight Routes

Freight destinations inside the region are generally located in its freight activity centers, which are described in Chapter 1 of this document and shown in **Figure F.7**. Overall, more than 90 percent of freight trips starting or ending in the SRTC planning area have their origin or destination in one of the region's activity centers.[6] Providing effective freight connections to and from these areas are key in supporting the efficient movement of goods throughout the region. SRTC coordinates with WSDOT and local agencies to identify these key connections through the Freight Goods and Transportation System (FGTS) and SRTC's Freight Priority Network.

Freight Goods & Transportation System

Routes that play a pivotal role in regional freight movements are classified as part of the state's Freight and Goods Transportation System (FGTS). The FGTS classifies freight corridors based on the annual freight tonnage they move. These classifications are listed in **Figure F.10**. It is updated every two years. The region's FGTS corridors, as of the most recent update completed in 2019, is shown in **Figure F.11**.

Freight Priority Network

In addition to FGTS, SRTC identifies the region's highest priority freight routes as the Regional Freight Priority Network. It is updated with every Metropolitan Transportation Plan (MTP) update. It includes all T-1 and T-2 FGTS corridors, as well as high priority truck routes identified in the Inland Pacific Hub study and Truck Freight Economic Corridors (as designated by the state of Washington). Major rail lines and air facilities in Spokane County are also included in the network, which is shown in **Figure F.12**.

Review of Regional Freight Routes

Regional freight flows are generally concentrated along routes identified in the Regional Freight Priority Network. **Figure F.13** shows truck freight flows in the region, which are highest along I-90, the Freya/Market Street Corridor, Trent Avenue, and Division Street.

Figure F.14 displays the region's roads by FGTS classification and truck volume. As the map shows, volumes generally align with these classifications, however, there are some routes with relatively higher truck volumes have not yet been identified as FGTS corridors. In particular, Spotted Road, from Airport Drive to Geiger Boulevard, stands out as an unclassified corridor with significant freight volume. Additionally, some routes with lower FGTS classifications have volumes the potentially warrant a higher classification. These include:

- Trent Avenue, from Mission Avenue to Division Street
- Euclid Avenue, from Sullivan Road to Barker Road
- Marietta Avenue, from Sullivan Road to Euclid Avenue
- Barker Road, from Euclid Avenue to SR 290

It is important to note that, while these routes have relatively high freight volumes based on the ATRI trip data, this data is not the equivalent of a volume count. However, SRTC intends to pursue further refinement of its ATRI trip data to potentially utilize it to inform FGTS classifications in cases where freight volume counts are unavailable. Given the limited extent of freight counts in the region, doing so would provide a cost-effective solution in instance where an actual count is not feasible.

5 SRTC. Horizon 2040, 201

6 ATRI, 2019

Figure F.10: Freight and Goods Transportation System (FGTS) Classes

Route Class	Freight Tonnage Classification Criteria
T-1	More than 10,000,000 tons per year
T-2	4,000,000 to 10,000,000 tons per year
T-3	300,000 to 4,000,000 tons per year
T-4	100,000 to 300,000 tons per year
T-5	At least 20,000 tons in 60 days and less than 100,000 tons per year

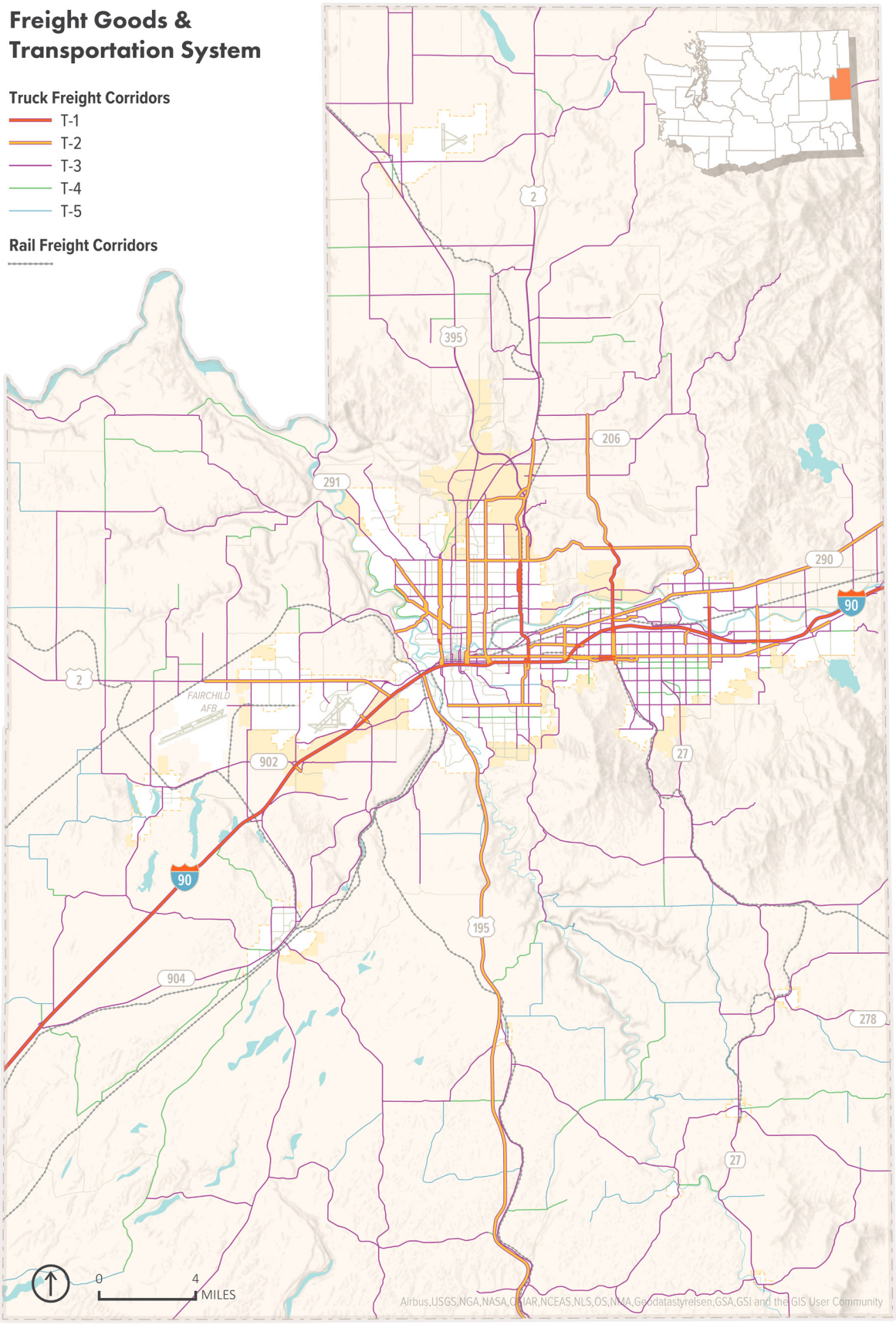


Figure F.11: Freight Goods and Transportation System (FGTS)

