HDR

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West Coast Clean Transit Corridor Initiative

Interstate 5 Corridor

California, Oregon, Washington

FINAL REPORT

June

2020

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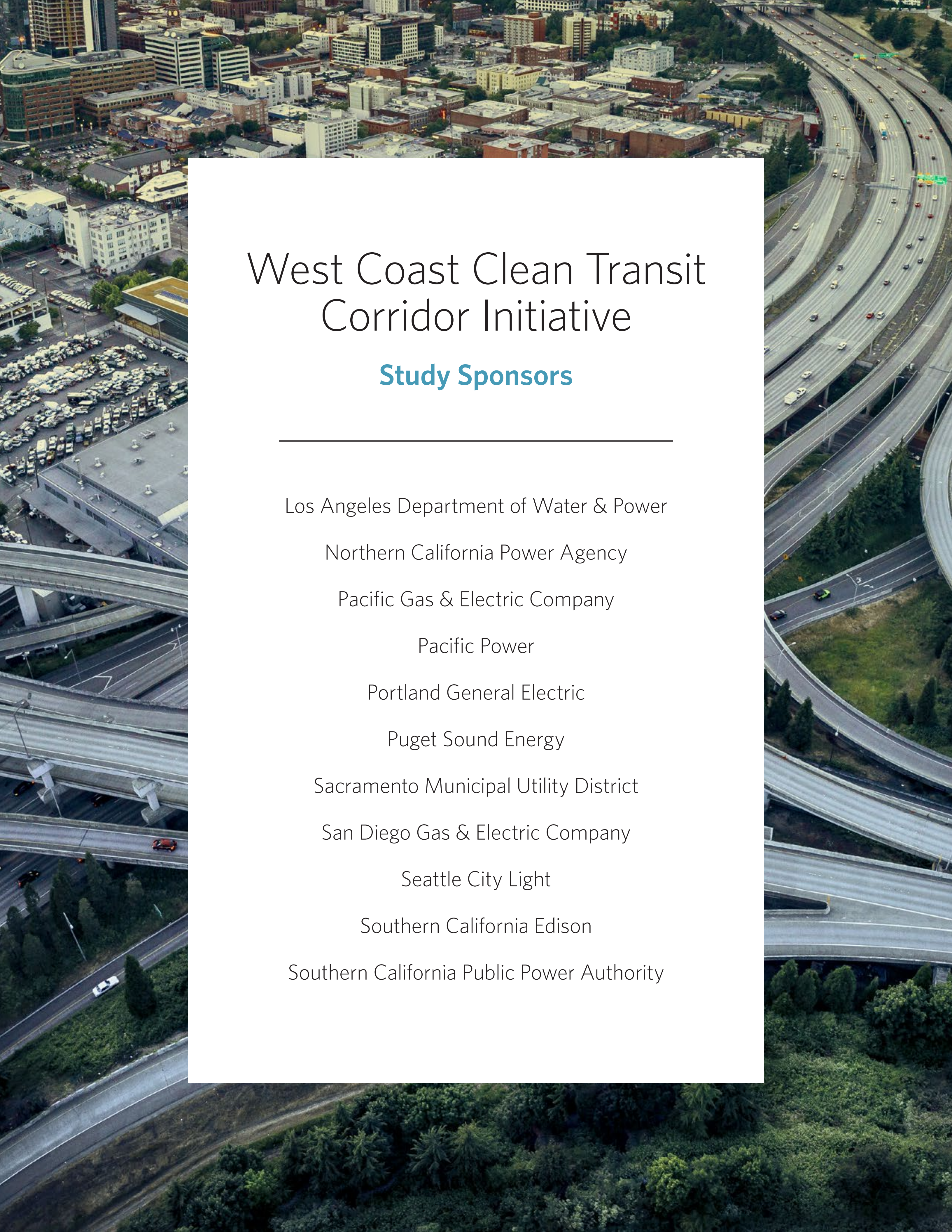
Abbreviations and Acronyms

AADT	annual average daily traffic
AC	alternating current
CARB	California Air Resources Board
DC	direct current
EV	electric vehicle
HD	heavy-duty
HVIP	Hybrid and Zero-emission Truck and Bus Voucher Incentive Project
I-5	Interstate 5
kW	kilowatt
kWh	kilowatt hour
LADWP	Los Angeles Department of Water and Power
LD	light-duty
MD	medium-duty
MW	megawatt
NCPA	Northern California Power Agency
PGE	Portland General Electric
PG&E	Pacific Gas & Electric Company
PSE	Puget Sound Energy
SCE	Southern California Edison
SCL	Seattle City Light
SCPPA	Southern California Public Power Authority
SDG&E	San Diego Gas & Electric Company
SMUD	Sacramento Municipal Utility District
SR	State Route
TCO	total cost of ownership
ZEV	zero-emission vehicle

Definitions

Area	A region defined by the rate of urbanization and industrialization. These areas are separated between urban/metro and rural.
AC charging	An alternating current (AC) power connection to the electric vehicle's on-board charging module, which converts the AC power to direct current (DC) power. The DC power is then supplied to the vehicle's battery system.
Charger	An electric fuel dispenser device that can have one or more ports for charging an electric vehicle. Some chargers consist of a power box and a dispenser as two separate items.
Charging equipment	Three levels of electric vehicle charging equipment are available: AC Level 1 charging, AC Level 2 charging, and fast charging. Charging equipment is classified by the rate at which the batteries are charged. Level 1 and Level 2 chargers are typically used for passenger vehicles at home or at work while the vehicle sits idle. Fast chargers as public infrastructure are needed for electric trucks because Level 1 and Level 2 chargers cannot replenish the energy required to operate these vehicles fast enough.
Charging site	A property upon which a number of electric vehicle chargers and associated electric equipment, designated spaces, lighting, and other amenities are installed to accommodate electric vehicles and their drivers.
DC fast charging	A DC power connection from a DC charger directly to the electric vehicle's battery system. DC fast charging substantially increases the charging speed, compared with AC charging.
Electric vehicle	A vehicle with a motor powered by electricity. Electric vehicles are also referred to as zero-emission vehicles because they do not emit air pollutants associated with vehicles powered by internal combustion engines. In this report, unless stated otherwise, electric vehicle means a battery electric vehicle as opposed to a fuel-cell electric vehicle.
Heavy-duty (HD) truck	Heavy-duty trucks include long-haul tractor-trailer trucks and transit buses. They are generally considered to be in the Class 7 or Class 8 weight category.
Kilowatt (kW)	A watt is a unit of power, and power is the rate at which energy is produced or consumed. One kilowatt equals 1,000 watts, and it is used to describe energy consumption at the household level. For example, a dishwasher uses approximately 1.2 kilowatts.

Kilowatt hour (kWh)	A kilowatt hour is 1,000 watt-hours, and it is a unit used to measure the amount of power used over a period of time. For example, a refrigerator uses approximately 540 watts and it runs about eight hours each day, meaning it uses approximately 4 kilowatt-hours per day.
Light-duty (LD) vehicle	A light-duty vehicle is a passenger vehicle in the Class 1 or Class 2 weight category.
Location	In this report, the vicinity in which an electric vehicle charging site would be best positioned.
Medium-duty (MD) truck	Medium-duty trucks include cargo vans, delivery trucks, and shuttle buses. They are generally considered to be in the Class 3 through Class 6 weight categories.
Megawatt (MW)	One megawatt equals 1,000 kilowatts, and it is used to describe energy consumption at the level of cities and generating plants. Wind turbines typically generate around 2 to 3 megawatts of power each.
Port	Connector device or cable that is part of a charger and is used to connect to an electric vehicle when it needs to be charged.
Total cost of ownership (TCO)	The cost of purchasing, operating, and maintaining an electric vehicle over the time it is owned. Calculating the TCO should take into account any applicable governmental subsidies and/or incentives for encouraging the use of electric vehicles.



West Coast Clean Transit Corridor Initiative

Study Sponsors

Los Angeles Department of Water & Power

Northern California Power Agency

Pacific Gas & Electric Company

Pacific Power

Portland General Electric

Puget Sound Energy

Sacramento Municipal Utility District

San Diego Gas & Electric Company

Seattle City Light

Southern California Edison

Southern California Public Power Authority

Executive Summary

As light-duty electric vehicles continue to gain momentum, electric utility companies in the West Coast states of California, Oregon, and Washington have conducted the West Coast Clean Transit Corridor Initiative study to assess the charging infrastructure medium- and heavy-duty electric trucks will need as they travel along the approximately 1,300-mile-long Interstate 5 (I-5) corridor and interconnecting highways.

The planning and design of charging sites for medium- and heavy-duty electric trucks are more complex than for sites that serve electric passenger vehicles.

Trucks such as cargo vans, delivery trucks, shuttle buses, and long-haul tractor-trailers are large motor vehicles usually used for transporting goods and materials. They require more space for maneuverability, serve a wider variety of vehicle types, and consume more electricity at a higher rate, which means they require more planning and coordination with electric utilities to make sure the electric grid is prepared to support them. Although heavy-duty trucks account for only 5 percent of the vehicles on US roads, they contribute a disproportionately high 23 percent of all transportation emissions. Both medium- and heavy-duty electric trucks are, therefore, an essential part of plans to transition to cleaner energy sources, and they are essential to achieving air quality and climate goals.

The West Coast Clean Transit Corridor Initiative, which includes nine electric utility companies and two agencies representing more than two dozen municipal electric utilities, studied how to facilitate the planning of electric charging sites for trucks along the entire length of I-5—a heavily traveled route that begins at the US-Mexico border and travels north along the West Coast to the US-Canada border. This report documents the study findings, and provides background information on the following topics:

- regulations, policies, and programs pertaining to vehicle electrification efforts
- trends in the electric truck market
- truck traffic volumes and trucking facilities along I-5

A technical memorandum was prepared in support of this report: *West Coast Clean Transit Corridor Initiative, Interstate-5 Corridor, Background Research Technical Memorandum*. It provides information on the following topics:

- background research on transportation electrification efforts
- input from electric truck manufacturers, charging technology providers, truck fleet operators, and other stakeholders
- existing and forecast truck market potential, including conventional and electric trucks
- trends in the charging technology market
- existing and planned electric truck charging infrastructure

This report makes recommendations for **27 conceptual locations for public charging sites along I-5**. The charging sites would be located about 50 miles apart, ideally no more than one mile away from the interstate. Through 2025, the study assumes that sites would serve mainly medium-duty (MD) trucks. As the electric truck market grows and the heavy-duty (HD) truck market expands beyond 2025, every other site would be upgraded to also serve HD trucks. This report also identifies a forecast with two time horizons: First, a near-term 2025 forecast with projections of MD electric trucks sales along with the proposed public charging infrastructure along I-5 to support them. Second, a longer-term 2030 forecast with projections of MD electric trucks sales as well as HD electric trucks sales along with the proposed expansion of every other MD charging site to meet the need to support HD electric trucks.

This vision for providing electric charging infrastructure along I-5 will require purposeful commitment and investments from different stakeholders. This report identifies challenges associated with electrification of MD and HD trucks traveling along the highway corridor, and provide recommendations to address these challenges.

The lessons learned from the West Coast Clean Transit Corridor Initiative can be applied to other regions and routes across the West Coast states and the rest of the nation.

Key Findings

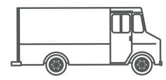
Growth in Electric Vehicle Use. The last five years have witnessed extensive growth in light-duty (passenger) electric vehicles (EVs), driven by several factors, including improvements in battery technology. These advances in battery technology are also helping MD electric trucks reach cost parity—in terms of total cost of ownership—with conventionally fueled trucks. The advancements in battery technology have increased range and helped develop use cases for MD EVs while at the same time demonstrating the feasibility of widespread adoption of HD electric trucks in the future. By 2030, it is estimated that MD and HD electric trucks could make up over 8 percent of all trucks on the road in California, Oregon, and Washington. Chapter 3, Electric Truck Market Projections, provides more information regarding the future electric truck market.

Policies and Programs. This study identified more existing MD and HD truck electrification policies and programs in California compared to Oregon and Washington, where policies and programs have primarily focused on light-duty EVs. However, the policy context is changing. Oregon and Washington recently passed legislation that enables electric utilities to develop transportation electrification plans and creates grant and assistance programs for electrified transit. Oregon set a new statewide goal to transition its state-owned motor vehicle fleet to electric by 2035. Clean fuel policies in all three West Coast states continue to drive transportation electrification. Continued government support—through policies, regulations, and incentives—will be essential to advance the adoption of electric trucks by fleet operators.

Options for Expanding Infrastructure Programs. State, federal, and private programs that provide funding for charging infrastructure can help accelerate EV adoption. To date, electric utility infrastructure programs that support MD/HD EVs have primarily focused on fleets that charge at a single location (usually their home base). Expanding these programs to support charging for fleets that travel along corridors and rely on public fueling stations could further accelerate electric truck adoption.

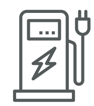
Definitions

Light-duty electric vehicles are essentially passenger vehicles.



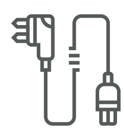
Medium-duty electric trucks include cargo vans, delivery trucks, and shuttle buses.

Heavy-duty electric trucks include long-haul tractor-trailer trucks and transit buses.



Chargers are electric fuel dispenser devices with one or more ports for charging an electric vehicle.

Charging sites are properties featuring electric vehicle chargers and associated equipment, parking spaces, lighting, and other amenities that accommodate electric vehicles and their drivers.



Ports are connector devices or cables that are part of a charger and connect to an electric vehicle when it needs to be charged.

Perspectives of Fleet Operators. Interviewed fleet operators (see the background research technical memorandum) identified the need for publicly available charging infrastructure in the three West Coast states to support their operations. They noted less investment in charging infrastructure in Oregon and Washington to date. Operators with limited funding but with an interest in deploying electric trucks stated that better access to public charging would accelerate deployment of EVs because their trucks could use public sites. Their electric trucks could use the public sites, allowing the fleets to avoid significant capital costs involved with installing charging sites on their own property. This will help drive the adoption of electric trucks.