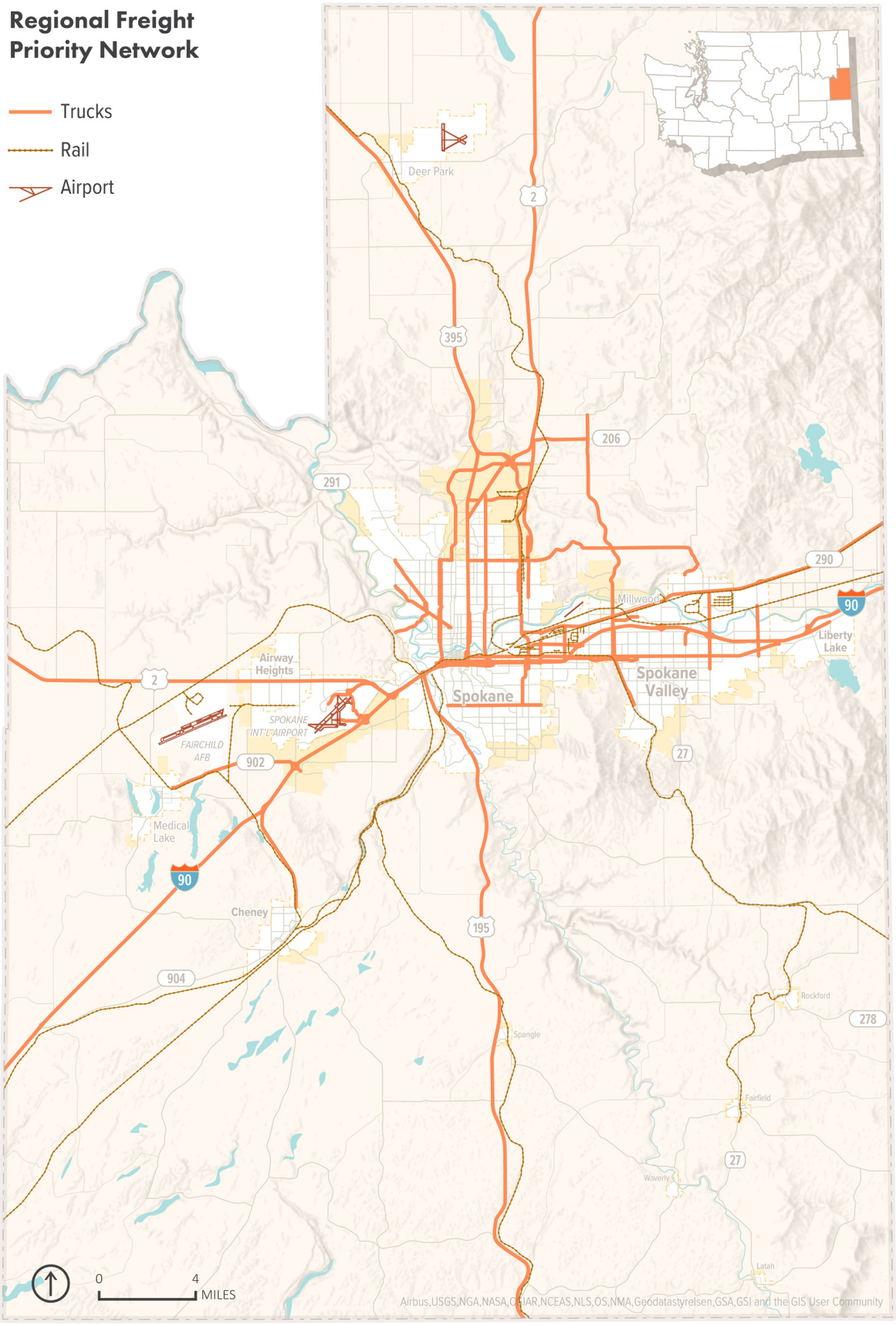


Figure F.12: Regional Freight Priority Network

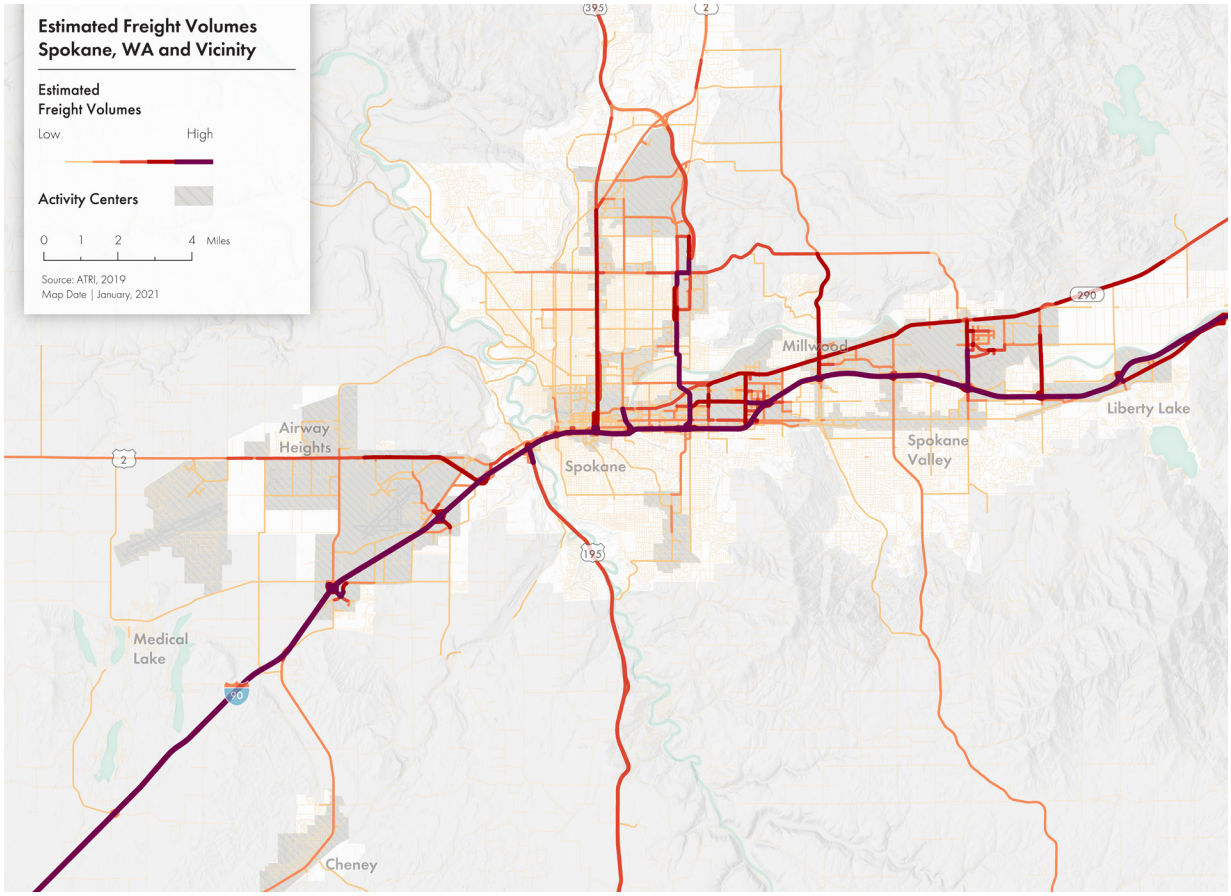


Figure F.13: Truck Freight Flows

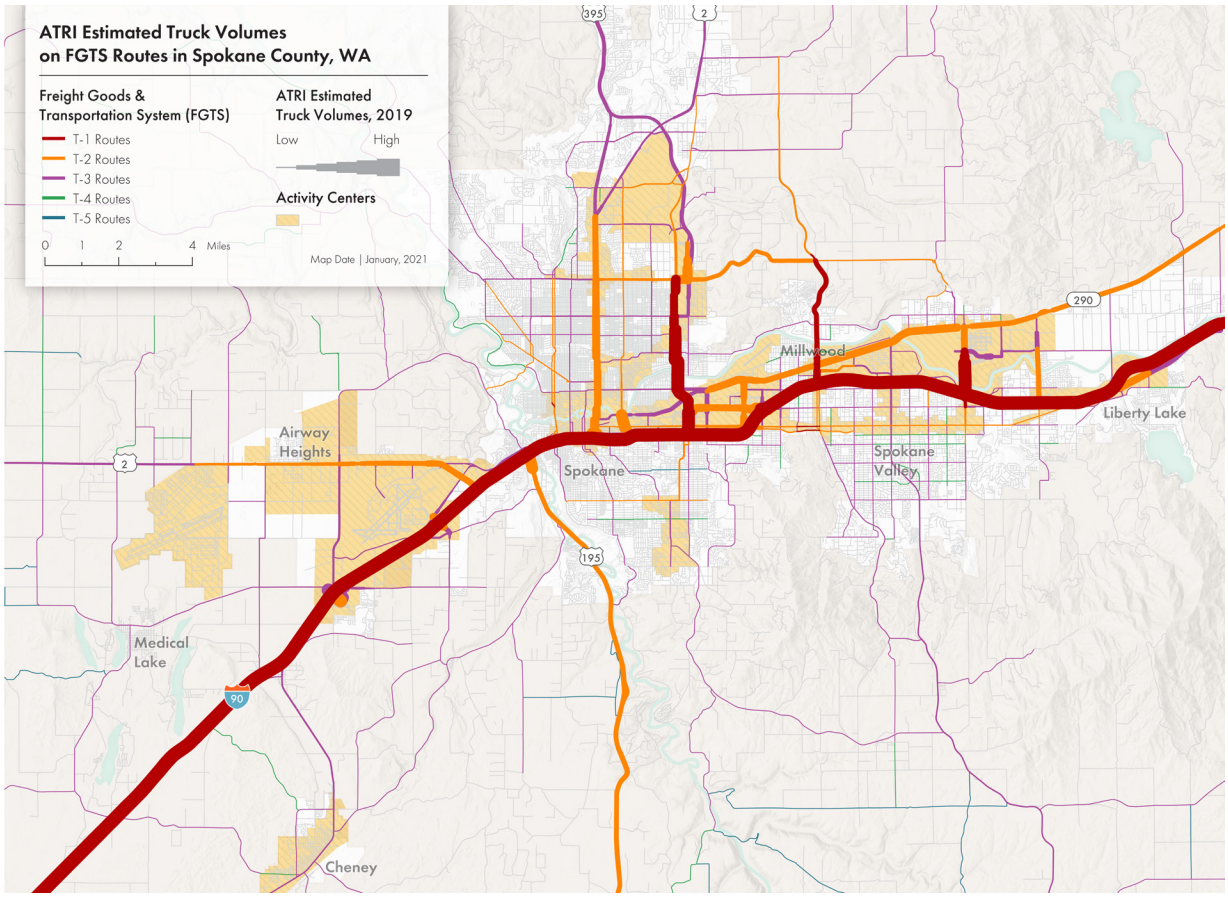


Figure F.14: Estimated Truck Freight Volumes by FGTS Route

Freight Activity Flows

Identifying and understating the characteristics of key transportation routes relied on by freight is an essential step in effective regional freight planning. As discussed in the previous section of this profile, transportation needs vary, depending on the type of freight activity.

Methodology

To better understand freight needs in the Spokane region, SRTC utilized ATRI trip data to evaluate how freight flows vary by freight industry sector, which can also be though of as freight activity type. Each truck trip in the database was assigned likely activity types, based on the freight sector classification of the employment at its origin and destination locations. This was done by giving every TAZ in the region a score of zero to 100 for each of the four freight industry sectors: 1) Extraction, 2) Production, 3) Distribution, and 4) Consumption. The scores were based on the sector's share of total freight employment in each TAZ. Truck trips were then also assigned a score of zero to 100 for each of the four categories, based on the sectors' share of total freight employment in each trip's origin and destination TAZs. The results of this analysis are provided in **Figures F.15 through F.18**, which show the region's freight activity flows for each of the four freight sector categories.

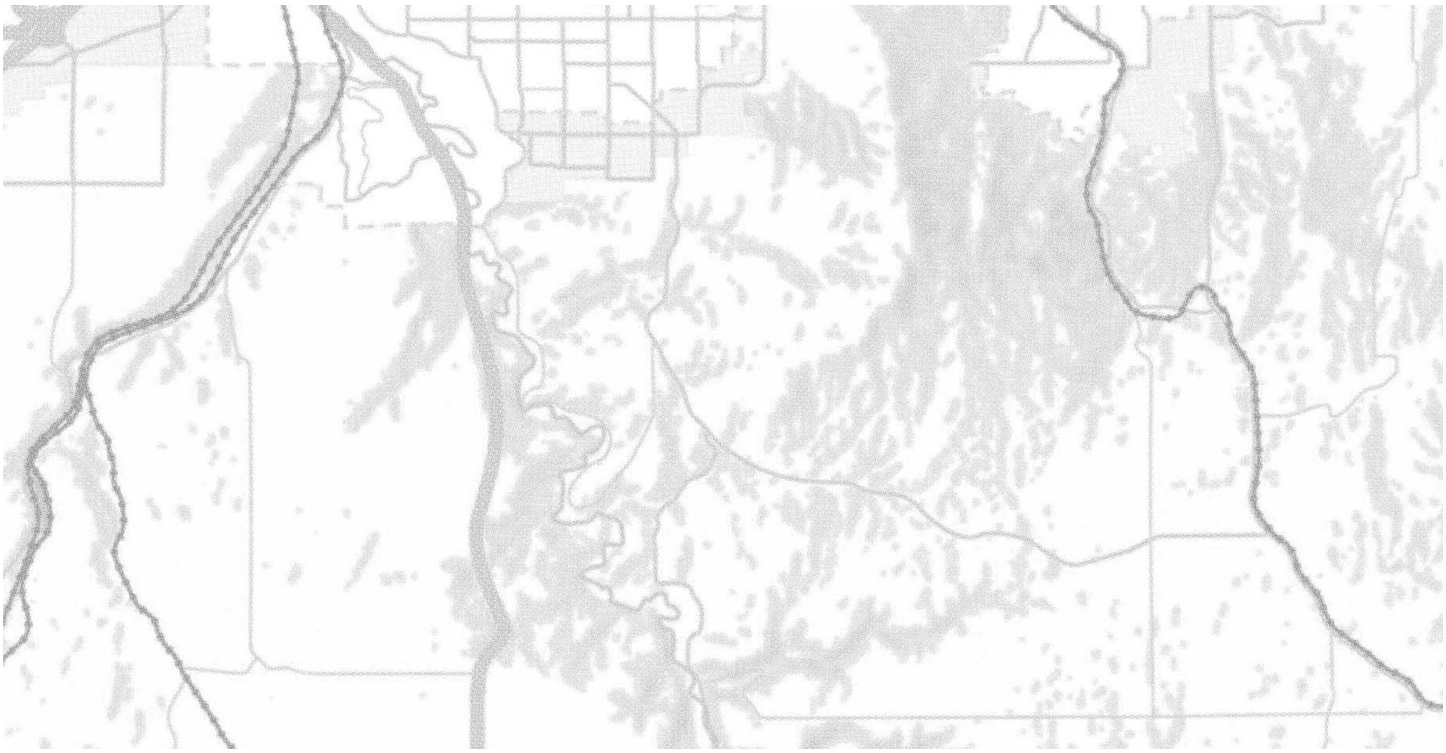
External Freight Connections

In addition to the point-level GPS data discussed previously, ATRI provided SRTC with an aggregated dataset of over 50,000 truck trips in the SRTC planning area with an origin and/or destination outside of the region. These we aggregated to census tracts in the Pacific Northwest—the states of Washington, Oregon, and Idaho—and counties for the rest of the contiguous United States. It also included data for the Canadian provinces of British Columbia, Alberta, Saskatchewan, and Manitoba; which was aggregated to Census Geographic Units.

As with the point-level data, this dataset included unique vehicle identification numbers and timestamps. This information was evaluated, using time and distance thresholds, to identify trip origins and destinations. These trip ends were then used to identify significant external freight connections to the region, both in the Pacific Northwest, and the United States as a whole.