Standardization of Infrastructure. A network of publicly available charging sites can help promote standardization of electric charging infrastructure for electric trucks. Just as drivers of conventional trucks today utilize standardized diesel fueling equipment at truck stops and gas stations, a standardized system of electric charging equipment for electric trucks would help drivers make the transition to EVs with more ease. Standard charging equipment would also allow fleets to plan their routes, knowing how long each stop would take and how far their vehicles could travel.

Range of Electric Trucks. The MD trucks projected to be on the road during the next five years will have an average range of approximately 90 to 120 miles. The HD electric trucks expected to be on the road during the next 10 years would have a much longer range: between 230 and 325 miles, on average. With a goal of keeping the electric truck batteries at an optimal charge of between 25 and 80 percent, the recommended distance between stops for charging for MD electric trucks is 50 miles, and for HD electric trucks is approximately 100 miles.

Proposed Charging Site Locations and Electric Loads. This study identified conceptual locations for 27 charging sites to support MD electric trucks along I-5 for a 2025 forecast. The sites would be spaced approximately 50 miles apart. Each would be equipped with up to ten 350 kW charging ports, for up to a 3.5 MW peak load.

As part of the 2030 forecast, which could develop sooner based on market conditions, 14 of the 27 MD charging sites would be expanded to accommodate HD electric trucks. These sites would be everyother MD site and thus spaced approximately 100 miles apart. Combined MD/HD charging sites would be equipped with up to an additional ten 2 MW charging ports (using the High Power Charging for Commercial Vehicles standard), for a maximum 23.5 MW peak load. This co-location approach would minimize the need for additional grid upgrades, reduce permit processing times, leverage land availability, and minimize costs.

For both MD and combined MD/HD sites, managed charging techniques or distributed energy resource solutions such as battery energy storage systems could be used to reduce peak load.

Electric Utility Capacity. Most electric utilities in California, Oregon, and Washington have enough capacity in urban areas along the I-5 corridor to support interconnections with the proposed MD charging sites. In rural areas, capacity constraints would be encountered for some electric utilities in the three West Coast states. The potential need to install new distribution circuits in rural areas could significantly increase the cost of a charging site interconnection, and would most likely require additional time and planning. In all locations, most loads over 10 megawatts would require extensive upgrades to the electric grid and, most likely, a new customer-dedicated substation. Therefore, there is a high probability the proposed HD charging sites would require a new substation and a new line interconnection. Load capacity in the grid changes frequently over time, and future load interconnections for electric truck charging infrastructure will require additional current-status coordination with electric utilities.

Challenges

Site Infrastructure Cost Uncertainty. The costs of building charging sites for electric trucks can be challenging to predict given the numerous variables, such as equipment selection, site location, distance from the electric utility interconnection, electric circuit capacity and associated upgrades, permits, and labor costs. Consequently, individual assessments that require in-person site visits are necessary on a site-by-site basis, making accurate system-wide assumptions difficult and time-consuming.

Public Funding Focuses on Vehicles. Government incentives designed to accelerate early EV deployment such as vouchers or grants, have mainly focused on vehicle cost or private infrastructure and not public infrastructure. Even though some grants provide incentives to invest in charging infrastructure, they are not multi-jurisdictional and available in all the states that a highway corridor crosses.

Timing of Infrastructure Upgrades. The proposed charging sites for electric trucks could take significant time to plan, permit, design, and construct presenting a chicken-egg dilemma to prepare infrastructure for future EV adoption. The proposed charging sites for MD electric trucks under the 2025 forecast could each take between one and two years to plan and build. The proposed charging sites to serve HD electric trucks under the 2030 forecast could each take between three and five years to plan and build.

Lack of Knowledge Regarding Electric Trucks. The background research conducted for this study (see the background research technical memorandum) found that fleet operators have difficulty understanding the range of electric trucks currently available and which trucks would work best for them. Fleet operators also struggle to identify the total cost of ownership for electric trucks.

Real Estate Constraints for Charging Sites in Urban Areas. Constraints in the availability of real estate for potential charging site locations in urban areas could pose a challenge. Although most industrial zones have the capacity for additional load interconnections, these areas tend to be densely developed, with limited large areas that would allow ingress and egress of electric trucks for charging. Most existing truck stops are not generally located in metropolitan areas, and identifying real estate in highly dense urban areas will be a challenge to overcome with proper planning.

ZERO EMISSION MD/HD

Electric Truck Availability

BY THE YEAR

2030

8%

MEDIUM & HEAVY-DUTY ELECTRIC TRUCKS

projected to be on the road in

California, Oregon & Washington

Opportunities

Electric Utilities as Drivers of Electric Truck Adoption. By taking a lead role in transportation electrification efforts on the West Coast, electric utilities have the opportunity to be important proponents of electric truck adoption—and the related benefits of cleaner air and reduced greenhouse gas emissions. Stakeholders such as fleet operators and electric truck manufacturers are very interested in infrastructure along I-5 and want to be engaged, and electric utilities could play a leadership role in this clean transit initiative.

Building on Existing EV Programs. Several electric utilities in California— Los Angeles Department of Water & Power, Pacific Gas & Electric Company, San Diego Gas & Electric Company, and Southern California Edison—have programs aimed at supporting the adoption of electric trucks. Other electric utilities in California, Oregon, and Washington may implement similar programs to move forward with the goals set for the I-5 corridor.

Partnerships. Establishing partnerships between electric utilities, electric truck manufacturers, charging equipment providers, fleets, and state agencies can encourage technology growth and adoption. Such partnerships will be essential for the successful implementation of infrastructure improvements. A high-profile corridor with public charging infrastructure, such as I-5, can be a catalyst for fleets to make larger investments in electric trucks. Truck stop operators—such as Love's Travel Spots, Pilot Flying J, TA-Petro, and others—can be essential partners to engage during the planning stages for building out the charging sites identified in the study.

Utility Efforts to Date

Nearly all the utilities interviewed for this study are developing or implementing programs promoting light-duty passenger vehicle electrification.

For electric trucks, several programs are under way:

Pacific Gas & Electric Company
Its EV Fleet program will prepare 700 sites for charging infrastructure to support 6,500 electric trucks—a $236 million investment.

San Diego Gas & Electric Company
Its $107 million electrification program was recently approved to support between 3,000 and 6,000 electric trucks.

Southern California Edison
Its Charge Ready Transport program will develop 870 charging sites to support 8,490 electric trucks—a $343 million investment.

Los Angeles Department of Water and Power
LADWP's Charge Up L.A. Program now includes rebate incentives to support installation of Medium Duty and Heavy Duty charging infrastructure for Class 3 through Class 8 Electric Trucks.

Recommendations for Moving Forward

As infrastructure providers, market facilitators, and trusted advisors, electric utilities are uniquely positioned to leverage this report's key findings and build on opportunities to overcome the challenges identified above. This report supports the proposal to develop 27 charging sites located 50 miles apart along I-5 to support MD electric trucks by 2025, with the ability to expand 14 of those sites to accommodate HD electric trucks by 2030.

Three areas of recommendations focus on electric system planning, building stakeholder collaboration, and the electric utility role promoting EV business cases, with specific next-step actions in each area. The 10 next-step actions detailed below are general across all three western states, and across all electric utilities in the study. Each state and each electric utility have their own regulatory environments, business goals and planning processes, which means the implementation of these steps will vary by state and electric utility. None of the recommendations are intended to be directed at any particular state or electric utility.

1) Begin long-term system planning and detailed site evaluations for development of corridor charging sites.

Begin a proactive approach to electric grid planning needs, irrespective of ownership models and exact site locations, to avoid electric utility lead times from becoming a barrier to charging deployment. *(Additional discussion may be found in Chapter 3, Electric Truck Market Projections, and in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*

Prioritize deployment of MD charging sites close to the I-5 corridor while also planning for future expansion of those sites to accommodate HD charging. *(Additional discussion may be found in Chapter 3, Electric Truck Market Projections, and in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*

Leverage results from this study to identify specific sites and begin conducting interconnection studies, right-of-way analyses, examination of real estate records for ownership and zoning, and specific site development cost estimates. *(Additional discussion may be found in Chapter 4, Truck Network Along the I-5 Corridor, Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor, and in the background research technical memorandum in Chapter 4, Truck Market Overview.)*

2) Leverage the electric utility role as an Energy Advisor to enhance collaboration and engagement across a broad range of stakeholders.

Collaborate across the broad range of industry stakeholders through the creation of working groups, task forces, and joint pilot programs to plan infrastructure, determine use cases and charging patterns, and identify priority regions and locations for deployment. *(Additional discussion may be found in the background research technical memorandum in Chapter 3, Stakeholder Engagement.)*

Serve as a trusted infrastructure provider by developing a charging site design guideline document to educate site hosts on site design, safety standards, and charging station configuration to help lower site development costs. *(Additional discussion may be found in the background research technical memorandum in Chapter 2, Overview of Electric Vehicle Technology and Investment, Chapter 3, Stakeholder Engagement, Chapter 5, Electric Truck Charger Market Overview, and Chapter 6, Existing and Planned Electric Truck Charging Infrastructure.)*

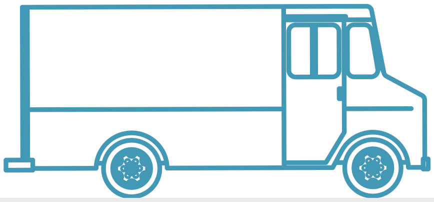
3) Leverage electric utilities' expertise to develop ways of improving the experiences of site customers, fleet owners, and drivers and build positive business cases for MD and HD EVs.

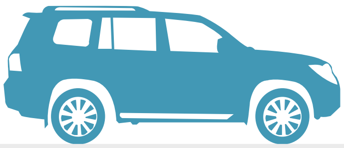
Support the creation of robust, dependable, and long-term funding of incentive programs for electric truck technology. *(Additional discussion may be found in Chapter 2, Regulatory and Political Landscape, and in the background research technical memorandum in Chapter 6, Existing and Planned Electric Truck Charging Infrastructure.)*

Work closely with commercial customers to develop electrification program designs to help accelerate MD/HD EV adoption. *(Additional discussion may be found in the background research technical memorandum in Chapter 2, Overview of Electric Vehicle Technology and Investment.)*

Develop informational materials to help educate fleet operators on the grid regarding vehicle total cost of ownership tools as a means for fleet operators to gain a better understanding of how electric trucks would work for them. *(Additional discussion may be found in the background research technical memorandum in Chapter 3, Stakeholder Engagement.)*

Investigate the business case for potential ways to manage site peak loads (i.e., managed charging and Distributed Energy Resource solutions) and reduce costs for charging sites. *(Additional discussion may be found in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*





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1. Introduction

The West Coast Clean Transit Corridor Initiative promotes an initial strategy for encouraging transportation electrification infrastructure along Interstate 5 (I-5) for medium-duty (MD) and heavy-duty (HD) electric trucks. The study investigated a wide range of commercial electric vehicle (EV) use cases and their charging technology solutions across multiple vehicle classes. This report provides recommendations for charging infrastructure locations along I-5 from southern California to northern Washington and describes the impact that MD and HD electric trucks would have on the electric grid.

Existing publicly available electric charging sites for personal vehicles are located throughout the I-5 corridor; however, these charging sites were excluded from the study because they would most likely not be able to accommodate MD and HD trucks for a variety of reasons—such as accessibility, charger spacing, and electric grid capacity. Thus, this study has examined where publicly available electric charging sites could be implemented to foster adoption of MD and HD electric trucks.

This report covers a broad range of topics related to transportation electrification for electric trucks and the proposed infrastructure along I-5. The following bullets provide an overview of the report:

- **Executive Summary** summarizes the report, key findings, challenges, and opportunities related to implementing electric truck infrastructure, and recommendations for electric utilities to move forward.
- **Chapter 1** introduces the reader to the West Coast Clean Transit Corridor Initiative and provides an orientation to the topics covered in subsequent chapters.
- **Chapter 2** discusses the regulatory and political landscape with regard to transportation electrification in California, Oregon, and Washington.
- **Chapter 3** describes the projections of future sales of electric trucks, and the projections of how many electric trucks will be on the road in the West Coast states in the near future.
- **Chapter 4** characterizes the truck network along the I-5 corridor, including:
    - existing and projected truck traffic patterns
    - existing freight activity centers, truck stops, and truck parking areas
- **Chapter 5** presents the proposed charging site locations along the I-5 corridor and interconnecting highways. It also provides a summary of discussions held with electric utility representatives regarding each proposed location.
- **Chapter 6** provides conclusions from the study, with recommendations for the electric utilities to consider in terms of advancing electric truck infrastructure along the I-5 corridor.
- **Chapter 7** lists the references used in the preparation of this report.

A technical memorandum was prepared in support of this report: *West Coast Clean Transit Corridor Initiative, Interstate 5 Corridor, Background Research Technical Memorandum*. It provides information on the following topics:

- background research on transportation electrification efforts
- input from electric truck manufacturers, charging technology providers, truck fleet operators, and other stakeholders
- existing and forecast truck market, including both conventional and electric trucks
- trends in the charging technology market
- existing and planned electric truck charging infrastructure

2. Regulatory and Policy Landscape

This chapter summarizes current policies affecting MD/HD electric trucks, as relevant to the West Coast Clean Transit Corridor Initiative. It provides an overview of goals, laws, regulations, incentives, and grants in California, Oregon, and Washington.

California, Oregon, and Washington are working to substantially reduce the greenhouse gas and criteria air pollutant emissions from the transportation sector, which are the driving force behind policy efforts to encourage the adoption of electric trucks. In 2018, the Intergovernmental Panel on Climate Change issued a warning: humans must substantially decrease human-made greenhouse gas emissions or risk exceeding 1.5° Celsius of global climate warming—the level scientists agree is the tipping point for more drastic ecological and environmental consequences (Intergovernmental Panel on Climate Change 2018). In 2018, transportation accounted for about 28 percent of all energy use in the US, and reducing transportation emissions is an essential part of any strategy to reduce greenhouse gas and other emissions that harm human health (Davis and Boundy 2019). As an example, studies have demonstrated that, to meet California's 2050 climate goals, 70 percent of all vehicle miles traveled must be powered by electricity. This includes not just light-duty (LD) personal vehicles, but MD/HD commercial trucks as well (ICF International and Energy and Environmental Economics, Inc. 2014). For this reason, California, Oregon, and Washington are all taking a proactive approach to planning for an electric future.

Although the focus of this report is trucks, the LD EV market has emerged before the MD or HD markets. Most policy efforts related to EV adoption are, thus, aimed at LD vehicles. Policies aimed at stimulating LD EV adoption could be replicated to help stimulate the deployment of MD and HD EVs as the market matures. The effectiveness of programs supporting the LD EV market growth is a good sign that similar programs could be considered for larger vehicles. Similarly, infrastructure and technology advances resulting from LD EV adoption may have some synergy for MD and HD adoption. Upgrading electric utility hardware to meet the power demand of LD EV charging, for example, may pave the way for the installation of MD and HD EV charging infrastructure. It is, therefore, important to consider LD electrification policies to better understand the landscape that MD and HD EVs will be entering.

California

California has had a focus on the environment, and that history has made the state a climate action leader in the US, having set ambitious climate change goals including achieving carbon neutrality by 2045 and having 5 million EVs on the road by 2030. Reducing emissions from transportation is a linchpin of California's climate and air quality strategies. Part of this strategy includes reducing petroleum use in vehicles by 50 percent over the same time span (State of California 2019). The statewide environmental strategy includes research and development programs, investment plans, industry support, incentives, and regulations (US Department of Energy 2019).

The California Air Resources Board (CARB) is a government agency charged with establishing state air quality and greenhouse gas regulations, including the Cap-and-Trade Program, the Low Carbon Fuel Standard, and the Zero-Emission Vehicle (ZEV) Program (CARB 2019a, 2019b, 2019c). In 2009, CARB and CALSTART launched the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low-NOx Engine Incentives to accelerate the purchase of cleaner, more efficient trucks and buses in California. This program helped build the market by reducing the upfront cost of MD/HD trucks and buses by providing a purchase incentive in the state of California (CARB 2019d). These state-level policy actions have provided significant underlying market support to help drive EV adoption for the MD/HD market.

CARB approved a $533 million plan to fund clean car rebates, zero-emission transit and school buses, clean trucks, and other innovative, clean transportation pilot projects. The Fiscal Year 2019–20 Funding Plan for Clean Transportation Incentives, largely funded with cap-and-trade proceeds, is part of California's strategy for improving air quality and reducing greenhouse gas emissions in the transportation sector, the state's largest source of air pollution and climate-changing gases. CARB uses this state-level funding to accelerate development and early commercial deployment of the cleanest vehicle technologies and to improve access to clean transportation for all Californians (GreenCarCongress 2019a).

For buses specifically, CARB recently approved an official requirement to transition all public bus fleets to ZEVs by 2040 (CARB 2018). The bulk of this transition is expected to occur after 2023 and would require a nine-fold increase in the amount of zero-emission buses on the road as compared with today. California Governor Gavin Newsom signed Assembly Bill 784 into law, thereby exempting zero-emissions transit buses from the state sales tax until 2024 (GreenCarCongress 2019b).

With regard to freight, the California Sustainable Freight Action Plan facilitates collaboration between state, regional, and local governments to evaluate potential projects for local agencies and the state to prioritize investments (California Department of Transportation 2016). This collaborative effort is working on three pilot projects that seek to enhance the sustainability of California's freight transport system, with measurable goals including improving freight sustainability by 25 percent and deploying more than 100,000 freight vehicles capable of zero-emission operation by 2030. One of the pilots, the Advanced Technology for Truck Corridors Pilot Project, unites state agencies to promote new technologies that increase efficiencies and encourage the use of ZEVs and near-ZEVs on primary freight corridors.

Following the large boost provided to the EV market by the state supported programs, the three largest electric utilities in California recently gained approval from the California Public Utilities Commission to make their own significant investments in advancing MD/HD vehicle electrification.

Oregon

Oregon has passed multiple laws, grants, and incentives related to alternative fuels and advanced vehicles, mostly aimed at the LD vehicle market or residential customers. Oregon's Clean Vehicle Rebate program offers cash rebates to drivers for the purchase or lease of EVs. Go Electric Oregon, a program established by multiple state agencies as a result of Executive Order 17-21, has a stated goal of getting 50,000 EVs, ranging from LD to HD, on the road by 2020. The state recently crossed the halfway point of meeting its EV goal, and EV use is increasing by roughly 35 percent per year. In 2019, Oregon established requirements for purchases and leases of ZEVs for state fleets and required that all LD vehicles owned or leased by the state of Oregon be ZEVs by 2029. The state is looking toward the example of California's programs to maintain consistency in regulations across borders. Goals include improving charging infrastructure, converting fleets to EV or low-emission vehicles, conducting outreach to consumers and electric utilities, and providing incentives.

In 2009, the Oregon state legislature passed House Bill 2186, authorizing the Oregon Environmental Quality Commission to adopt rules to reduce the average carbon intensity of Oregon's transportation fuels by 10 percent over a 10-year period. The 2015 Oregon state legislature passed Senate Bill 324, allowing the Oregon Environmental Quality Commission to fully implement the Clean Fuels Program in 2016. This may be achieved by improving the carbon intensity of fuels sold in the state or by investing in alternative fuels, which can support greater plug-in EV adoption. Under the Clean Fuel Standard, electric utilities in Oregon can generate credits from EV chargers owned by the electric utility and from residential EVs charging in their service territories. This is a good example of a state policy that is supporting electric utility programs to advance EV adoption.

In 2016, Oregon passed a clean energy bill (Senate Bill 1547) that requires the state to transition away from coal-fired generation by 2030. The landmark legislation also increased the state's renewable portfolio standard from 15 percent renewable generation to 50 percent by 2040.

Electric utilities are required to submit implementation plans on a biannual basis to demonstrate how they will comply with the renewable portfolio standard requirements. The standard ensures that electrification across all sectors, including transportation, will come from increasingly cleaner and renewable sources of power to meet Oregon's greenhouse gas emission reduction goals.

Electric utilities in the state, including Pacific Power and Portland General Electric (PGE), also offer grants and other programs aimed at accelerating EV adoption. For example, Pacific Power launched a grant program in 2019 that will offer $1.45 million in funding for workplace and public charging in Pacific Power's service area.

At the state level, actions by the Oregon Department of Transportation, Oregon Department of Energy, Oregon Department of Environmental Quality, and the Oregon ZEV technologies can support reducing emissions and improving public health. TriMet, the Portland metropolitan area transit agency, recently deployed its first five all-electric transit buses. The Federal Transit Administration's Low and No Emission Vehicle Deployment Program grant funded these vehicles. PGE owns and maintains the electric charging equipment through a partnership with TriMet, saving enough money to allow the purchase of another electric bus. Josephine Community Transit, a rural transit agency in southwestern Oregon, is currently testing two operational electric buses. These programs show how state and federal policies can support electric utility programs to accelerate MD/HD EV adoption in Oregon.

Washington

Washington has set progressively increasing goals for reducing greenhouse gas emissions. In 2007, the state pledged to reduce overall emissions to 1990 levels by 2020, to 25 percent below 1990 levels by 2035, and to 50 percent below 1990 levels by 2050. Expanding the adoption of EVs will be key to reaching these goals. Three strategies are guiding electrification efforts in the state: accelerating EV adoption, strengthening the charging network, and synergizing actions throughout the region. The state has a target of 50,000 plug-in EVs deployed by 2020, with the expectation that most will be LD vehicles (Washington State Department of Transportation 2015). Public charging infrastructure has already been installed at 449 sites. In line with this study's goals, most of these sites are clustered around the length of I-5.

In 2019, Washington passed legislation that extends an EV charging infrastructure grant program and various tax exemptions for the purchase of EVs.

Most of Washington's efforts to get EVs on the road have targeted LD vehicles so far. Recently, Governor Jay Inslee announced a slate of clean transportation initiatives, including a sales tax incentive for electric cars and electric buses. The state's target of making 10 percent of its new passenger vehicle purchases ZEVs was recently upped to 50 percent (Washington State Department of Transportation 2015). The Alternative Fuel Commercial Vehicle Tax Credit, which provides up to 50 percent of the incremental cost of an EV, was expanded at the beginning of 2018 to include MD/HD vehicles (Washington State Department of Revenue 2017). This is expected to stimulate the electrification of private commercial fleets, but applies only until January 2021 if not extended.

In April 2019, Governor Inslee signed House Bill 2042 into law, which reinstated tax incentive programs for electric and other alternative fuel vehicles and charging infrastructure and enabled public and private electric utilities to invest in EV charging or hydrogen fueling site infrastructure. The new legislation also provides $3.6 million in funding for electric car-sharing demonstration projects in low-income and rural communities, $36 million in grants for transit authorities to purchase equipment for electric and zero emission buses, and $1 million annually to build out Washington's fast-charging network.

In July 2019, Governor Inslee signed House Bill 1512 into law, allowing both public and investor-owned electric utilities to adopt plans for electrifying transportation, including deploying EV supply equipment infrastructure but not including incentives toward the purchase of EVs. The legislation specifically granted new authority to public electric utilities in the state to offer incentive programs in the electrification of transportation for its customers, including the promotion of electric vehicle adoption and advertising programs to promote the electric utility's services, incentives or rebates. The legislation requires that public electric utility investments in electrification incentives do not increase net costs to ratepayers in excess of one quarter of one percent.

Recommendations for strengthening the network of publicly available chargers in the state include increasing awareness of charger locations, simplifying building codes and zoning issues, engaging electric utilities, and exploring funding options for charger construction.

The Plug-In Electric Vehicle Charging Infrastructure Funding Pilot Program is an example, providing funding to install 15 charging sites along highway corridors in Washington (Washington State Department of Transportation 2020). The I-5 corridor is a focal point for charging site locations, particularly in the Seattle-Tacoma area.

In April 2019, Governor Inslee signed House Bill 2042 into law, which reinstated tax incentive programs for electric and other alternative fuel vehicles and charging infrastructure and enabled public and private electric utilities to invest in EV charging or hydrogen fueling site infrastructure. The new legislation also provides $3.6 million in funding for electric car-sharing demonstration projects in low-income and rural communities, $36 million in grants for transit authorities to purchase equipment for electric and zero emission buses, and $1 million annually to build out Washington's fast-charging network.

In October 2019, the Washington Department of Ecology announced $4 million in funding to install or upgrade existing publicly available fast chargers, with individual grant awards up to $600,000 per project. The state is prioritizing projects within 1.5 miles of high-traffic corridors, which would include I-5, and that will benefit disproportionally affected communities. All of these programs are examples of how state and federal policies can directly accelerate MD/HD EV adoption in Washington.

3. Electric Truck Market Projections

This chapter discusses forecasts for future sales of electric trucks in the three West Coast states. Developing forecasts for the future adoption of MD/HD electric trucks is crucial to planning the deployment of charging infrastructure. Projections of future market behavior are—by definition—speculative and will depend on the data used as inputs. Looking toward the future of this market based on conditions today provides one set of estimates for how the market may adopt these technologies. However, it is important to remember that this is a dynamic, emerging market. The spread of technology, as modeled for this study, is not deterministic, but rather subject to the influence of many factors.

Currently, fleets experience a “chicken and egg” dilemma when considering whether to adopt electric trucks: if charging sites were widely available, fleets would be more likely to adopt; if more fleets adopted, there would be more incentive to install charging infrastructure. Expanding the availability of charging infrastructure in advance of EV truck sales could dramatically affect the results presented here by providing more confidence to fleets that the market is heading toward electrification and that their electric trucks will not be stranded without a place to recharge. Projections based on what is known about the market today should not be taken as justification to build or not build charging infrastructure. Rather, the installation of charging infrastructure will itself encourage the future adoption of electric trucks.

The goal of these projections is to simulate the demand-side behavior of the electric truck market over the next 10 years. Fleet owners’ decision-making process for acquiring electric MD/HD trucks was approximated quantitatively and, where required, qualitatively. Beginning with the projected total market sizes, the demand response was modeled to include a variety of factors, with adjustments toward more or less aggressive adoption outcomes to produce a range of forecasts. The model quantified fleet owners’ behavior using probability curves to represent their attitudes toward electric truck technology. For example, a lower total cost of ownership (TCO)—including fuel, maintenance, and purchase price—over the life of the vehicle would increase the probability of a given fleet adopting. However, a lower TCO does not guarantee adoption of an electric truck because purchase decisions are more complicated than a single equation. Despite a low TCO, for example, an electric truck might only be available at a high incremental cost that falls outside the fleet’s budget, preventing a purchase. Fleets may have little access to capital to invest in this technology. Or, the fleet might prefer its usual truck manufacturer and perceive an electric truck from a start-up company as too risky.

The likelihood of adoption was adjusted based on the range of acceptable payback periods, as calculated using the vehicle manufacturer suggested retail price, fuel costs, and any available incentives. The modeling effort also incorporated electric truck suitability for a fleet’s operations and defined the addressable market within each vehicle segment. This stage integrated electric truck technology readiness levels and the ability to meet the operational demands of the segment.

Factors the model considered include:

- TCO over the vehicle lifetime
- fleets’ access to capital
- fleets’ tolerance for different payback periods
- size of the addressable market
- performance demands, by market segment

These variable parameters were represented by probability curves that were tuned based on market and fleet behavior knowledge to reflect different adoption rates. Adjustment factors were assigned to each parameter that affected the market adoption rate, based on the likely ranges of values these parameters may take. Four forecasts with market adoption curves over the 10-year time frame (2020 to 2030) were developed using estimates for adoption as well as assumptions on policy intervention.