Within the Pacific Northwest, the Spokane region's most significant freight connections include the Seattle and Portland metropolitan areas, as well as neighboring Coeur d'Alene, Yakima, and the Tri-Cities region, which includes the cities of Kennewick, Pasco, and Richland. The overall frequency of external origins and destinations in the Pacific Northwest, for truck trips to and from Spokane County, is shown in **Figure F.19**.

Outside the Pacific Northwest, the region's most significant freight connections are mostly located either in the West Coast or Intermountain West regions. They include California's Central Valley, the Greater Los Angeles region, Missoula, Billings, Boise, Salt Lake City, and Las Vegas. Additionally, significant connections exist with several Midwestern metropolitan areas, including Fargo, Sioux Falls, the Twin Cities, and Chicago. More detail is shown in the map provided in **Figure F.20**.



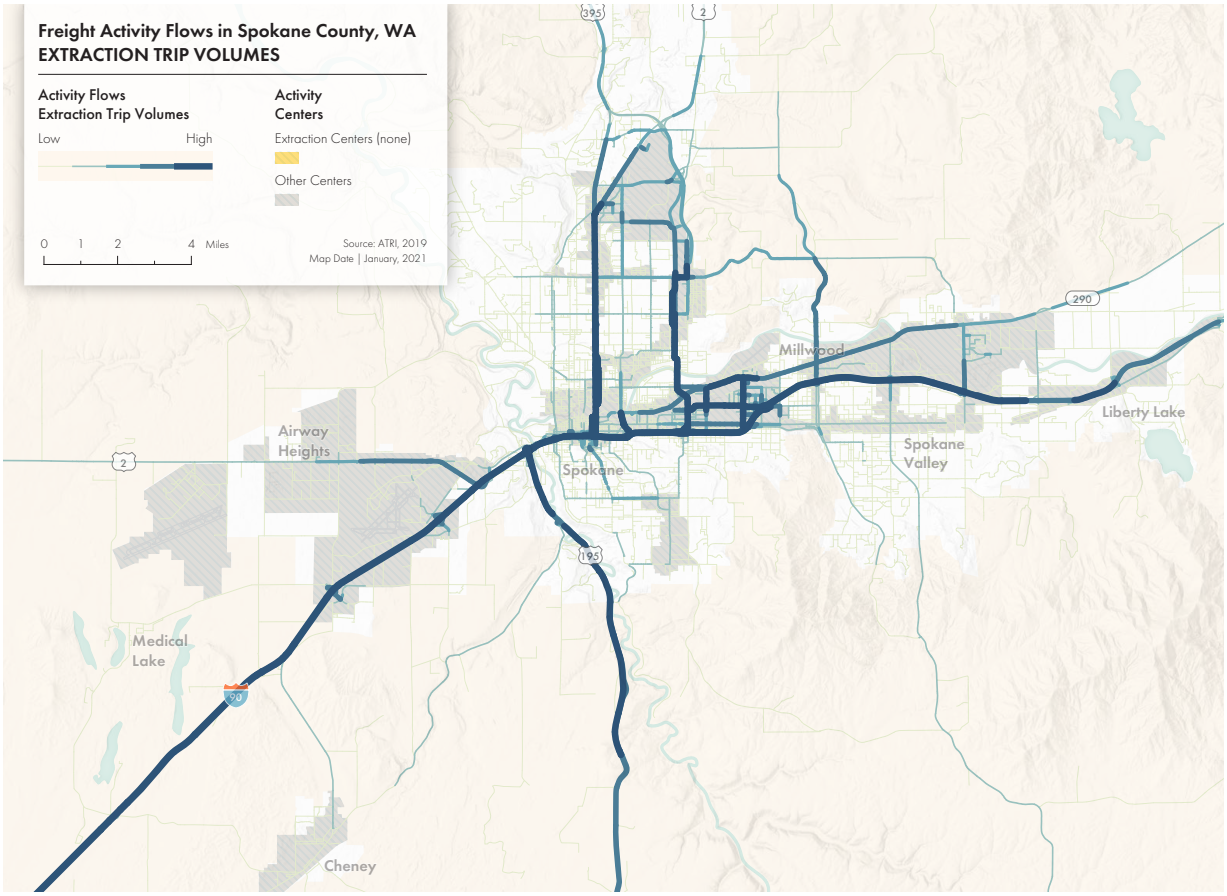


Figure F.15: Extraction-Based Freight Activity Flows

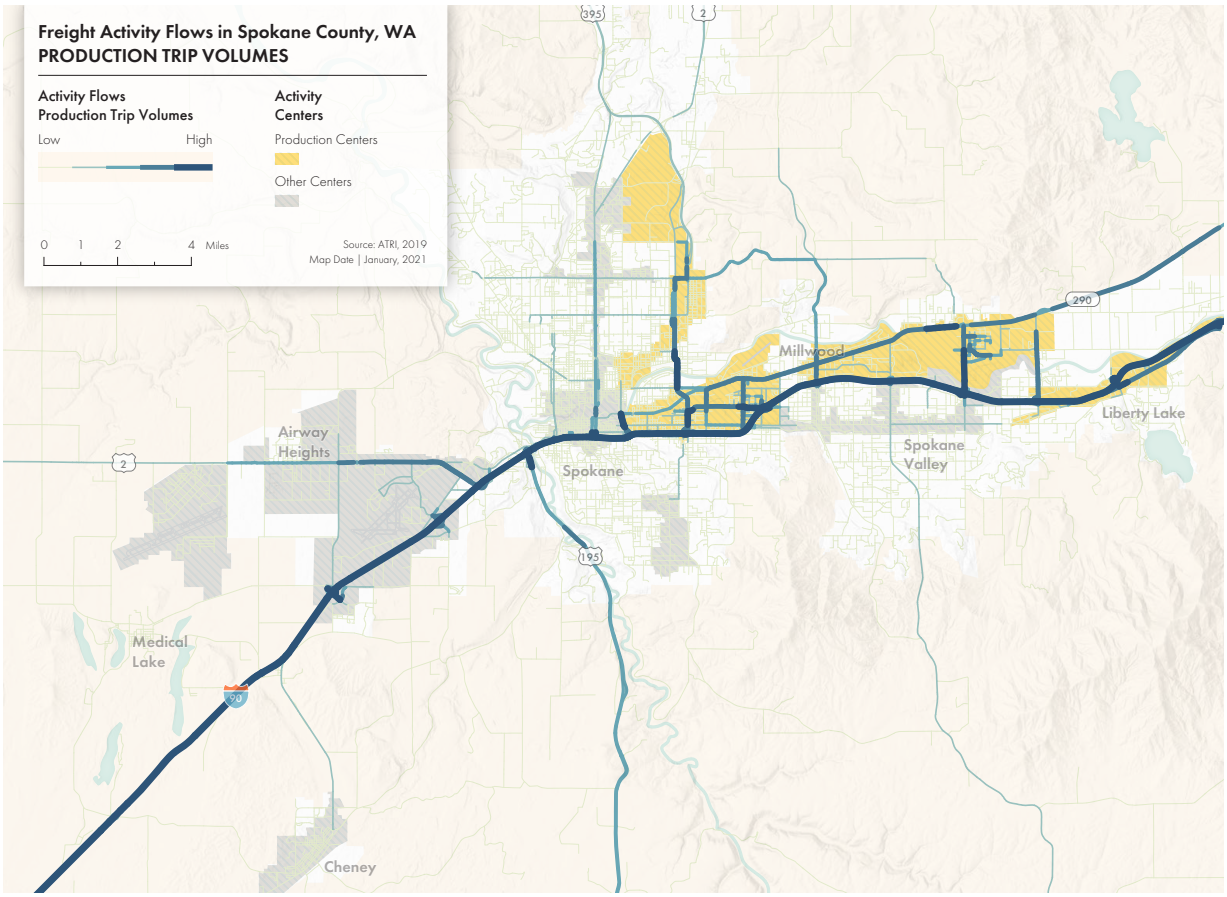


Figure F.16: Production-Based Freight Activity Flows

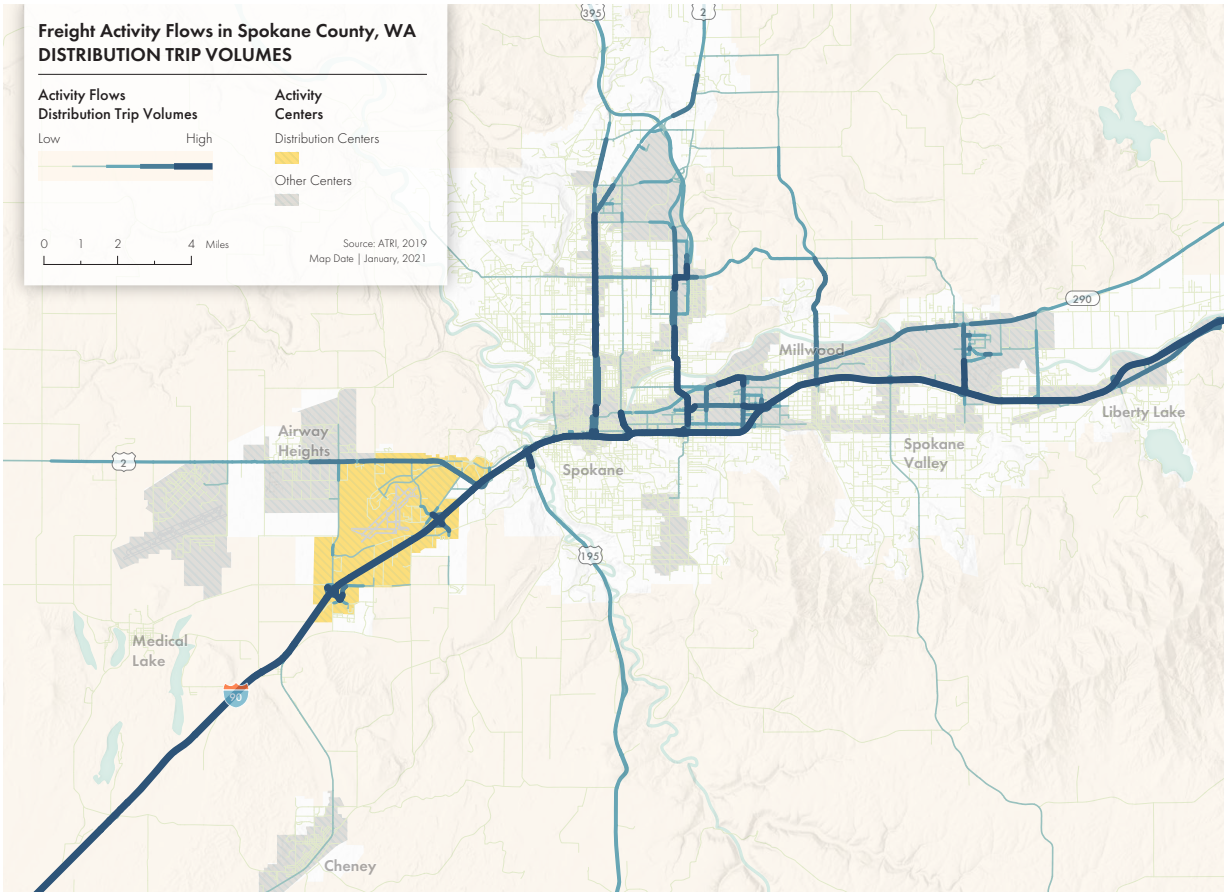


Figure F.17: Distribution-Based Freight Activity Flows

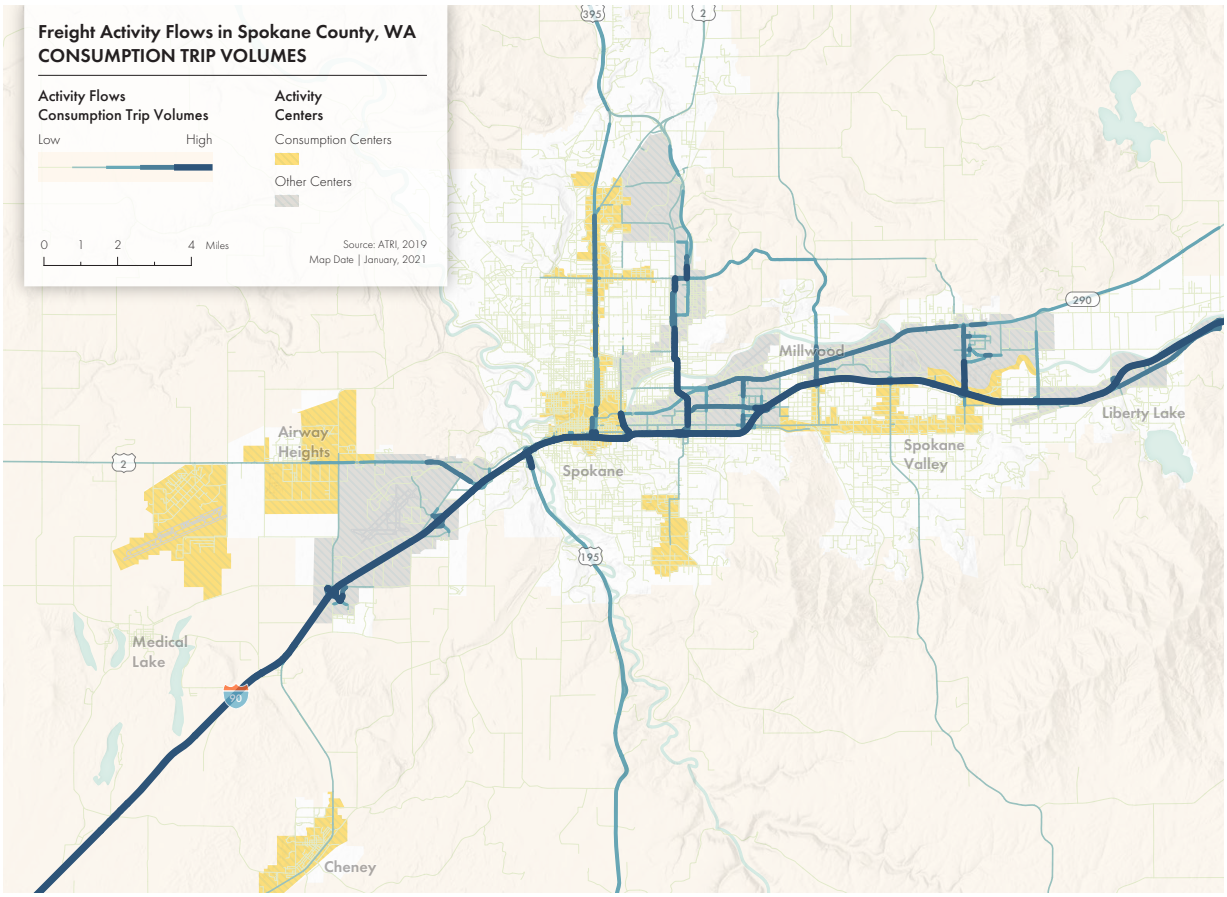


Figure F.18: Consumption-Based Freight Activity Flows

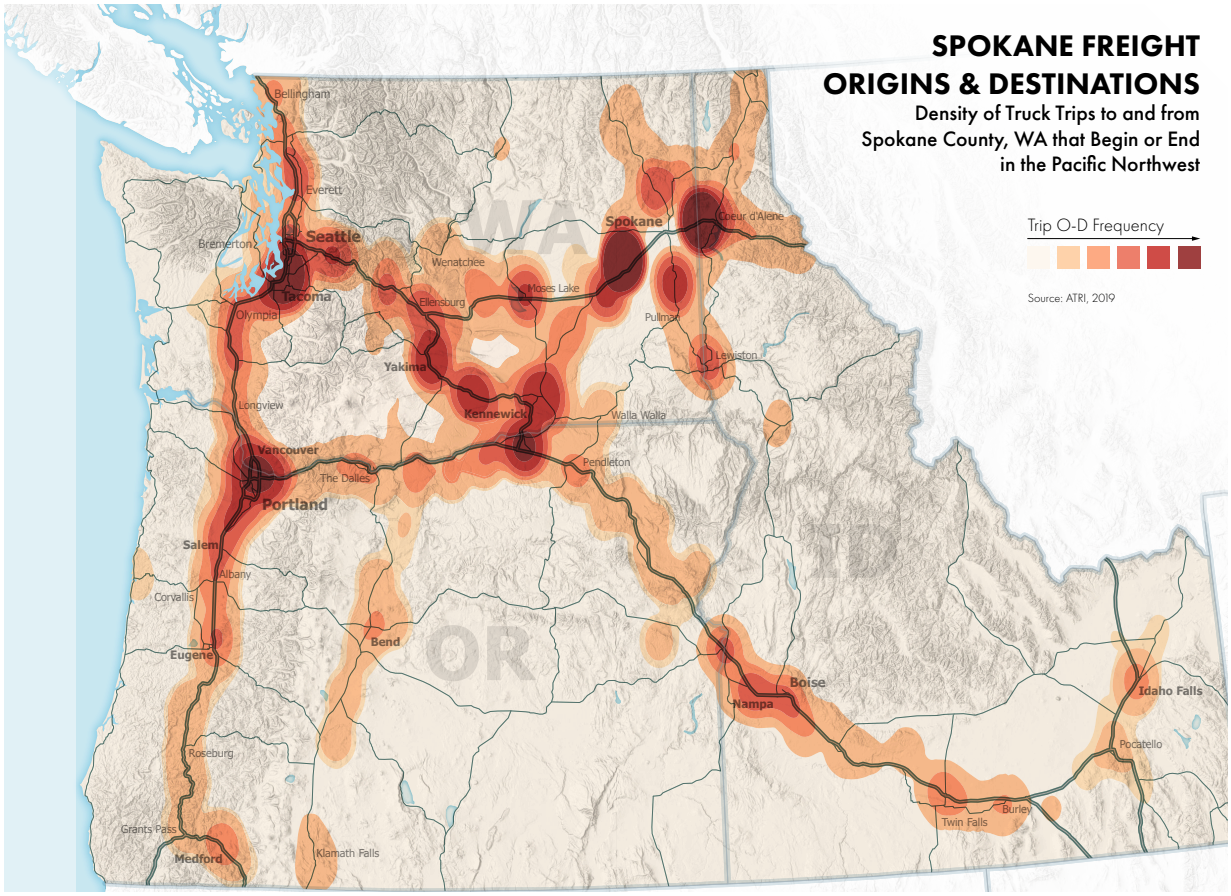


Figure F.19: Spokane's Freight Connections in the Pacific Northwest, in 2019

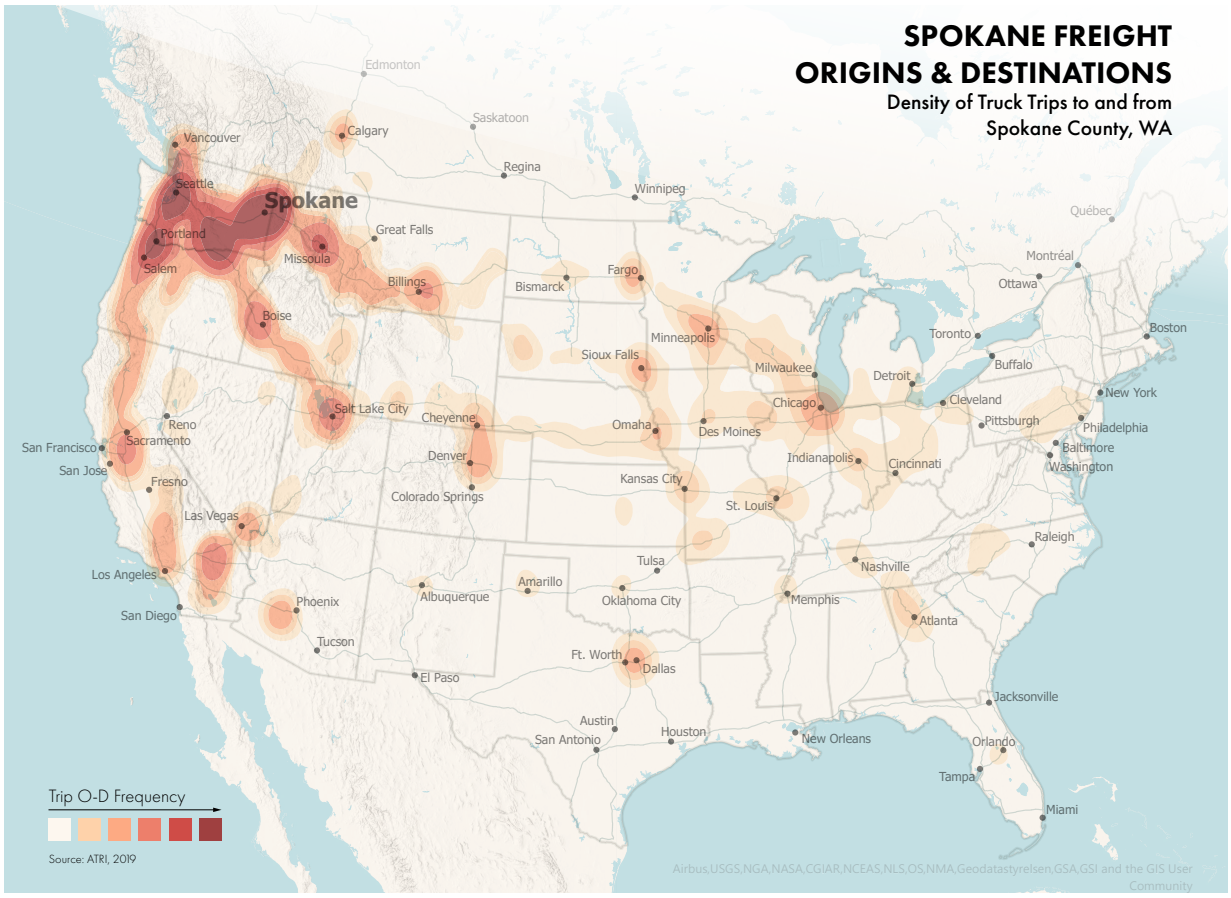


Figure F.20: Spokane's Freight Connections in the United States and Western Canada, in 2019

Freight and Equity

While freight movement and development are critical to the Spokane region's economy, they can also lead to equity and environmental justice related concerns. Freight-related impacts may include pollution, such as air and noise pollution; increased congestion; traffic safety concerns; increased stormwater runoff due to impervious surfaces; conflict with bicycle and pedestrian traffic; vibrations due to large vehicles and heavy machinery; and disruption to historically and culturally sensitive areas.[7, 8] As the federally designated MPO for the Spokane region, SRTC is required to ensure that equity issues are evaluated in its transportation planning efforts.