Forecast 1 uses a low estimate for factors driving an increase in adoption over time and assumes no incentive funding. Forecast 2 uses high estimates for adoption factors and also assumes no incentive funding. Forecast 3 combines the low estimate for adoption of Forecast 1 with hypothetical incentive funding on the level of California's state-funded program, HVIP, presuming it was available in all three states. Forecast 4 includes this level of incentive funding across all three West Coast states, but uses the high adoption estimate factors. Forecasts 3 and 4, therefore, reflect actual incentive levels in California today, and presume Oregon and Washington enact similar incentives in the relevant time frame. The approach used to develop the different forecasts does not mean the structure of policies and incentives in California should be identically replicated in Washington or Oregon. However, given the longer history of state policies in California and the higher adoption rates of EVs there, it can serve as an example for projection models showing how state-level actions can help drive EV adoption for the MD/HD market. The approach used in Forecast 4 is presented in the report to highlight the influential role of state-level actions in encouraging EV adoption. Table 1 lists the differences between the four forecasts.

Table 1: MD and HD EV Adoption

Forecast	Adoption Rate Estimate	Incentive Availability
1	Low	No
2	High	No
3	Low	Yes
4	High	Yes

The following sections of this chapter present the modeling results for California, Oregon, and Washington. The background research technical memorandum provides additional information regarding both the electric and conventional truck markets.

California

Already incentivizing in the adoption of MD/HD EVs, California is forecast to continue embracing the technology at greater levels than other parts of the country. Figure 1 shows how much of this market success in the MD EV space might be attributable to the statewide incentives offered by CARB. A purchase incentive (voucher program) such as HVIP directly addresses one of the main fleet concerns in adopting EVs: purchase price. Comparing Forecast 1 and Forecast 3, it appears that roughly 10 percent more statewide sales are forecast for 2020 thanks to the incentives available. The effect of the incentives grows to over 20 percent by 2030. Under Forecast 4, using high adoption rate factors, the uptake of MD EVs is faster earlier in the timeline, but adoption eventually levels off and by 2030 reaches the same maximum market share predicted by Forecast 3. The two curves merging and leveling out is likely attributable to a plateau being reached wherein the cost of EVs is more competitive than conventional vehicles, and further improvement in pricing continues to incrementally boost adoption over time. Forecast 2 is comparable to Forecast 1 in that neither assume purchase incentives are available. The effect of using high-adoption rate factors when there are no incentives reaches its greatest extent in 2030, with a difference of under 5 percent of total sales share.

On the HD electric truck side, adoption overall is forecast to be slower (Figure 2). However, after 2025, adoption begins to accelerate for Forecast 2 (high-adoption rate factors and no incentives). This is likely attributable to the cost of operating an HD electric truck falling to a point where it is competitive with conventional trucks. The intensive duty cycles of HD trucks and the lower operating cost per mile for EVs can make the overall payback period shorter than for MD vehicles if HD EV prices continue to decline. The gap between the Forecast 1 and Forecast 3 adoption rates shows how important the incentives are in creating this early market, before prices

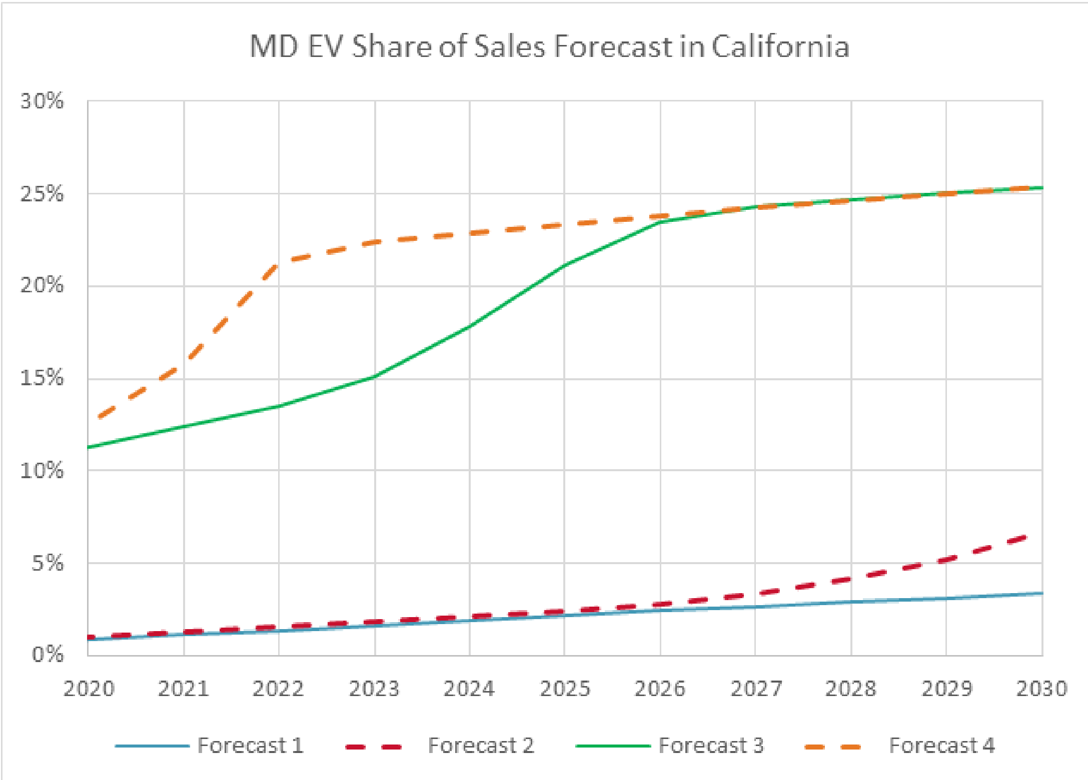


Figure 1: MD EV Share of Sales Forecast for Four Forecasts in California

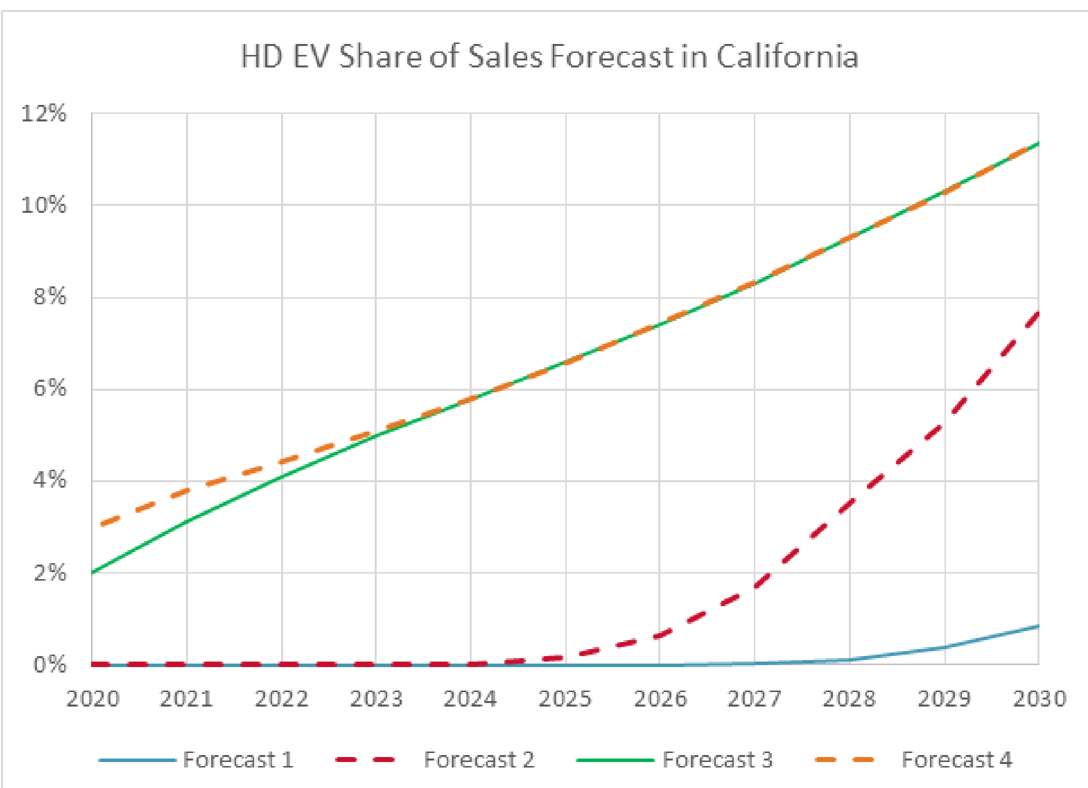


Figure 2: HD EV Share of Sales Forecast for Four Forecasts in California

have dropped to the range of conventional models. The separation between Forecasts 3 and 4 is minimal and only occurs in the first few years, indicating that the variation attributable to general market conditions is smaller than that caused by incentive funding.

Oregon

Oregon's (Figure 3) and Washington's (Figure 5) projected adoption of MD EV trucks looks similar to the pattern projected for California, with differences caused by the differing fuel prices and overall truck volume growth projections for each state. The effect of using more positive adoption factors is smaller in Oregon, as shown by the small separation between Forecasts 1 and 2. Forecast 4 again shows a more rapid uptake in the early years, but eventually levels out to the same adoption rate as Forecast 3.

Without incentives (Forecast 2 – using high adoption rate factors), the HD EV market in Oregon is not projected to take off until 2027, close to the end of the projection window (Figure 4). The growth rate is still promising because it appears to be accelerating. With incentives presumed at the level of California HVIP, Oregon could begin seeing the first HD EVs adopted in the next year or so, growing to nearly 8 percent of sales by 2030.

Washington

The growth rates of the MD/HD electric truck markets in Washington fall roughly in between those of California and Oregon. There is lower adoption than in California, but more than in Oregon. Incentives again prove to be a large stimulus to the adoption of MD EVs (Figure 5). Growth is not expected to reach 5 percent of sales by 2030 without incentives. The effect of the incentives is much greater than the difference between more optimistic versus more pessimistic adoption estimate factors.

Figure 6 shows the HD EV market growth in Washington. The pattern here mirrors closely that of Oregon. Forecasts 1 and 2 show the value of incentives, with very slow growth in adoption when no incentive funding is presumed.

All West Coast States

Figures 7 and 8 show projections for the entire West Coast market of California, Oregon, and Washington. These projections are essentially sales volume-weighted averages, so California has a disproportionate effect on the overall numbers. The effect of incentives is clear, and combining all three states results in a picture similar to what is predicted for California but lower by a couple percentage points overall.

Other recent estimates of EV truck sales percentages have been made, and the assumptions used resulted in outcomes that are either more or less optimistic than the forecasts in this study. A recently issued report that focused on the Seattle area estimated that MD EV sales would start between 2020 and 2025 and would grow to between 10 and 30 percent of sales by 2030. For HD EVs, that study estimated sales to begin in 2025 and grow to 0 to 2 percent of total sales by 2030 (Daniels and O'Donnell 2019). That study's approach differed from this study in that it included Class 3 to 7 trucks in MD, assumed linear growth between previously made estimates, and considered only one city. A comparison to this study's modeling effort shows that for MD EVs, a wider range of possibilities is presented in this report, and the aggressive adoption estimates are a little higher. For HD EVs, the aggressive adoption estimates presented here are again higher, while the conservative low adoption factor estimates are close to zero in both this study and the Seattle-area study.

Another study by the National Renewable Energy Laboratory covering the entire US predicts between approximately 1 and 25 percent of MD truck sales to be EV, and approximately 0 to 15 percent of HD truck sales to be EV by 2030 (Mai et al. 2018). The National Renewable Energy Lab predictions extended to 2050, with MD EVs topping out at approximately 60 percent and HD EVs at approximately 30 percent in the high forecasts. However, their low forecasts stayed close to approximately 1 to 3 percent through 2050 for both sizes of vehicles. They also predicted an accelerating trajectory that levels off, rather than a linear growth in sales. In this context, the results presented here are well within the range of what other groups have projected for MD and HD EV sales in the future, with some forecasts indicating very low EV truck sales in states without incentive programs.