Potential Freight-Related Equity Issues

Low income and minority communities are among the first and hardest impacted by freight. The American Planning Association (APA) recognizes that the "lowest cost solution" in terms of land use and land acquisition may result in disproportionate burdens on minority and lower income communities.[3] Freight corridors are often centered around highways, major arterials, and commercial industrial land uses. Previous research has highlighted how the location of highways and interstates took a disproportionate toll on urban minority communities.[9] Previous research has also indicated that minorities and people experiencing poverty are more likely to experience adverse air quality due to proximity to freight corridors.[3] Furthermore, nonwhite and low income communities are more likely to be exposed to sources of industrial air pollution – such as freight.[3, 10, 11]

Modal conflict between freight and active transportation is an additional concern. The presence of freight truck traffic poses an acute safety risk for cyclists – both in terms of accident risk and severity of accident outcomes.[12] The national rate of vehicle ownership is lower for people of color than for white people. Lower income commuters are more likely to rely on alternative modes of transportation such as walking or bicycling to work.[13] Furthermore, those with disability, the aged, and the very young are more likely to be dependent on alternative transportation modes for independent mobility.[14] Individuals and households without access to vehicles—such as those who can't afford a car payment or vehicle maintenance—may be cut off from employment opportunities and other important destinations if safe, affordable, and timely alternatives to vehicle transportation are not available.

Indicators of Potential Disadvantage

To analyze potential freight impacts, SRTC pursued a methodology based on the procedure followed by DVRPC, the MPO for the greater Philadelphia region.[15]

SRTC's freight environmental justice analysis focused on environmental justice populations as defined through six key indicators of potential disadvantage (IPD). These are:

- Income
- Racial or ethnic minority status
- Limited English proficiency
- Vehicle access
- Age dependency (youth and elderly individuals)
- Disability status

Racial and ethnic minorities, as well as people with lower incomes, have been disproportionately exposed to transportation-related hazards such as pollution. Individuals with disabilities, those who—either by choice or necessity—do not have access to a vehicle, and individuals with limited English proficiency are likewise especially vulnerable to negative transportation impacts. Youth and the elderly populations may be more vulnerable to transportation-related safety hazards. The IPD categories relate to protected groups as established in Title VI and Executive Order 12898 (environmental justice).

For each IPD category, potential disadvantage is defined in terms of burden from health and transportation impacts. The six indicators are displayed in **Figure F.21** along with the definition of each measure and countywide, state, and national averages.

7 APA. 2021. APA Policy Guide on Freight. Accessed June 21, 2021. https://www.planning.org/policy/guides/adopted/freight/.

8 Ross, Catherine, Adjo Amekudzi, Subhrajit Guhathakurta, and Timothy Welch. 2015. Freight Impacts on Small Urban and Rural Areas. Final Report, Atlanta, GA: National Center for Transportation Systems Productivity and Management, USDOT.

9 Karas, David. 2015. "Highways to Inequity: The Disparate Impact of the Interstate Highway System on Poor and Minority Communities in American Cities." New Visions for Public Affairs 9-21.

10 Perlin, Susan A., Ken Sexton, and David W.S. Wong. 1999. "An examination of race and poverty for populations living near industrial sources of air pollution." Journal of Exposure Analysis and Enzironmental Epidemiology 29-48.

11 Sanom, Garrett, Juan Parras, Ana Parras, Yudith Nieto, Yvette Arellano, Philip Berke, Thomas McDEonald, Eva Shipp, and Jennifer A. and Horney. 2017. "The Impacts of Exposure to Environmental Risk on Physical and Mental Health in a Small Geographic Community in Houston, TX." Journal of Community Health 813-818.

12 Pokorny, Petr, and Kelly Pitera. 2019. "Truck-bicycle safety: an overview of methods of study, risk factors and research needs." Springer Open. June 18. Accessed June 2021. https://etrr.springeropen.com/articles/10.1186/s12544-019-0371-7.

13 American Community Survey (ACS). 2019. MEDIAN EARNINGS IN THE PAST 12 MONTHS (IN 2019 INFLATION-ADJUSTED DOLLARS) BY MEANS OF TRANSPORTATION TO WORK. Accessed June 21, 2021. https://data.census.gov/cedsci/table?t=Commuting%3AEarnings%20%28Individuals%29&tid=ACSDT5Y2019.B08121.

14 Raya, Richard, and Victor Rubin. 2006. Safety, Growth, and Equity: Transportation. PolicyLink.

15 DVRPC. 2021. "Philly Freight Finder." dvrpc.org. Accessed July 29, 2021. https://www.dvrpc.org/webmaps/phillyfreightfinder/freight-center-story.html

Figure F.21: IPD Categories

IPD	Metric	Spokane County	Washington State	United States
Income	Percent of individuals with incomes below 200 percent of the Federal Poverty Level.	32.2%	26.9%	31.9%
Minority Status	Percent of population belonging to one or more racial or ethnic minority groups.	15.4%	30.9%	38.9%
Language	Percent of households with limited English proficiency.	1.2%	3.8%	4.4%
Vehicle Access	Percent of households with no vehicle access.	7.2%	6.9%	8.7%
Age Dependency	Percent of population that is age dependent (i.e., under 18 or over 65 years old).	61.3%	59.0%	61.4%
Disability Status	Percent of non-institutionalized population with a disability	14.5%	12.6%	12.6%

2019 ACS 5-Year Estimates

SRTC analyzed each of the IPD populations at the census tract level. Every tract was assigned a score for all six IPDs indicating the its level of concentration for each of these categories relative to the average value for the SRTC planning area as a whole. This was based on the number of standard deviations from the mean. The scores for the individual IPD category were then converted to an overall IPD score, indicating the overall concentration of potentially disadvantages populations in a given tract.

Tracts with values within 0.5 standard deviations of the countywide mean were considered to be average and assigned a score of 2. Tracts between 0.5 and 1.5 standard deviations above the countywide mean were considered to be above or below average and assigned a score of 3, while tracts between 0.5 and 1.5 standard deviations below the countywide mean were considered below average and assigned a score of 1. Tracts more than 1.5 standard deviations above the countywide average were considered to be well above average and assigned a score of 4. Tracts more than 1.5 standard deviations below the countywide average were considered well below average and assigned a score of 0. **Figure F.22** illustrates the conversion of standard score values to IPD score for each IPD category.

Each tract's IPD scores for each IPD category were then added to produce an overall IPD score value. The total IPD scores were again normalized and compared countywide to identify which tracts were above average or well above average overall. Maps displaying the comparative IPD scoring values for each tract in the SRTC planning area, for each individual IPD category, can be found in Chapter 2 of Horizon 2045 (**Figures 2.4 through 2.9**).

As with tract-level IPD category scores, block group-level scores for minority and low income were added and compared to the countywide average to produce an overall IPD score. The block group analysis was performed in part as a response to feedback from subject matter experts who were consulted as part of the Spokane Regional Freight Profile. Although most potentially disadvantaged block groups coincide with census tracts that had already been identified, the analysis resulted in locating several additional areas with relatively high concentrations of potentially disadvantaged populations , such as in the West Plains near Airway Heights and Cheney, as well as several block groups in southeastern Spokane and Spokane Valley.

Areas of Potential Disadvantage

Census tracts that scored above average or well above average were categorized as areas of potential disadvantage (APD). Above average in this context means that the geographies' combined score for all indicators was significantly higher than the countywide average. Block groups that scored above average or well above average and that are not included in an already-included tract were also categorized as an area of potential disadvantage. **Figure F.25** shows the Spokane region's combined tract- and block

Figure F.22: Standard Score to IPD Score Conversion

Standard Deviations from Countywide Mean	IPD Score
< -1.5	0 WELL BELOW AVERAGE
-1.5 to -0.5	1 BELOW AVERAGE
-0.5 to 0.5	2 AVERAGE
0.5 to 1.5	3 ABOVE AVERAGE
>1.5	4 WELL ABOVE AVERAGE

group-level APDs, overlayed against its freight routes classified as FGTS corridors. Many of the region's highest-volume freight corridors overlap significantly with APDs—particularly in North Central Spokane, East Central Spokane, northern Spokane Valley, and the West Plains.

Geographies are classed as "above average" if the area contains a higher proportion of potentially disadvantaged residents than the countywide average (+ 0.5 to 1.5 standard deviations). Geographies classed "well above average" contain a significantly higher proportion of potentially disadvantaged residents (greater than 1.5 standard deviations) when compared to the county as a whole. Geographies that scored well above average are colored in red, while those that scored above average are colored in orange. The population density of each geography is indicated by the level of transparency.

The region's APDs are distributed throughout most of its urban areas, with the exclusion of Liberty Lake and Deer Park. Several trends can be identified. North Spokane east of the Y, North Central near Market Street, East Central, and the area around downtown scored highest for overall disadvantage and include a well above average concentration of multiple potentially disadvantaged populations. This overall area includes each of the thirteen census tracts that scored highest for overall potential disadvantage. They include an inter-sectional overlapping of multiple potentially disadvantaged groups, such as lower income individuals, LEP households, and racial or ethnic minority populations. Of these tracts, only the immediate downtown area did not score above average in the low-income category.

Populations with lower income, present in Spokane County at a higher rate than the state or federal averages, were found to be most densely concentrated in the area around downtown, the lower North Side, Hillyard, East Central, Cheney, and north Spokane east of the Y—though the North Side, Airway Heights, and parts of Spokane Valley adjacent to I-90 are also areas of note. As the most prevalent potentially disadvantaged group in Spokane County, the distribution of lower income residents strongly correlates to the areas of greatest potential disadvantage and intersects several other indicators.

Parts of the rural County, such as the areas northwest of Fairchild Air Force Base and east of US 2 and south of SR 206, notably include an above average percentage of disabled residents. Although population densities are lower in the rural county, residents in rural Tracts are also located further away from critical health care services, which are concentrated in the urban area and especially south of downtown. Also of note is the US 195 corridor south of I-90, which was identified as an area of potential disadvantage largely by virtue of well above average concentration of disabled and age dependent residents.

Outside of the US 195 corridor and lower Moran Prairie, the age dependent population is concentrated in the northern and eastern portions of Spokane County, including some rural areas that did not score highly on other measures of potential disadvantage.

LEP populations are most concentrated in North Spokane east of the Y, East Spokane south of I-90, and in the northern portion of East Central. Airway Heights, parts of Spokane Valley (particularly in the north near I-90 and the river), and the West Plains are also areas of note.

Households without vehicle access are primarily concentrated in urban Spokane adjacent to downtown and/or the river—though two tracts in far North Spokane east of Division Street/US 2 also scored quite highly.

Figure F.25 shows the Spokane region's APDs overlayed against its freight routes classified as FGTS corridors. Many of the region's highest-volume freight corridors overlap significantly with APDs—particularly in North Central Spokane, East Central Spokane, northern Spokane Valley, and the West Plains.

Beyond this analysis, much more work remains to be done. SRTC hopes to expand our equity planning in the coming years by developing a multimodal equity planning framework. Components could include an equity-based needs analysis to profile specific project impacts while identifying more clearly the transportation needs and barriers faced by individual communities of potential disadvantage. Through this planning process, SRTC could more effectively operationalize equity measures within project analysis and prioritization.