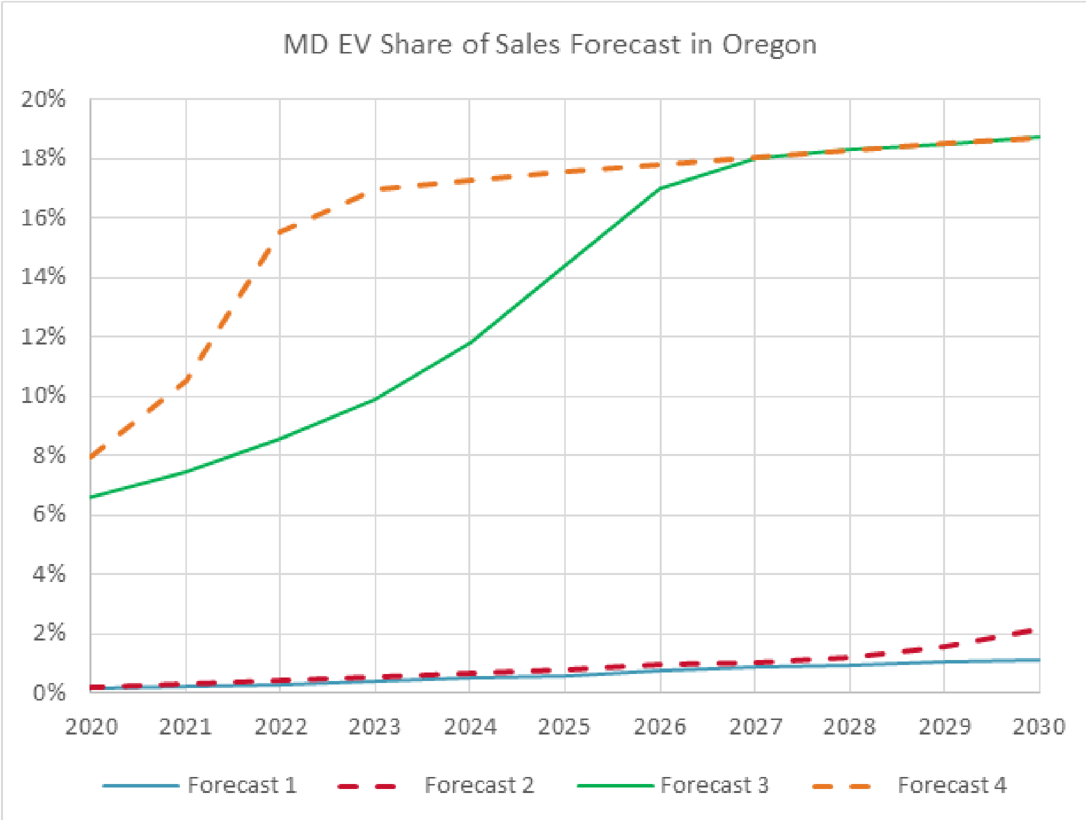


Figure 3: MD EV Share of Sales Forecast for Four Forecasts in Oregon

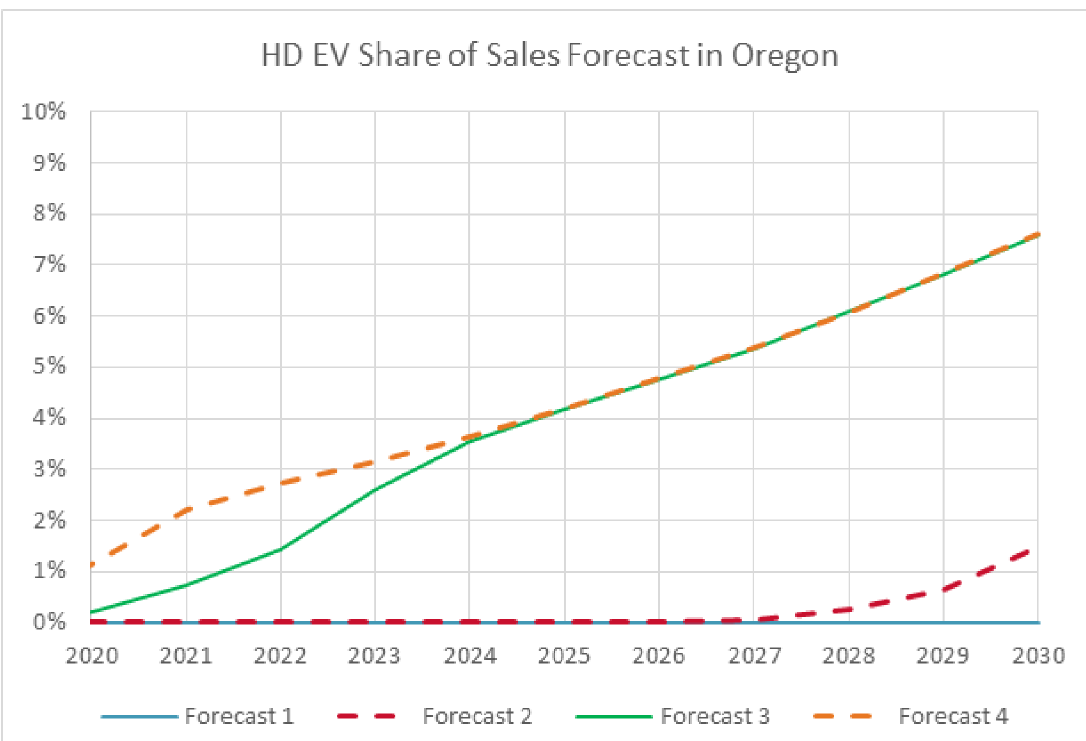


Figure 4: HD EV Share of Sales Forecast for Four Forecasts in Oregon

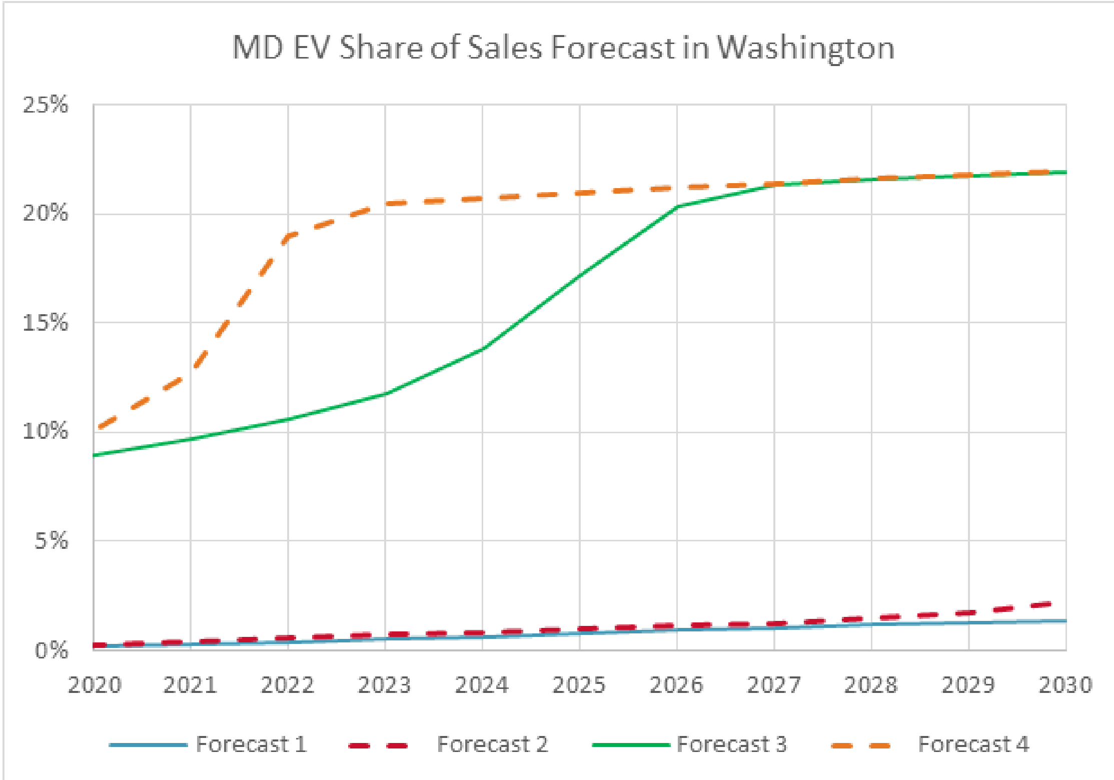


Figure 5: MD EV Share of Sales Forecast for Four Forecasts in Washington

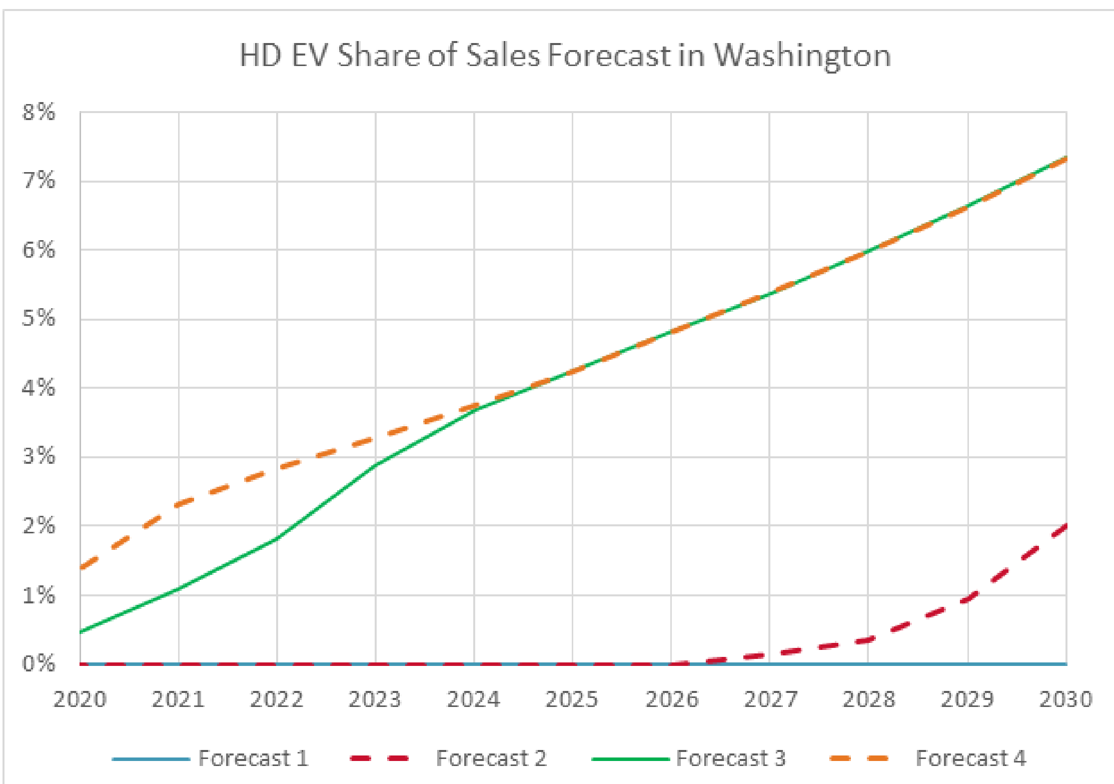


Figure 6: HD EV Share of Sales Forecast for Four Forecasts in Washington

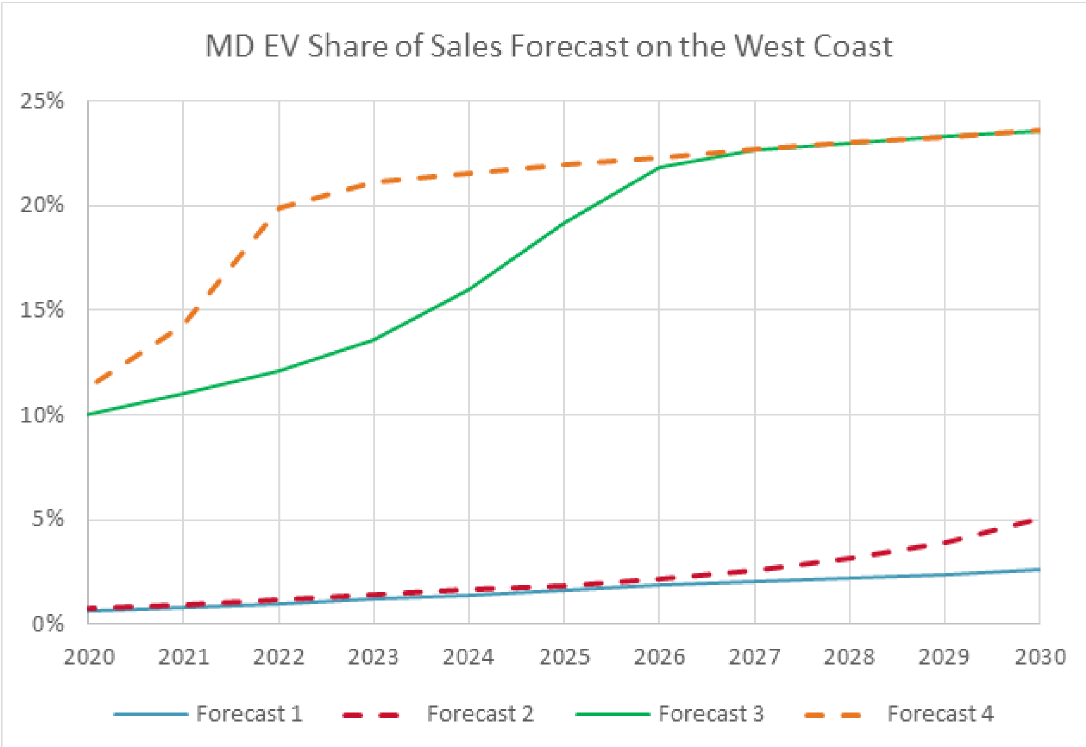


Figure 7: MD EV Share of Sales Forecast for Four Forecasts on the West Coast

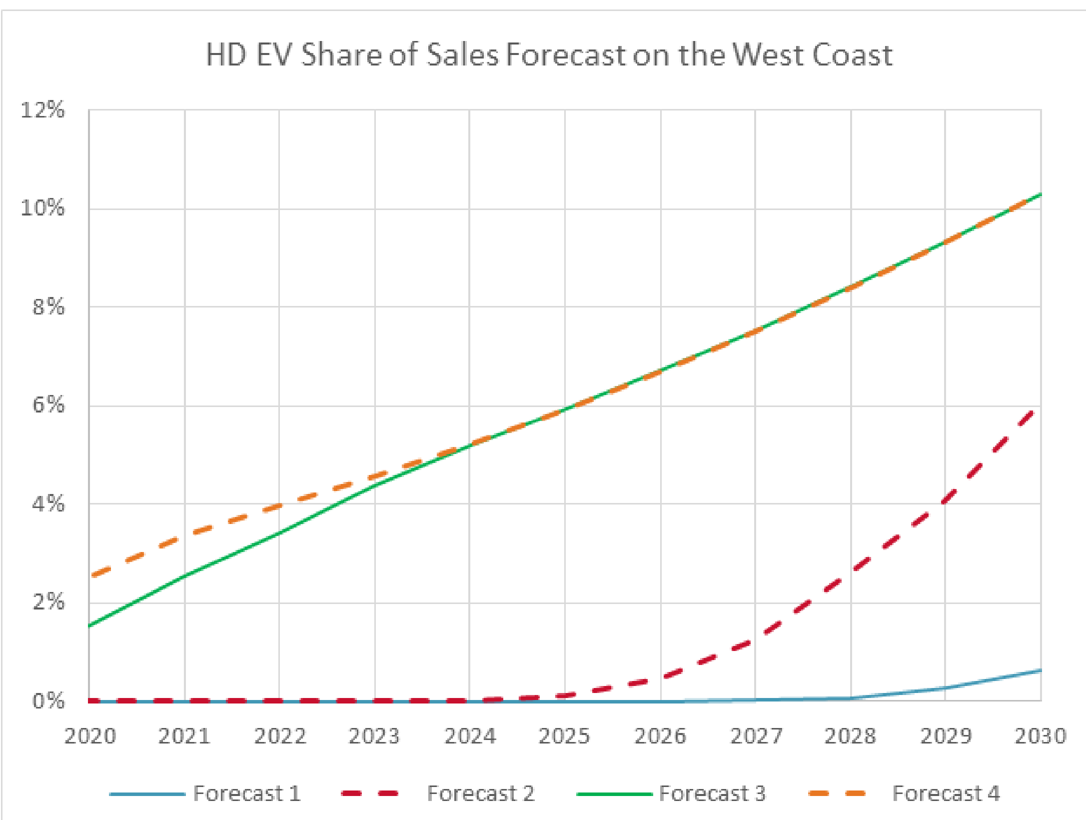


Figure 8: HD EV Share of Sales Forecast for Four Forecasts on the West Coast

The data from Figures 7 and 8—reflecting high-adoption factors and all three states having incentive programs similar to the current California HVIP—were used in this report to forecast the number of MD and HD EVs operating on the I-5 corridor. Figure 7 shows that in 2025, the MD EV share of sales will be above 20 percent. However, the number of MD EVs actually in use on the roads of the West Coast states is a function of the cumulative sales from today to 2025. This report includes a forecast for total trucks of all types on the road in 2025 (see Table 6 in the background research technical memorandum). With the growing percentage of MD EVs, the cumulative effect is a 4.4 percent projection of MD EVs when compared with all MD trucks in the West Coast states by 2025.