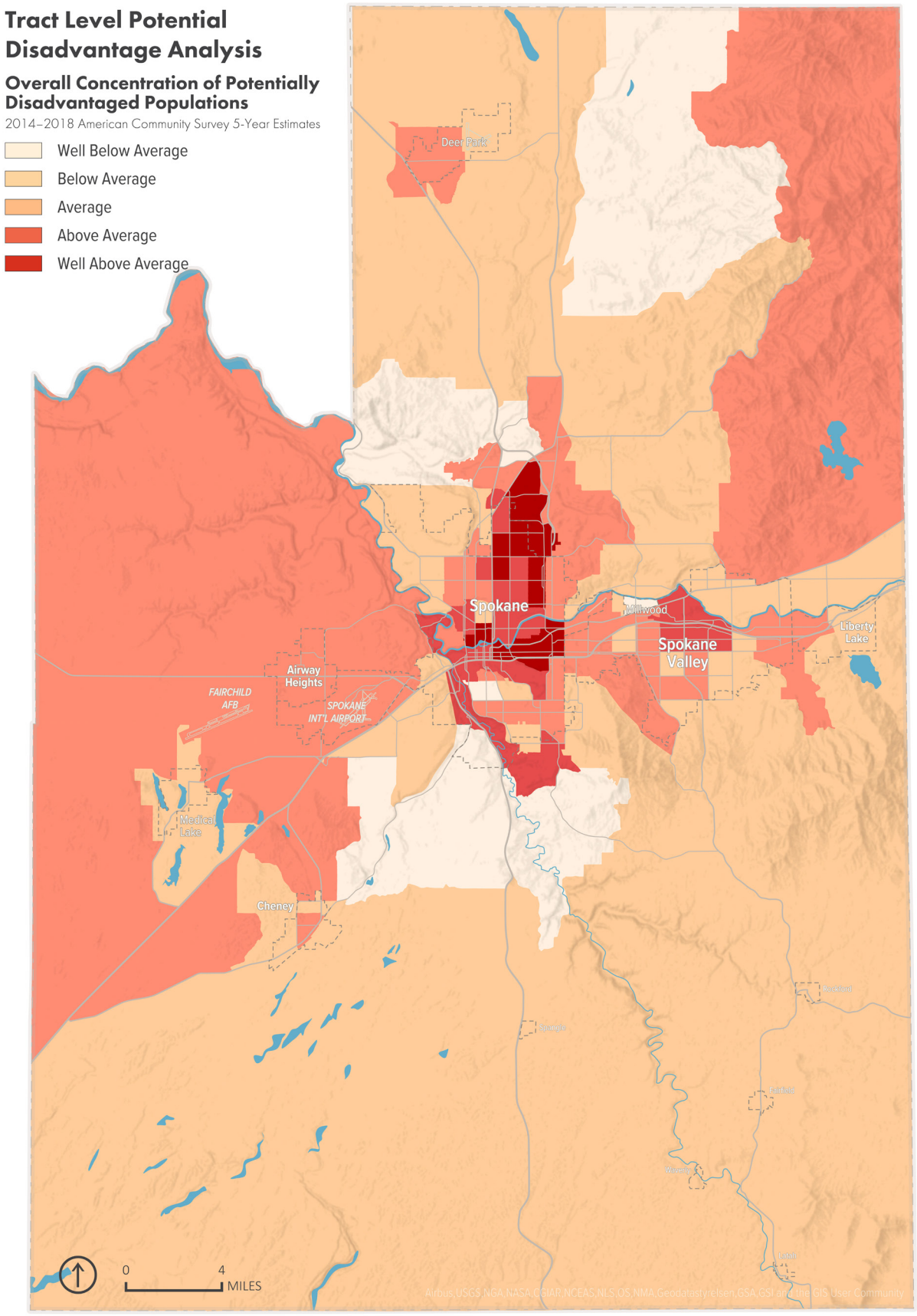


Figure F.23: Concentrations of Potential Disadvantage by Census Tract

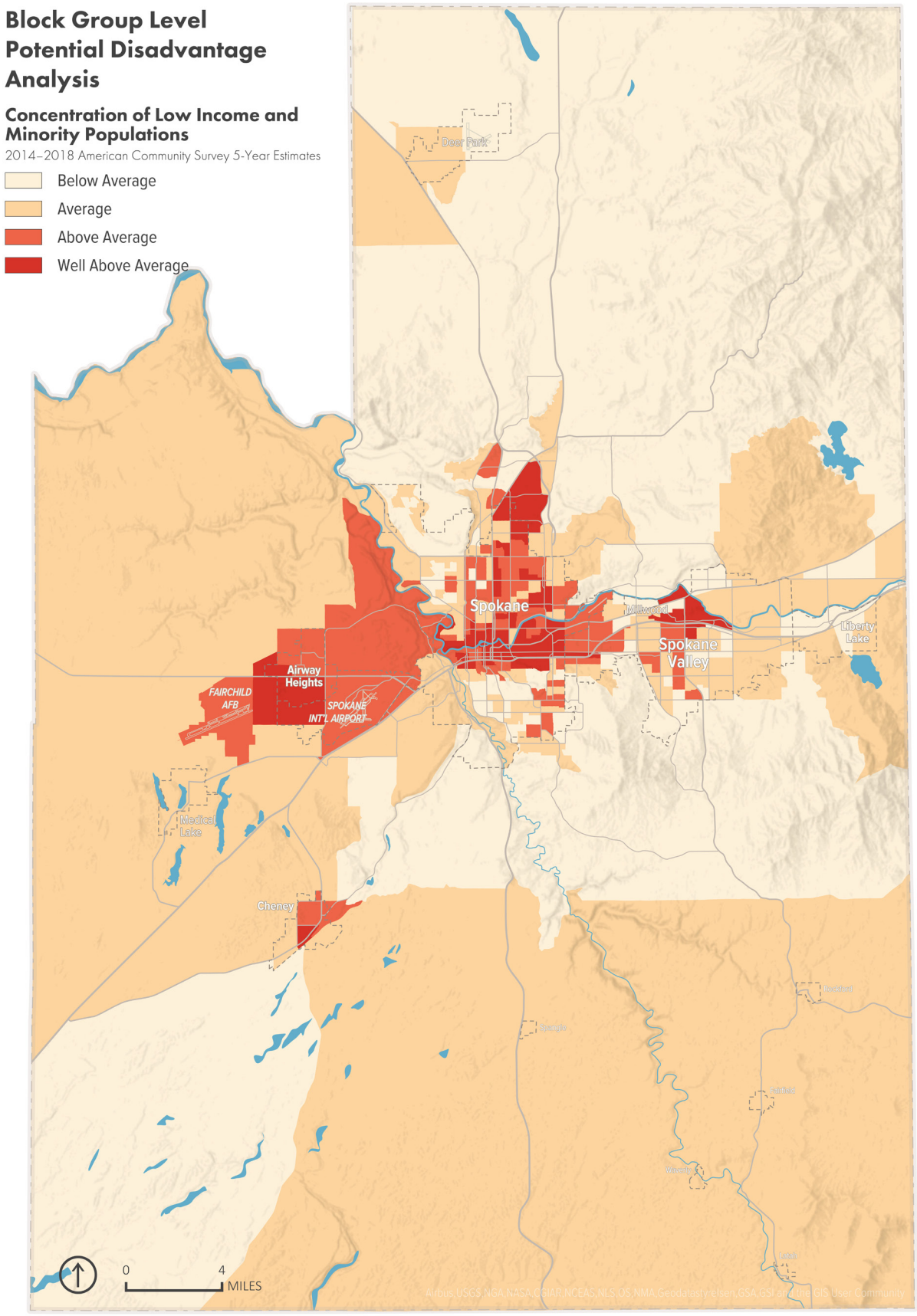


Figure F.24: Low Income and Minority Populations, by Block Group

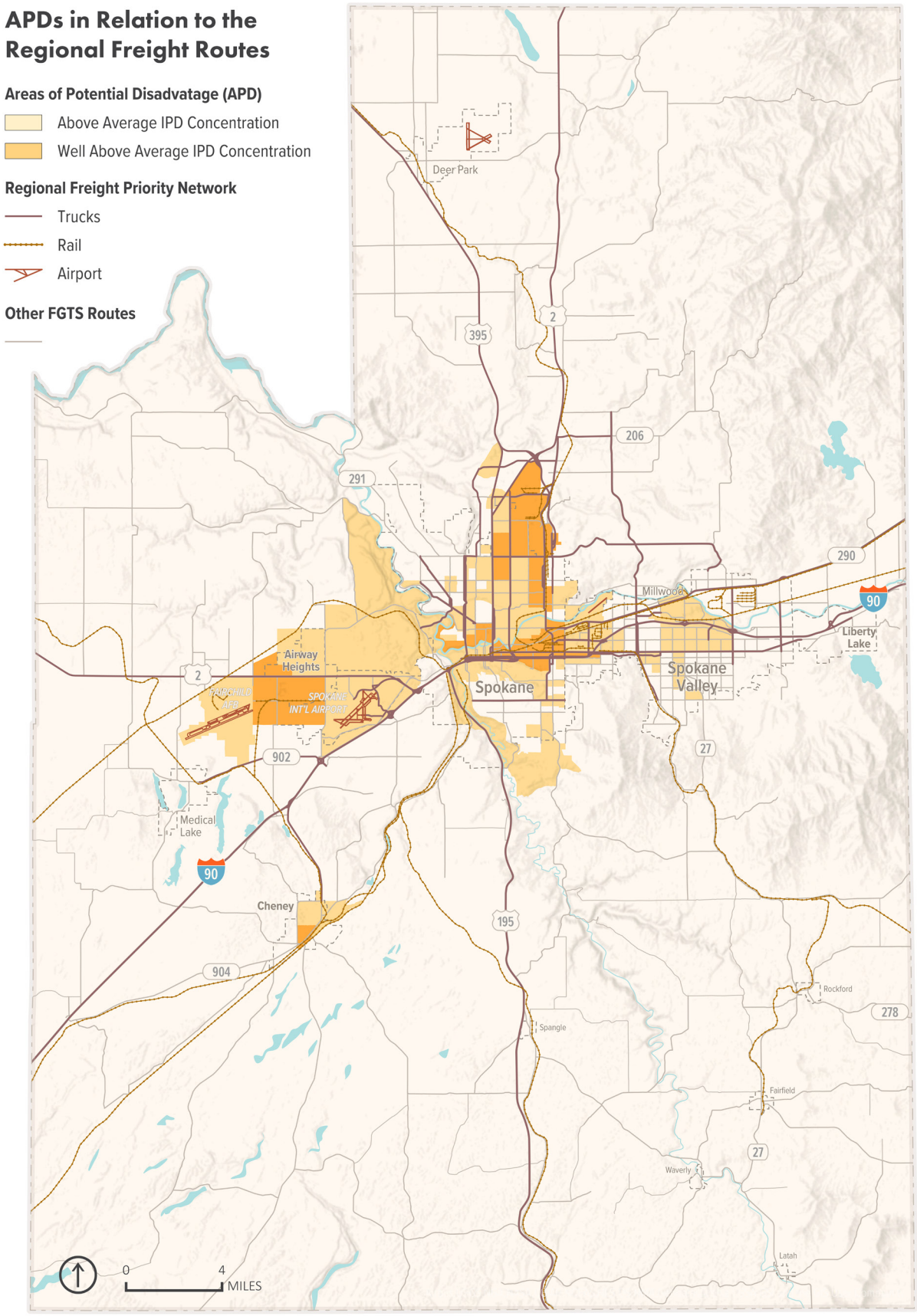


Figure F.25: FGTS Corridors and APDs

Stakeholder Engagement

SRTC worked to develop the Spokane Regional Truck Freight Profile between January 2020 and May 2021, to enhance the freight modal analysis in Horizon 2045. The SRTC Transportation Technical Committee (TTC) approved the establishment of a freight SME team to guide the effort. SRTC staff reached out to public and private sector freight stakeholders from the Spokane region. The SME team was comprised of Individuals from local public development authorities, freight logistics companies, state and local freight planning staff, and regional railroad staff.