Similarly, for both MD and HD trucks in 2030, Figure 7 shows a projection of MD EV sales at nearly 24 percent and Figure 8 shows a projection at over 10 percent of HD EV sales. The cumulative sales of EV trucks from today to 2030, when compared with all types of MD and HD trucks in use on the roads in West Coast states (see Table 6 in the background research technical memorandum), results in an 8.3 percent projection of MD and HD EVs when compared with all MD and HD trucks on the road in the West Coast states by 2030.

4. Truck Network Along the I-5 Corridor

This chapter provides an overview of the truck network along I-5. This analysis helped the study team identify locations within the study corridor that would be stronger candidates for locating electric truck charging sites, based on trucking activity (see Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor, for further discussion of the proposed charging site locations). Three factors of trucking activity were considered: highway truck volumes, truck-related land use locations, and major truck stops and parking areas:

- Highway truck volumes (existing and future): Highway truck volumes show which areas of the highway have the heaviest concentration of truck traffic. This indicates the best opportunities to serve electric trucks that might exit the highway for charging.
- Freight activity centers/locations of truck-related industries: Freight activity centers (such as warehouses and distribution centers) indicate areas where trucks, trips originate or terminate. Providing charging sites near these activity centers would offer convenience for truck drivers.
- Locations of major truck stops: Truck stops and truck parking areas indicate where truck drivers currently stop to fuel up and take rest breaks—additional convenient locations for truck charging sites.

Maps were produced to portray the geographical distribution of these three factors along the I-5 corridor through California, Oregon, and Washington, as well as along the major intersecting routes (including I-8, I-10, I-80, I-210, I-710, SR-60, and SR-99). The data presented in these maps were used in combination with other data to identify promising locations for future truck charging sites along I-5.

Highway Truck Volumes

Truck volume data were gathered and mapped to show both existing (2017) and future (2030) annual average daily traffic (AADT) for trucks on I-5 and the intersecting corridors. The AADT was gathered from the Federal Highway Administration Freight Analysis Framework, which examines freight movements among states and major metropolitan areas over specific highways.

Existing Volumes (2017)

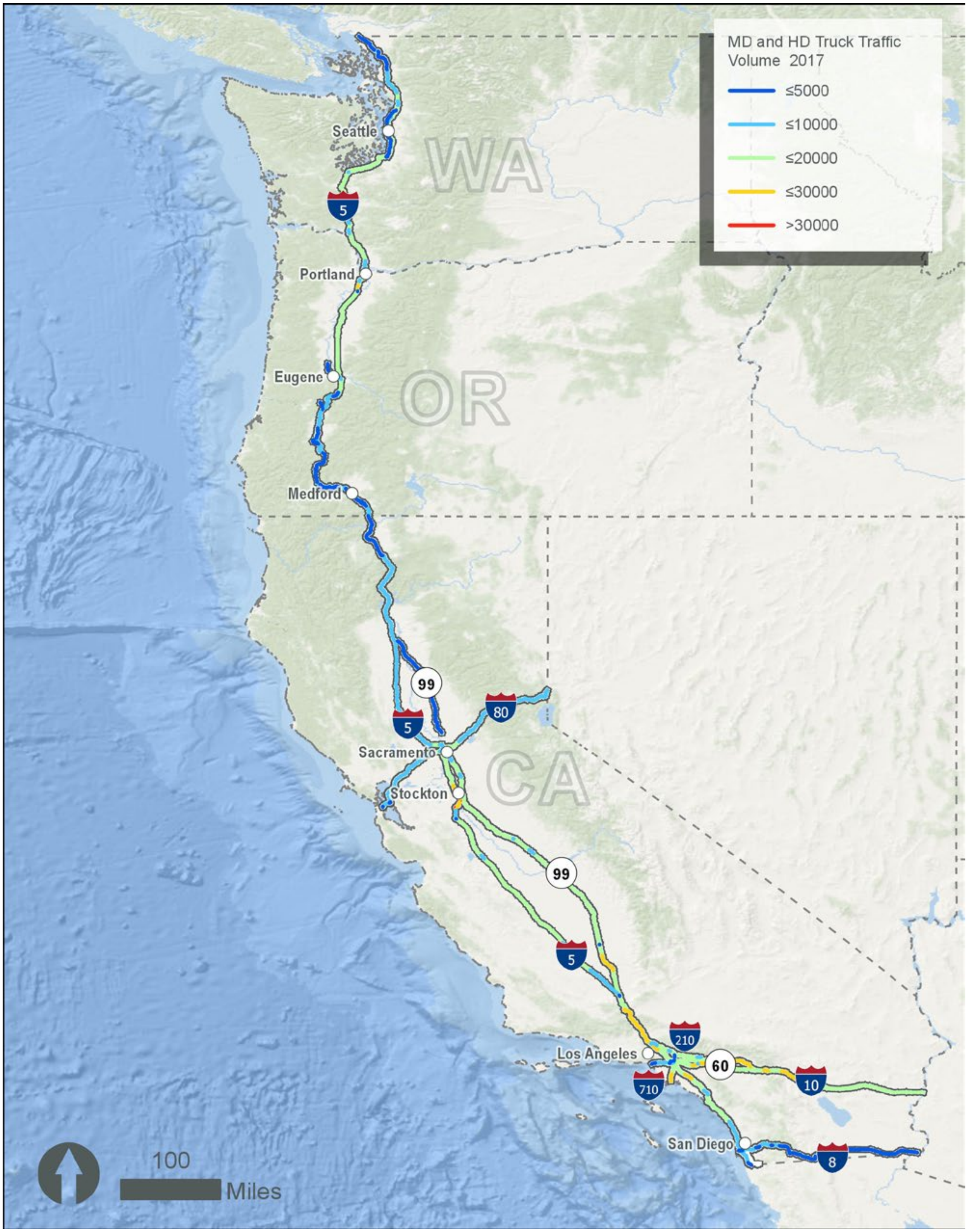
The Freight Analysis Framework database provided truck AADT estimates for 2012 and 2030. To determine the 2017 truck AADT on I-5 and the intersecting corridors, the compound annual growth rate of truck volumes from 2012 to 2030 was calculated and applied to the 2012 truck volumes for five years of growth (through 2017). Figure 9 shows the 2017 truck AADT along I-5 and the intersecting corridors.

The data in this section have been condensed to summarize the existing combined AADT; additional maps showing AADT in specific areas of the I-5 corridor are in Appendix A, *Truck Network Supporting Documentation*.

As shown in Figure 9, the highest 2017 truck volumes along I-5 occurred in southern and central California, generally between San Diego and Sacramento. High truck volumes also occurred between Eugene and Portland, in Oregon, and between Portland, Oregon, and Seattle, Washington. With regard to intersecting routes, portions of I-10, I-210, SR-60, and SR-99 in California showed high truck volumes.

Future Volumes (2030)

To forecast the 2030 truck AADT, the compound annual growth rate was applied to the 2012 truck volumes (from the Freight Analysis Framework) to generate 18 years of growth. The 2030 AADT along I-5 and the intersecting corridors is shown in Figure 10. The figure shows notable growth in the truck volumes, particularly in southern and central California and in Oregon near Portland. Several stretches of I-5 between Los Angeles and Sacramento will carry over 30,000 trucks per day by 2030.



Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 9: Existing (2017) MD/HD Truck Volumes

Freight Activity Centers

The most recently available employment data (2015) from the US Census Bureau's Longitudinal Employer-Household Dynamics program were used to determine the locations of freight activity centers or truck-related industries along I-5. The dataset identifies worker locations and job concentrations that are classified as "transportation and warehousing."

Existing freight activity centers are shown in Figure 11. As shown in the figure, Los Angeles has the biggest concentration of freight activity centers, followed by Seattle, San Francisco, and Portland.

Truck Stops and Truck Parking Areas

The locations of existing major truck stops and parking areas were identified through the results of the Federal Highway Administration's Jason's Law Truck Parking Survey. This survey provides public and private truck parking areas, and the number of spaces at each facility. The Federal Highway Administration truck stop parking data were supplemented with data from several national truck stop companies, including Love's Travel Stops and TA-Petro, regarding truck stop locations and the number of parking spaces per facility.

The locations of truck stops and parking areas along the I-5 corridor are shown in Figure 12. As the figure shows, truck stops and parking areas are fairly evenly disbursed along the length of I-5 in the three West Coast states and tend to be located outside of major metropolitan areas.

Summary of Truck Network Findings

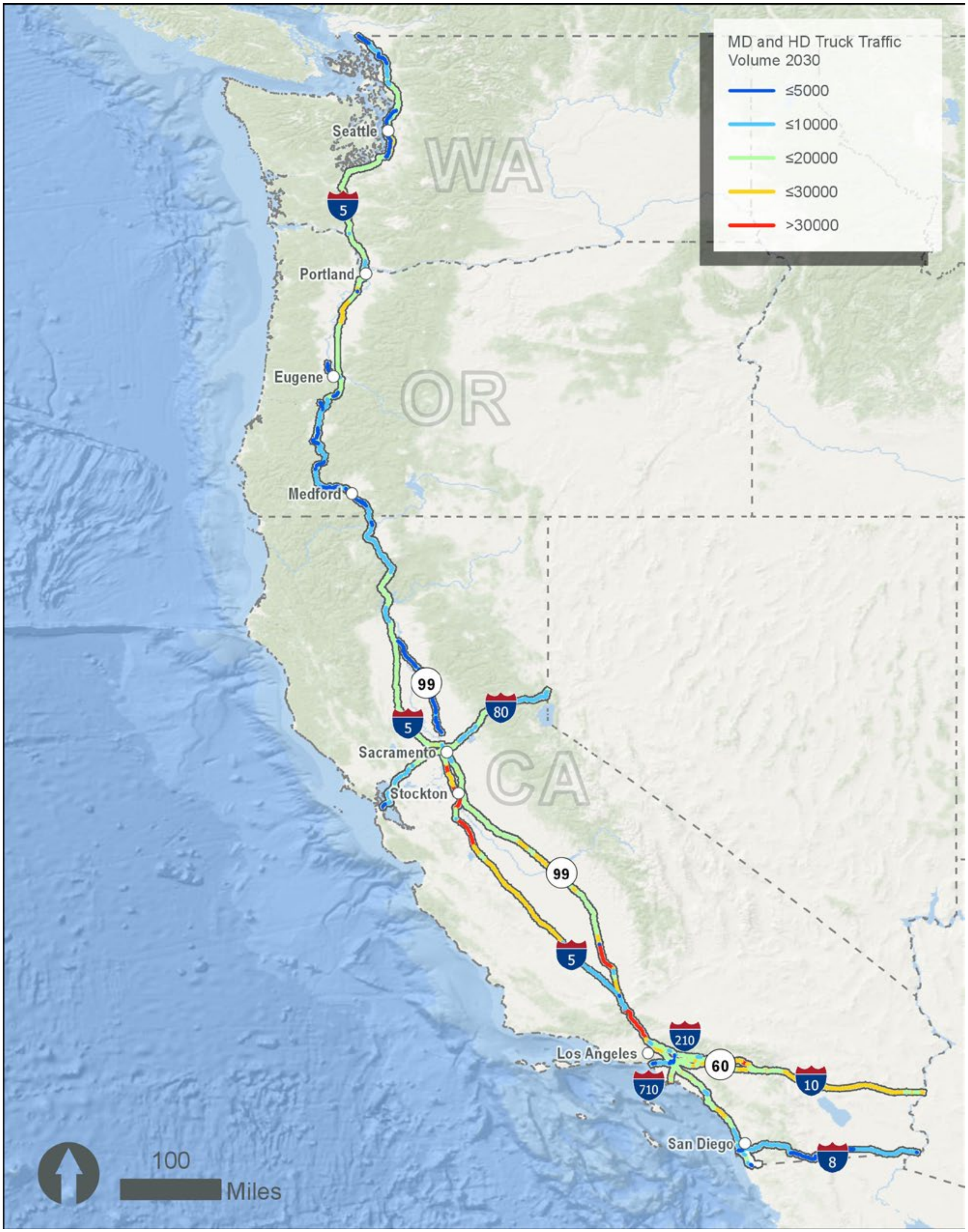
As shown in the existing and future truck AADT maps presented in Figures 9 and 10, both the existing and future truck volumes are highest in the areas passing through or adjacent to major metropolitan areas such as Los Angeles, Sacramento, and Portland. By 2030, the truck volumes along I-5 and the intersecting corridors are forecast to increase, particularly in California's Central Valley (on I-5, I-80, and SR-99) and on I-5 between Portland and Seattle.

The locations of truck-related industries presented in Figure 11 indicate that the freight-generating locations along I-5 are mostly concentrated at the ports and in major metropolitan areas. The areas along I-5 with the highest concentration of truck-related industries are in Los Angeles and Seattle.