At the project's onset, a survey was distributed to the SME team to capture input about the current and future freight related needs and concerns in the Spokane region. Additionally, there were survey questions to gauge interest in various freight-related planning topics, to better understand how project staff could gather information and engage with the SME team. A summary of this survey is included at the end of this document.

SME Team

SRTC staff would like to acknowledge members of the Freight SME Team and guest participants for their contributions to this profile. These individuals helped to identify regional freight challenges, needs, conflicts and areas of improvement, reflected in the profile. Their respective areas of expertise within the freight industry and freight planning provided critical insight into the relationships of freight and land use, equity, and the regional economy.

SME Team Workshops

The Freight SME Team met virtually over the course of 14 months between February 2020 and April 2021. The various profile components were divided and discussed in six workshops. The SME feedback, comments, and suggestions helped to guide the work efforts. A summary of topics discussed, and SME feedback can be found in **Figure F.27**.

SME Team Feedback

The contributions of the SME team resulted in several significant outcomes. Most notable is the development of regional freight-related goals with corresponding objectives. The goals and objectives are critical pieces to the freight profile element of Horizon 2045 and provide the missing links between the SRTC's existing guiding principles and policies and the freight needs in the region. The goals and objectives serve as steps toward addressing freight-related safety, economic, and environmental concerns expressed by the SME team that are representative of the region.

The SME team and project staff identified a future opportunity to work closely with WSDOT to review FGTS classifications for regional freight routes that lack sufficient freight volume data. Through this effort, preliminary analysis suggests that some corridors may be over or under classified. Recognizing the limitation in available freight data on all corridors, combining SRTC and WSDOT resources may be helpful in future FGTS corridor analysis.

Another major outcome from the work of the SME team was understanding that different types of freight have different transportation needs. Project staff developed freight activity flow maps that show how freight moves throughout and within the Spokane County region. This analysis was tied to feedback from the SME team and provided

By overlaying the FGTS routes with environmental justice communities, as recommended by the SME team and identified as best practice through literature reviews, areas with a high concentration of potentially disadvantaged populations were identified. While further analysis is needed, project staff were able to highlight areas of the region where freight and vulnerable populations may have the most conflict points.

Figure F.26: Freight SME Team

Name	Agency or Organization Represented
Adam Jackson	City of Spokane Valley
Barry Green	Spokane County
Bob Westby	WSDOT
Brent Vander Pol	Peninsula Truck Lines
Charlene Kay	WSDOT
David Guthrie	Northeast Public Development Authority
Don Karls	BNSF
Inga Note	City of Spokane
Jason Beloso	WSDOT
Jeff Bosma	Fast Way Freight System
Johan Hellman	BNSF
Kara Mowery-Frashefski	City of Spokane
Matt Ewers	Inland Empire Distribution Systems
Megan McIntyre	BNSF
Reeve Geary	BNSF
Ron Pate	WSDOT
Stephen Semenick	BNSF
Todd Ableman	City of Cheney
Todd Coleman	Airway Heights Public Development Authority
Trevor Daviscourt	WSDOT
Wenjuan Zhao	WSDOT

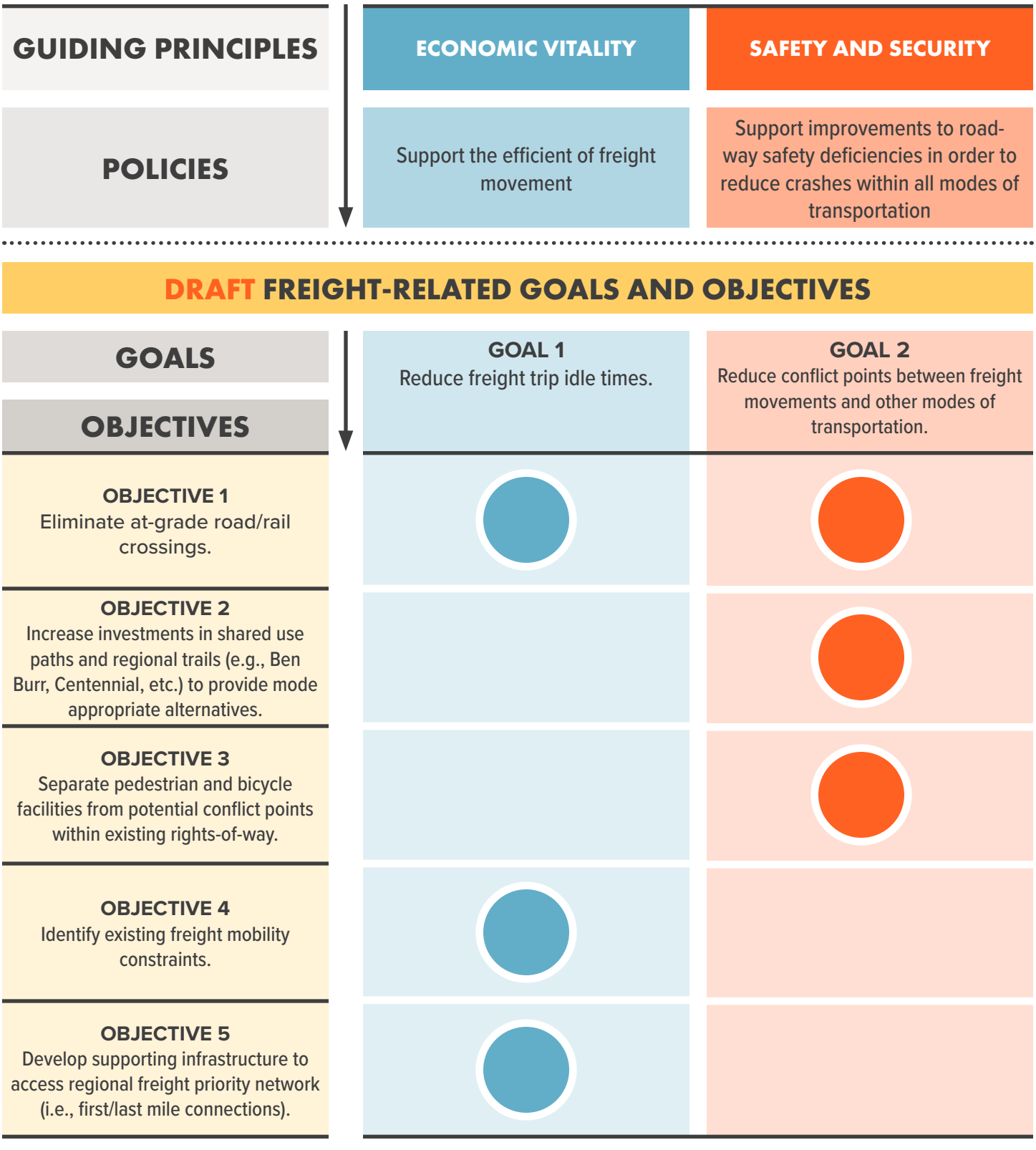
Figure F.27: SME Team Workshop Topics and Feedback Summary

Workshop Topics and SME Team Feedback	
WORKSHOP 1 Kick Off	• SME team reviewed the project scope and timeline. • Examined earlier regional freight study efforts. • Discussed regional freight-related concerns and threats from the SME team through an introductory survey and live poll questions
WORKSHOP 2 Freight Activity Centers/ Truck Parking	• Brainstormed around attributes that characterize a freight activity center and helped define freight activity centers. • SME feedback helped to shape what type of data to consider when mapping freight activity centers, but also identified data that should be acquired for future freight element updates. • Most of the team believes freight truck parking poses safety, reliability, and environmental (idling) problems in the Spokane region for freight traveling through Spokane. • Team members spoke about local public development authorities, their freight-related challenges, and opportunities.
WORKSHOP 3 ATRI Data Review/ Freight Industry Sectors	• Reviewed draft visuals from processed ATRI data. • Feedback from the earlier workshop aided in identifying freight activity centers based on freight trips, freight intensive sector employment and freight-related land use in addition to other considerations. • SME team reviewed maps of freight activity flows for freight intensive sectors: Extraction, Production, Consumption, and Distribution
WORKSHOP 4 Environmental Justice/ Freight Trip Origins and Destinations Review	• Reviewed visuals of regional freight origins and destinations. • Discussed freight as it relates to long-range planning • Discussed freight impacts to potentially disadvantaged communities • Examined maps of potentially disadvantaged communities in relation to freight routes and activity centers. • Identified potential conflict areas in the Spokane region and areas for future study
WORKSHOP 5 Freight Routes and Corridor Analysis/ Freight Connections	• Validated maps of regionwide freight volume estimates and discussed analysis for future FGTS (Freight and Goods Transportation System) classification review. • Reviewed visuals of regional freight origins and destinations and the connections across the nation.
WORKSHOP 6 Freight Goals and Objectives	• Literature review of peer MPO freight goals and objectives • Brainstorm freight-related barriers and potential solutions • Development of goals and objectives specific to the Spokane region based on brainstorm activity and literature review. • See matrix below for goals and objectives

Freight Goals & Objectives

As shown in **Figure F.27**, the final SME team workshop included the development of freight-related goals and objectives. The outcome of this process is summarized in the matrix displayed below, in **Figure F.28**.

Figure F.28: Freight Goals and Objectives Matrix



Next Steps

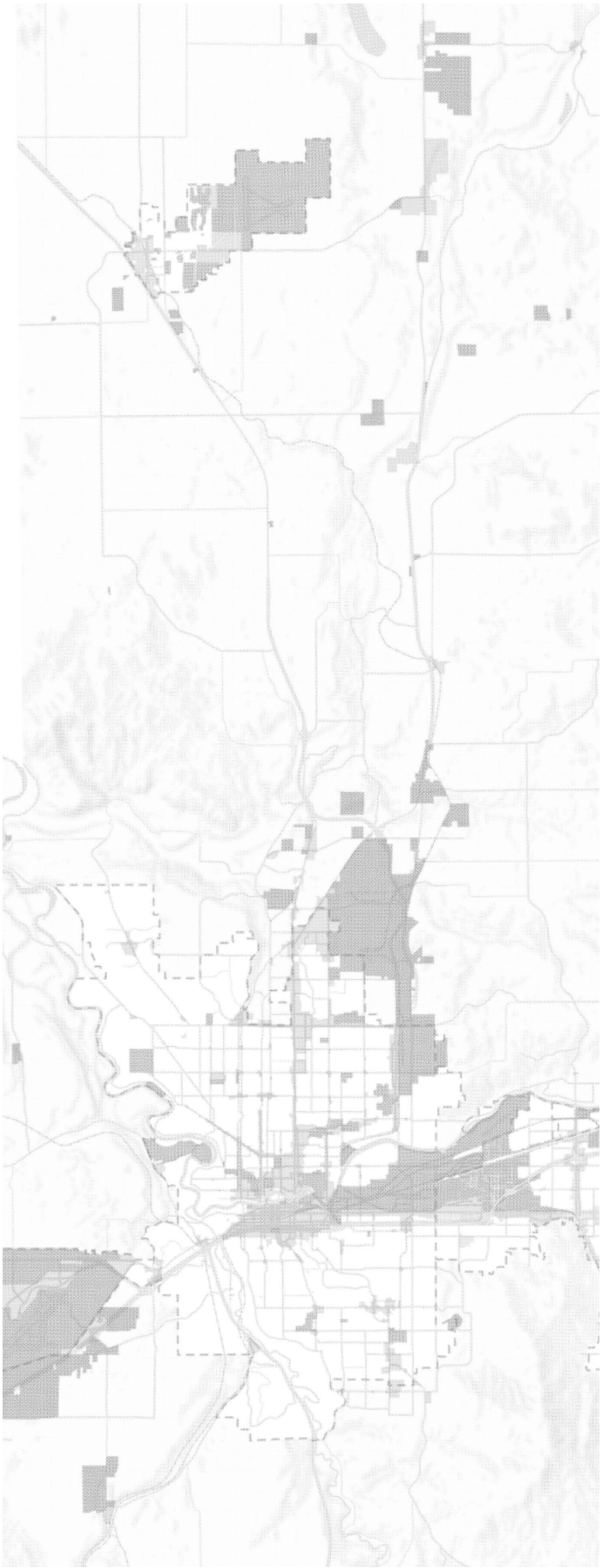
The Spokane Regional Truck Freight Profile has identified future opportunities to build on the preceding work. Importantly, SRTC hopes to work with WSDOT to potentially supplement FGTS classifications with passive data volume estimates for regional freight routes that lack sufficient freight volume data. Through this effort, preliminary analysis suggests that some corridors may be over or under classified. Recognizing the limitation in available freight data on all corridors, combining SRTC and WSDOT resources may be helpful in future FGTS corridor analysis.

In addition to future freight corridor analysis, SRTC will continue to monitor key performance indicators related to ruck parking and other freight-related issues. Staff will provide recommendations to the SRTC Board accordingly, based on these efforts.

This profile provides a broad look at the relationship between potentially disadvantaged communities and freight, however, this warrants further study, Additional analysis to identify and differentiate project impacts on potentially vulnerable communities is needed. To address this, and other gaps in our planning process, SRTC intends to expand our equity planning in the coming years by developing a multimodal equity planning framework. Components could include an equity-based needs analysis to profile specific project impacts while identifying more clearly the transportation needs and barriers faced by individual communities of potential disadvantage. Ultimately, SRTC anticipates operationalizing equity measures within project analysis and prioritization.

Future study regarding freight-related collision data in the region, to identify potential safety issues, is also warranted. Furthermore, while truck freight is the region's primary mode of freight, it is also important to understand other freight modes, such as air and rail. Additional study regarding these freight movements and impacts would yield additional insight and provide a more holistic picture of freight needs in the Spokane region.

The initial work of identifying freight-related goals and objectives should be incorporated into the long-range plan's policy framework. There is more work to be done to complete the framework and more effectively tie investment to performance objectives. This work will be continued in future plan updates.



Freight SME Team Survey Summary Report

Question 1

How do you think your area of expertise and insight about Freight in Spokane County could be beneficial to the MTP Freight Element?

- I have been in the truck freight industry in Spokane and inland area for 30 years. I have interacted with railroads and the coastal ports as well.
- 18 years at BNSF within the engineering department. My knowledge covers all track and crossing related infrastructure and how that affects the communities around BNSF.
- Experience in leading/participating in various regional studies over the past 33 years, including Bridging the Valley, Inland Pacific Hub, US 395 Freight Commodity Flow study, EWITS studies, various statewide freight studies (air, rail, truck, etc.), past freight coordination with ITD and British Columbia Ministry of Transportation. Research and planning associated with securing the Palouse Coulee Rail line and Geiger Spur. Understanding of the evolution of freight development in the Eastern Region along with freight interdependence, commodity flows, and gaps (limited understanding of current gaps).
- I have 30 years' experience in economic development and infrastructure including over 15 years at an international port.
- I have over 25 years working in the freight industry about rail, trucking and ocean freight. I do not believe neither I and any other person within SRTC has the expertise to decipher what is equitable or socially justice in evaluating projects.
- I can provide a statewide and to some degree national and international perspective on the topic.
- Understanding of the role short line railroads can fill in an overall freight strategy
- Traffic / Transportation engineer for Spokane County for 16 years, and over 30 years transportation, design and construction experience
- I have limited experience in freight planning, but my planning team at the City has many years of combined experience, helping to understand gaps in the system, important trends, and future needs.
- 30+ years in freight and truck operations.
- Several years' experience in railroad infrastructure and how it plays into the freight corridor.
- I can provide local insight to how freight impacts Spokane Valley's transportation network.
- I have 17 years of freight facility development and know how rail traffic flows in the

Question 2

How important is helping staff identify solutions to the following freight-related discussions for you and the agency you represent?

Rank	Freight-Related Topic
1	Current and planned freight-related projects
2	Identify freight-related safety concerns and issues in the region
3	Identify regionally significant freight needs
4	Define freight activity centers
5	Define freight activity centers and generators
6	Freight dependent industries and employers in the region
7	Inform freight policy objectives in the MTP
8	Review key freight routes and corridors in the region
9	Evaluate freight's role in the regional economy
10	Discuss methodology to incorporate freight projects into the MTP
11	Validate data sets are accurate representation of present trends
12	Identify region's primary freight commodities
13	Review commodity flow models
14	Freight-related equity &environmental justice issues in the region
15	Identify and confirm truck parking locations

Question 3

Please share how SRTC's Board of Directors (14 elected officials) can help your agency with regional coordination, freight-related projects or planning in Spokane County.

Assistance, communication & coordination with planning & building projects

- The expertise of the Board is helpful in determining coordination
- By listening to the operators and not the planners.
- SRTC can help by coordinating efforts to support infrastructure projects.
- County Commissioners are members of the Board
- Good communication during planning and building phases of projects

- Assistance with potential corridor projects to enhance freight mobility.

Understand region's freight objectives to increase freight mobility while considering land use decisions and impacts.

- Having a better understanding of the region's freight objectives and needs as directed by the Board is very helpful to the agency.
- Ensure shoreline railroads are considered in freight planning and land use decisions
- Identify and plan coordinated industrial land use development and transportation improvements.
- To be successful in recruiting business to the region we must have freight systems that are not only efficient in the last mile but throughout the entire region.

Question 4

What is your primary concern regarding freight-related projects or activities in Spokane County?

Safety:

- How road and rail freight travel effects public safety and BNSF.
- Safety and freight mobility.
- Overnight truck parking. Sharing freight corridors with bikes and peds. Road diets in the city making it very difficult to make freight deliveries without killing someone.

Efficiency:

- Increased congestion on I-90 and local streets will make it more difficult to move freight during all hours of the day efficiently
- That freight movement won't be the at the forefront of decision making. I'm afraid that other agendas will work to decrease the importance of efficient freight movement.

Regional Coordination:

- Opportunity for enhanced regional coordination and prioritization.
- Ensuring appropriate stakeholders are included in the planning process.

Future Freight Growth and Prioritization:

- Do they adequately allow for future growth and traffic flows?
- Review of truck route classification and making sure they are appropriate. The priority of freight in the MTP.
- Most freight benefits rely on improvements at DOT-impacted facilities: Argonne & I-90 bridge, Sullivan/Trent IC/ Pines GSP, Barker & I-90
- Lack of suitable development properties.

Question 5

Please describe the biggest challenge or threat that your company/agency is facing regarding freight.

Funding and Economic Downturn:

- Low investment levels
- Adequate funding to maintain service to freight.
- Limited funding.
- Decline in economy currently.
- An underfunded transportation network that may not be able to support the economic growth capacity of our agency.
- Reduced freight traffic from economic slowdowns. Operating safely in the COVID-19 environment.

Traffic Congestion and Safety:

- Traffic flows during peak times and safety concerns operating commercial vehicles alongside automobiles that are not educated on larger vehicles
- I-90 eastbound congestion and development of freight corridors within our area
- Additional travel time due to congestion.

Reliability and Efficiency:

- Truck parking, system reliability, system redundancy
- The seasonal restriction of road to freight

Policies:

- The elimination of independent drivers by State. One size fits all regulation, i.e. meal breaks, DOS-WA State over-regulating subverting the Fed rules, low carbon fuel standard tax.

ATRI Data Processing Methodology

Eastern Washington University (EWU) entered into a partnership with the SRTC in June, 2020 in order to provide Geographic Information System (GIS) support for the analysis of American Trucking Research Institute (ATRI) freight truck data. Two GIS datasets developed to SRTC specifications were delivered on August 31, 2020, one with trip origin/destination pairs and one with individual truck route paths.

Background

As the lead agency for regional transportation planning for Spokane County, SRTC is responsible for developing and updating a 25-year transportation plan, the Metropolitan Transportation Plan (MTP). The evaluation of freight truck travel throughout Spokane County is an important piece of plan development and the focus of the current contract. GIS software can allow for the rapid analysis of very large spatial datasets, and was selected as the appropriate technology for this project. The GIS program at EWU, represented by a team including Dr. Stacy Warren, geography professor, Kathleen Fulmer, internship coordinator, and Michael Hagar, undergraduate student, is able to provide GIS support to SRTC. At the same time, partnership with SRTC serves our goal of exposing GIS students to real world experience in GIS community projects.

Project Goals

SRTC identified a component of their MTP, the Freight Element, in which the volume, density, and related travel behavior of freight trucks in the county can be modeled through GIS analysis. SRTC had already acquired the ATRI dataset, with over 10 million individual GPS truck locations representing truck travel in Spokane over four separate months during 2019. The partners agreed that EWU would provide the following deliverables as a foundation for further analysis and long-range planning:

- Develop and implement a GIS methodology to code and generate route tracks from raw ATRI data and identify origin/destination pairs for individual freight truck trips.
- Employ ArcGIS Network Analyst geoprocessing tools to trace individual freight truck route trips from this data by snapping GPS locations to the nearest road surface and then interpolating movement between known points.
- Document this work in a methodology report, identifying and evaluating any approaches investigated and data sources considered while processing these large ATRI datasets.

Results

We analyzed a total of 10,922,854 raw ATRI GPS points collected from 26,364 individual trucks that traveled in and through Spokane county in the months of February, May, August, and October 2019. We determined those trucks made a total of 3,309,137 unique stops, resulting in 272,027 coded origin/destination pairs (Deliverable #1). As not every single origin/destination pair represented a meaningful trip, using ArcGIS Network Analyst's geoprocessing tools we ultimately distilled the results to 167,165 traceable routes in total (Deliverable #2).

In addition, we developed two distinct methods for parsing these large datasets with ArcGIS software, the first using stand-alone Python scripts and the second using Field Calculator modifications. All resources needed to implement both strategies are included in the methodology report. We also provide copies of supplemental data used in the analysis not directly requested by SRTC, including the roads network and revised street layer upon which it was based, and the tracking files used to construct individual truck routes.

Recommendations

Working with very large datasets representing truck behavior as captured by GPS receivers is fraught with challenges: inconsistent GPS receiver accuracy; outdated, incomplete or erroneous street data; and inadequate computer hardware for data analyses all complicate the process. We caution, first, that any future work involving this data should be conducted using the most powerful computers with the largest storage capacities realistically possible. Second, we repeatedly experienced marked improvement in routing accuracy by correcting what seemed to be very minor errors in the underlying street network. We recommend further quality control be applied to any street layers used in future analysis. Third, while computers can be upgraded and street data revised, we acknowledge that the GIS analyst is at the mercy of the accuracy inherent in the raw data itself. The single largest problem we encountered was bad data reported from GPS receivers. Trucks landed in the middle of wheat fields, on building rooftops, randomly exited and immediately re-entered the freeway, abruptly jumped to side streets, went silent for minutes to suddenly reappear miles away, and on a few occasions, traveled backwards in time and space. For now, this is a level of inconsistency we must live with: in some cases, we were able to reconstruct routes that likely include a few extra turns that never really happened; in more extreme cases the trucks had to be removed from the dataset. For future analysis, we would be very interested in exploring "intelligent autocorrection" methods to identify outliers and determine optimum correction strategies for aberrant GPS waypoints.