As shown in Figure 12, most of the truck parking areas are located outside of the major metropolitan areas. Truck stops are not generally located within metropolitan areas because these types of facilities typically serve longer-distance truck trips, and a truck driver would typically not stop and rest at the start of a trip. The largest clusters of existing truck stops are in the area north of Los Angeles, the area north of Sacramento, and the area just south of Portland. Figure 12 also shows that truck stops and parking areas are distributed along I-5 at fairly even intervals, illustrating how truck drivers need places to stop to refuel and rest even in rural areas with low truck volumes and few freight activity centers. This need for a well-developed network of refueling sites would also apply to electric charging sites.

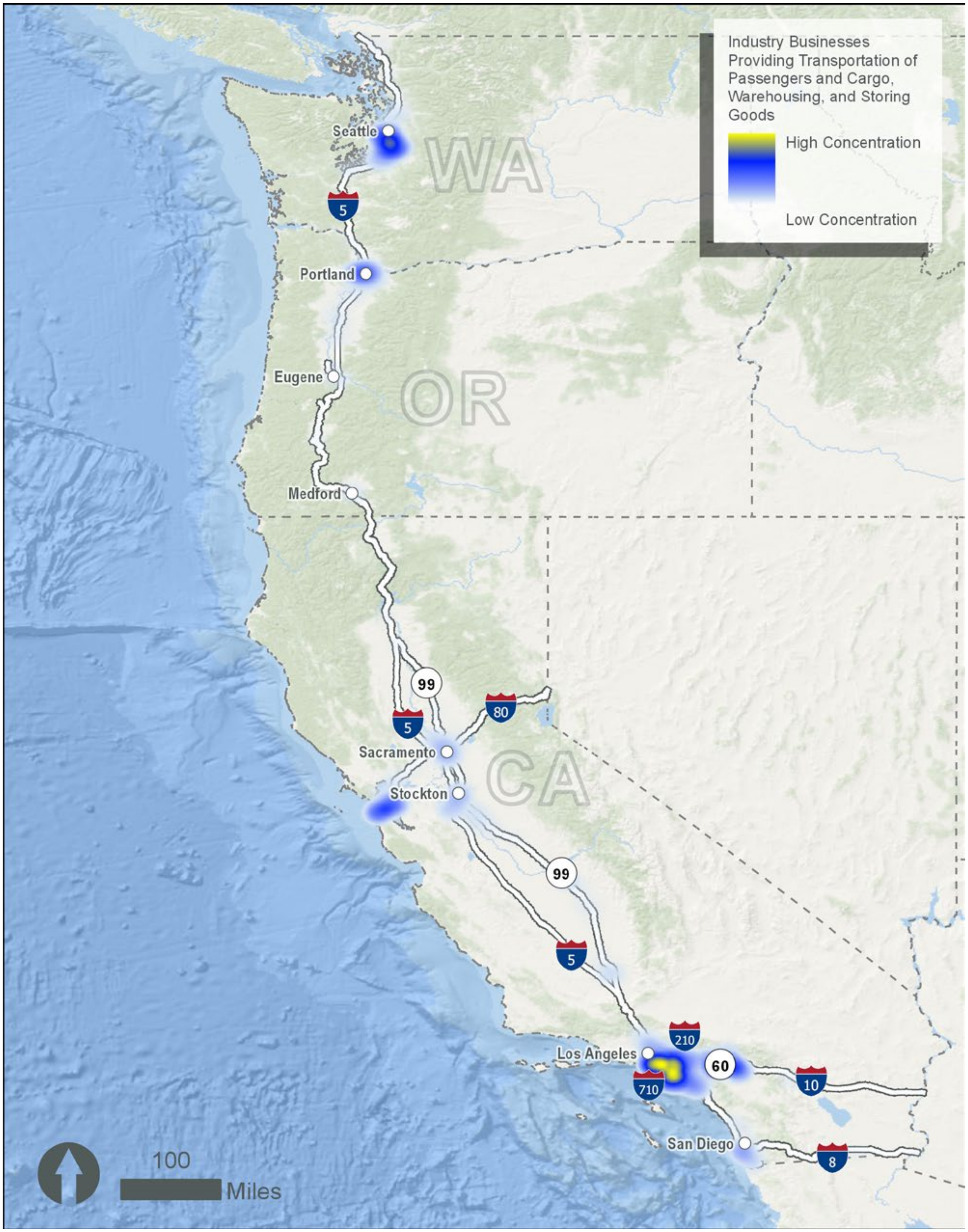
The findings presented in this chapter reinforces a more common hypothesis that a successful network of electric charging sites would need to be composed of multiple sites throughout the corridor regardless of truck volume at any one area. Leveraging the existing truck stop sites may be the most prudent path to effectively deploy future charging sites to support MD and HD EVs traveling along the highway corridor (also discussed in greater detail in Chapter 5).

Appendix A provides more detailed versions of the truck volume maps, truck-related industries maps, and truck stop maps, segmented by southern California, northern California, Oregon, and Washington.



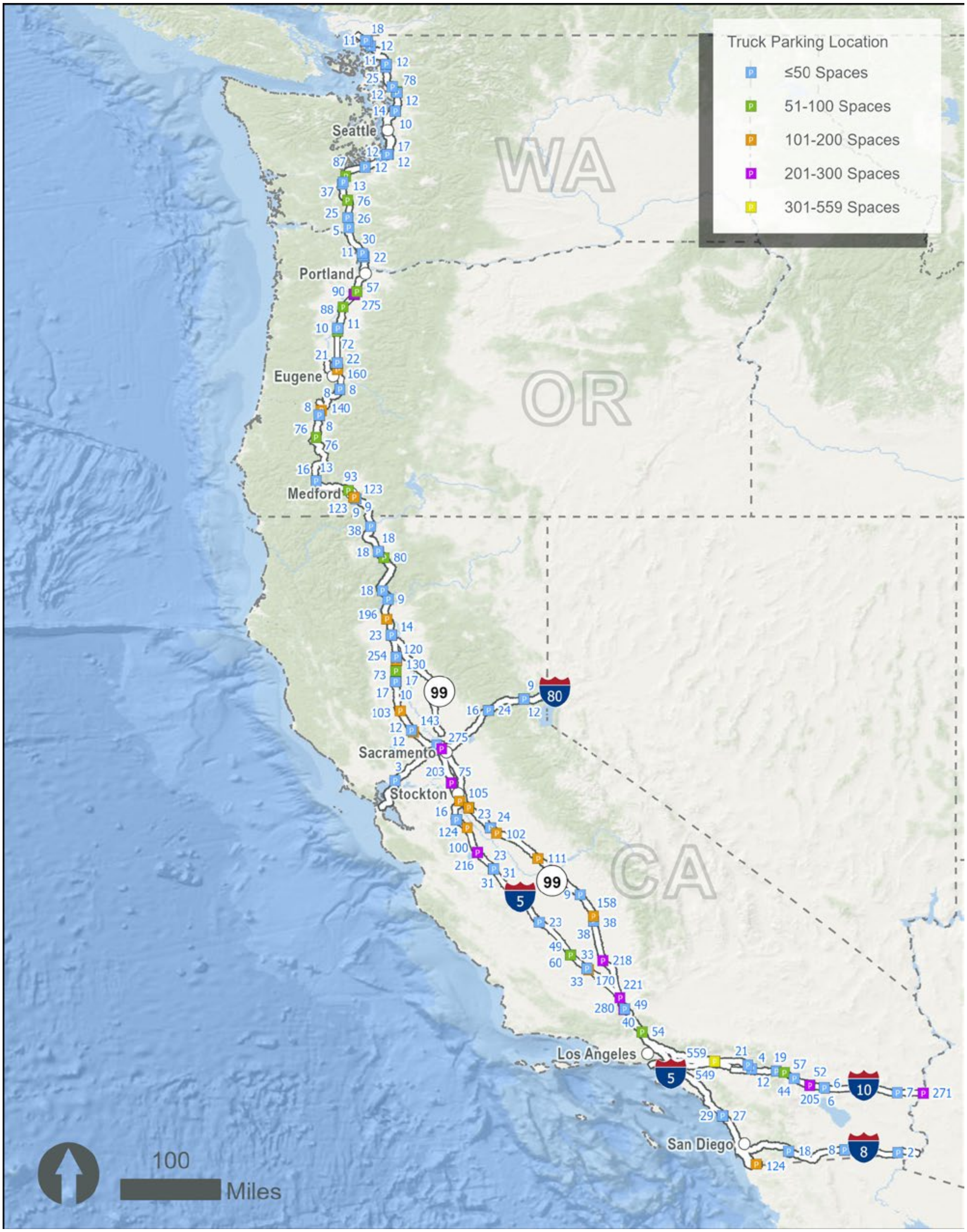
Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 10: Future (2030) MD/HD Truck Volumes



Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 11: Truck-related Industries Concentration



Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 12: Truck Parking Locations

5. Proposed Charging Site Locations Along the I-5 Corridor

This chapter presents the conceptual charging site locations for the I-5 corridor and major interconnecting highways, based on the assumptions and analyses of this study. It begins by discussing the methodology for determining the locations, then describes a potential deployment strategy for the proposed charging sites. It then lists the proposed conceptual locations for the EV charging sites, which can be considered for additional detailed analysis and potential deployment. It concludes with a discussion of projected costs for the proposed charging sites.

Methodology

The following sections describe the approach developed by this study to identify potential prime locations for public electric charging infrastructure needed along I-5 to support the existing and 2030 forecast adoption of MD/HD EVs. These site locations are recommendations and will need further in-depth analysis to ascertain whether each is indeed a suitable location for a charging site. Follow-up studies and analyses will be required to move on to the next steps of developing and deploying MD/HD charging infrastructure along I-5 and interconnecting highways.

This analysis began with examining the current and future ranges of MD/HD EVs, the optimal operating state-of-charge, and the distances MD/HD EVs can travel on a single charge.

Battery Charging Range

EV manufacturers recommend proper use and management of EV batteries to extend their lifespan. Generally, that means operating the batteries within a state-of-charge range that does not go too low in discharge, nor too high when recharging. The chemistry in most lithium-ion batteries does not have a memory effect and, therefore, no harm results from partially discharging the batteries as the vehicles are driven. However, continuous deep discharge to below 10 to 25 percent of the battery's capacity could more quickly degrade battery cells (CleanTechnica 2018; ClipperCreek 2018; Electrek 2017). For this study, we used a conservative 25 percent lower limit on the battery capacity (and, in turn, mileage range of the vehicles) to determine the minimum distance for when MD/HD EVs traveling along I-5 would need to recharge.

The upper limit to which an EV should be charged varies between manufacturers, but most recommend the battery not be charged to over 90 percent of its capacity on a daily basis. The speed of charging when using direct current (DC) fast chargers decreases drastically when the battery reaches 80 to 90 percent of capacity (InsideEVs 2018) because the vehicle's battery management system slows the charging rate to protect the battery. For this study, we used a conservative 80 percent upper limit on the battery capacity to determine the maximum distance MD/HD EVs would travel on I-5 before recharging.

Vehicle Mileage Range

This section discusses the mileage range of existing MD/HD EVs available in the US. The mileage range was considered when deciding on the spacing of the proposed charging site locations along I-5 and interconnecting highways. Table 2 summarizes the ranges of these vehicles, based on the data in Table 3, which lists available and near-term MD/HD EVs. Note that the mileage between recharging was determined based on the 25 to 80 percent battery range resulting in the optimal operating state-of-charge discussed in the previous section.

Table 2. Optimal State-of-Charge Mileage Range for Existing and Near-term MD/HD Electric Vehicles

Class	Description	Upper Limit 80% State-of-Charge Mileage	Lower Limit 25% State-of-Charge Mileage	Estimated Mileage Range Before Recharging
Medium-duty Electric Vehicles				
Class 3	Cargo vans, step vans, and MD trucks	72	23	49
Class 4	Step vans and MD trucks	79	25	54
Class 5	MD trucks	120	38	83
Class 6	Larger-capacity MD trucks and step vans, refuse trucks	94	29	64
Heavy-duty Electric Vehicles				
Class 7	HD trucks	184	58	127
Class 8[a]	Tractors (semis)	260	81	179

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

a Class 8 refuse trucks, yard tractors, and transit buses are available, but their mileage ranges were not included because they have very different duty cycles and charging scenarios.

As shown in Table 3, the distance between recharges for MD EVs ranges from 49 to 83 miles. A maximum distance of approximately 50 miles is, therefore, proposed between MD charging sites to accommodate all available and projected MD EVs traveling along I-5. Considering that the I-5 corridor is 1,380 miles long, this means 27 charging sites would be needed for MD EVs.

Table 3. MD and HD EV Mileage Ranges

MD Minimum Range	**MD** Maximum Range	**Midpoint** MD Maximum HD Minimum	**HD** Minimum Range	**HD** Maximum Range
49	83	105	127	179

For HD EVs, the distance between needed recharging ranges from 127 to 179 miles. Because the I-5 corridor must accommodate both MD and HD EVs, the midpoint distance between the MD maximum range (83 miles) and the HD minimum range (127 miles) was used to propose a distance between HD charging sites. That value was calculated to be 105 miles and was rounded down to 100 miles. Given the overall length of the corridor, 14 charging sites located approximately 100 miles apart are needed along I-5 for HD charging. These sites would need to be able to provide the higher electrical loads needed to charge HD EVs.

The proposed distances between charging sites are summarized as follows:

- The study proposes a total of 27 locations for charging facilities along the I-5 corridor.
- Charging sites for MD EVs would be located every 50 miles along I-5—at each of the 27 locations proposed.
- Charging sites for HD EVs would be located every 100 miles along I-5—every other MD site would be co-located with HD charging, for 14 HD charging locations.

The same estimated distances between proposed locations have been applied to the interconnecting highways, to provide an indication of where charging facilities might be considered along those routes. The study did not conduct the same level of analysis for those locations as for the I-5 corridor. Future follow-on studies can expand the examination of these highway charging locations.

Multiple challenges are associated with planning, designing, permitting, and building sites with publicly available electric charging infrastructure that can accommodate MD/HD EVs. The vehicles are larger, and the electric loads are significantly higher than those needed to support LD EVs. That is why existing LD charging sites were not considered as locations for MD/HD charging sites, because none were designed with trucks in mind.

Between 2021 and 2026, HD EVs will start to become commercially available and high-power charging equipment will likely become standardized. By 2030, technology advancements are expected to continue to lower the cost and weight for batteries while at the same time increasing battery capacity. HD EVs are projected to have longer range, lower maintenance costs versus diesel, and increased performance which will allow for a faster rate of adoption. Accordingly, HD trucks will become commercially viable in the earlier years but widespread deployment in the later years will mean the infrastructure identified as part of the study will not be needed until 2025-2030. While the average range for HD EVs is much greater than for MD EVs, the findings of this study indicate (as outlined previously) that every 100 miles is an appropriate separation for HD EV charging, which enables co-location of MD and HD EV charging sites. Co-location could help electric utilities plan for electrical load growth and increased MD/HD EV adoption, potentially creating savings for ratepayers and/or developers in the future by defining future upgrades for the proposed charging sites.

Fleet owners who were interviewed as part of the study indicated that as they transition their fleets to MD/HD EVs, they would also invest in charging infrastructure at their facilities. Fleet owners, however, have space limitations and potentially high costs associated with such investments—which could prompt them to use public charging sites where available. MD/HD EVs that make longer trips along I-5 would need to use publicly available chargers.

Charging Ports Needed per Charging Site

No studies of MD/HD EV truck charging demand have been conducted at this point in time. Until this need is filled, reasonable alternative methods of estimating demand must be used. Although LD charging is very different than MD/HD, there are LD studies and analysis that can be referenced. The Edison Electric Institute (2019) predicts the number of LD EVs in the US will increase from 1 million in 2018 to 19 million by 2030. The institute also forecast that 100,000 public DC fast charging ports would be needed to charge these vehicles. The National Renewable Energy Lab (2017) projects 15 million LD EVs will be on the road in 2030 in the US, and 25,000 public DC fast charging ports would be needed to power these vehicles. According to these projections, between 0.2 and 0.5 percent DC fast charging ports would be needed for every LD EV on the road.

The LD EV DC fast charging ports would probably be located close to highway exits, where the goal is to charge quickly and continue the trip with as little delay as possible. This is similar to the charging needs for MD/HD trucks traveling on highways. Given the lack of better alternatives, the projections from the Edison Electric Institute and the National Renewable Energy Lab were used to determine a proposed number of charging ports needed at each charging site along I-5 for the 2025 and 2030 forecasts developed in this study. The conservative ratio of 0.5 percent (0.005) charging ports per every EV was used to calculate charging ports needed at the I-5 charging sites.

It is important to emphasize that the number of charging ports needed at any given charging site will vary, depending on the site size, amount of truck traffic, alternative charging options in the area, and other factors. The detailed analysis needed to determine how many charging ports are needed at a particular site is beyond the scope of this study. To determine potential loads and power requirements at the proposed charging sites, however, assumptions were made across the corridor to provide a rough estimate of future power requirements for MD/HD charging sites along I-5. This study is not dictating the ultimate number of ports that would be needed, or stating the actual future peak load—future studies would be needed for those determinations.

Using the estimates for the projections of the total MD/HD EVs on the road discussed in Chapter 3, and the I-5 truck volume data discussed in Chapter 4, the number of EV trucks operating in the I-5 corridor was estimated. These projections were then used to determine how many charging ports may be needed at each charging site on I-5. As a "real world" check of the estimation process, the current number of fueling stations at diesel truck stops—as exemplified by a grouping of large truck stops in northern California—was determined for comparison purposes.

2025 Forecast

As outlined in Chapter 3 above, modeling done for this study indicates 4.4 percent of all the MD trucks in the western states are forecast to be EVs in 2025. This estimate is derived from the Forecast 4 projection of MD EVs on the road by 2025 for all three West Coast states. In order to determine how many of those EVs will be operating on the I-5 corridor itself, we then use the I-5 traffic volumes discussed in Chapter 4. Because the 2017 traffic volume data predict 10,000 MD vehicles traveling on I-5, MD EVs traveling on I-5 would total 440 (4.4 percent of 10,000). In terms of HD EVs in 2025, based on the literature review conducted for this study and discussed in the background research technical memorandum, only a handful of HD EVs will be commercially available by 2025, so we assumed negligible numbers of HD vehicles would be traveling on I-5 in 2025 (Table 4).

Table 4: Estimated MD/HD EVs Traveling Along I-5 in 2025

Type	2017 AADT MD/HD Vehicles	Projected Percentage of MD/HD EVs by 2025	Estimated 2025 AADT MD/HD EVs
MD	10,000	4.4%	440
HD	20,000	0%	0

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Using the 0.5 percent (0.005) charging ports per EV ratio described previously, these assumptions point to the need for about two charging ports at each I-5 charging site for MD EVs.

However, given the economies of scale when installing chargers, and the expected rapid growth in EVs on the road between 2025 and 2030, it is logical to plan for a future forecast with greater volumes of vehicles. The 2030 forecast is more relevant for determining the estimated number of charging ports needed and, hence, the estimated maximum electrical load at each charging site.

2030 Forecast

As outlined in Chapter 3 above, in the 2030 time frame, 8.3 percent of all MD/HD vehicles on the road in the western US are forecast to be EVs. This estimate is derived from the projections of MD/HD EVs on the road in the three West Coast states in 2030 (see figures in Chapter 3) using modeling for Forecast 4 (high adoption factors and high incentives). The next step is to estimate how many of those EV trucks will be operating on the I-5 corridor itself. As shown in Table 5, using the I-5 traffic volumes discussed in Chapter 4, there will be a total of 50,000 MD and HD trucks on the corridor. Therefore, about 1,660 MD EVs and 2,490 HD EVs would be traveling along I-5 in 2030.

Table 5: Estimated MD/HD EVs Traveling Along I-5 in 2030

Type	Projected 2030 AADT MD/HD Vehicles	Projected Percentage of MD/HD EVs by 2030	Estimated 2030 AADT MD/HD EVs
MD	20,000	8.3%	1,660
HD	30,000	8.3%	2,490

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Using the 0.5 percent charging ports per EV ratio, this means about eight charging ports would be needed at each MD charging site (every 50 miles) and about 12 charging ports would be needed at each HD charging site (every 100 miles), as summarized in Table 6.

Table 6: Charging Ports per Charging Site Needed in 2030

Site Component	MD	HD
Estimated 2030 AADT EVs	1,660	2,490
Percentage of charge ports per vehicles	0.5%	0.5%
Estimated charge ports per site	8	12

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

For the sake of simplicity, these estimates were averaged to 10 charging ports per charging site, as follows:

- 10 charging ports per MD EV charging site (using 350 kilowatt [kW] ports)
- 10 charging ports per HD EV charging site (using 2 megawatt [MW] ports)

The High Power Charging for Commercial Vehicles standard that is currently being developed would potentially be able to carry 4.5 MW with a CCS connector; however, for this study, each HD charging port is assumed to deliver 2 MW, and each MD charging port would deliver 350 kW. Therefore, each MD charging site under this forecast would have an estimated total system peak of 3.5 MW (10 charging ports at 350 kW), while each co-located MD/HD charging site would have an estimated total system peak of 23.5 MW (one MD charging site with 3.5 MW and one HD charging site with 20 MW). The total system peak load along the I-5 corridor to support these MD/HD charging sites would be 375 MW (Table 7).

Table 7: Estimated System Peak Load for 2030 Forecast

Charging Site Type	Total Sites	Charge Ports per Site	Total Charge Ports	Port (kW)	Total Peak Load (MW)
MD	27	10	270	350	95
HD	14	10	140	2000	280
				Total	375

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

While the projected theoretical peak 375 MW load may seem daunting, it is important to consider that this load would be distributed across 27 sites along the 1,380 mile I-5 corridor. Thus, no single electric utility would have to address the electrical grid upgrades to handle such a large load. Also, while this analysis projects an estimated maximum electrical load needed in this one forecast, many other forecasts are possible. Regardless of the electrical loads required, electric utilities and the developers of these charging sites can consider using managed charging and Distributed Energy Resources solutions such as battery energy storage systems to reduce peak demands and minimize the associated infrastructure investments.

This study presents just one conceptual forecast, using a conservative bias and making a number of assumptions. As feasibility analyses continue to establish next steps and provide greater detail, it is likely some of the proposed charging sites will have limitations on real estate availability, grid capacity, original investment, or other factors which would result in some of the sites along the corridor not being developed to reach the maximum peak demand estimated in this study. It is also possible that some sites may potentially be larger than the estimates in this study.

The timing of the deployment of HD charging sites will depend on the availability of HD EV models, their rate of adoption, acceptance of charging standards, and availability of products for high-speed charging infrastructure for this market sector. We have proposed that HD infrastructure be deployed by 2030 mainly to reflect the number of electric trucks projected to be traveling along I-5. Planning and ongoing feasibility analyses need to begin now, because a faster rate of adoption in the next few years could trigger the need to install these sites before 2030. Given the size of the projected peak loads, it could take several years to plan, permit, and construct the MD/HD charging sites. Because MD EVs will be commercialized sooner, we propose that MD charging sites be developed first (the 2025 forecast). As part of the planning stages for the MD charging sites, it would be important to evaluate land availability and grid capacity for co-located MD/HD sites to accommodate larger trucks.

Charging Site Forecasts Scenarios

The MD/HD EV market is still in its infancy in comparison with LD EVs, but it is advancing and will continue to do so at a rapid pace. With the growth in demand for MD/HD EVs, the need for publicly available chargers will continue to grow as well. In this study, we have developed 2025 and 2030 forecasts to describe the charging infrastructure needed to support the anticipated numbers of MD/HD EVs traveling along I-5.

The 2025 forecast would address charging needs within the next five years using technology currently available and focusing on serving MD EVs:

- 27 charging sites spaced at approximately 50 miles apart over 1,380 miles:
  - 5 sites located within five metropolitan areas (San Diego, Los Angeles, Sacramento, Portland, and Seattle)
  - 22 additional sites located in suburban and rural areas
- Up to 10 charging ports at each of the 27 sites
- 350 kW for each charging port (3.5 MW system peak for each site, estimated maximum)

The 2030 forecast would address charging needs over the next five to 10 years using technology with higher charging capacity that is currently being developed to serve HD EVs that are just now being introduced. The approach used in this study proposes the following as a 2030 forecast:

- 14 charging sites co-located at the previously constructed MD sites:
  - 2 sites located within two metropolitan areas (San Diego and Seattle being the start and the end of the I-5 corridor)
  - 12 additional sites located outside of metropolitan areas
- Up to 10 charging ports at each of the 14 sites
- 2 MW for each charging port (20 MW HD charging load, 23.5 MW system peak for each co-located site, estimated maximum)

It is important to note that electric truck recharging facilities will be different than conventional diesel fueling facilities. MD/HD EV recharging patterns will be unlike diesel truck refueling patterns primarily because MD/HD EVs currently have significantly less range and will refuel more often. That said, there will be some similarities in how diesel fueling sites and MD/HD EV charging sites function, and it is worthwhile to look at current diesel truck stops to see how refueling is managed.

A typical HD truck diesel fueling station has a row of fueling bays where trucks line up and pull in to refuel. When full, the truck then pulls out and parks some distance away, allowing the next truck to enter and pull up to the fuel pumps. Specifying the actual arrangement and configuration of electric truck charging sites is beyond the scope of this study but the amount of space required for electric truck charging is likely similar to if not exactly the same as that for diesel truck fueling. However, the ancillary electric charging equipment (transformers, switches, breakers, etc.) will need to be sited near the chargers and will take some additional space compared with diesel fueling facilities.

Further, a diesel truck at a fueling bay usually takes up to 15 minutes to fill up its tanks (with up to two 125-gallon tanks), and this length of time is somewhat comparable to how long an HD EV could take to charge based on the analysis discussed later in this chapter in the Electricity

Usage section. However, it should be noted that diesel trucks have higher range than current electric trucks and while the charge time per stop is similar to diesel fueling, electric trucks may require more frequent stops to charge. For example, an HD EV with a 550kWh battery and a range of 250 miles may be able to recharge 55 percent of its battery capacity (300kWh) with a 2MW charger in approximately nine minutes. The range for this 300kWh charge would then be approximately 140 miles and the need to stop to recharge would be more frequent than compared to a diesel truck. As the battery and the range increase, the time to recharge for an HD EV truck would also increase when using the same size charger.

As part of the research performed for this study, we identified several large truck stops at a traffic interchange on the I-5 corridor, located in Corning, California (Figure 13). The interchange provides access to three private truck stop facilities: one with 14 diesel dispensers and 254 parking spaces, another with 12 dispensers and a similar number of parking spaces, and a third with 11 dispensers and slightly fewer parking spaces. In total, the truck stops at this one I-5 interchange have 37 diesel dispensers and several hundred truck parking spaces.

This cluster of truck stops at a single traffic interchange provides one example of what future electric charging stations could look like, and the aerial photograph in Figure 13 clearly shows the rows of fueling bays with trucks entering and exiting. The number of fueling bays shown in this image further supports the estimate of 10 ports per charging facility for a large electric truck refueling site. It should be noted that existing laws (for example, Title 23) prohibit revenue-generating businesses at rest stops on federal highways, meaning private truck stops such as those in the photo, located just off the highway, are one option for future electric truck charging stations. In any case, the possibility of converting existing diesel truck stops into electric charging sites, and the design and installation of that charging infrastructure, are topics for follow-up studies. Similarly, the potential for overnight charging at lower rates is not considered here because the primary use of HD electric trucks in the time frame of this study will be daily regional haul, with all the current HD EVs being day-cab designs not intended for long-haul multiday travel applications. High-power DC fast charging will be the expectation for these day-cab truck operations.

Source: Google Maps and analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 13: Truck Stops at an I-5 Traffic Interchange in Corning, California

Existing truck stops could potentially be retrofitted to include charging infrastructure for MD/HD EVs, but charging sites in highly dense urban areas may have spacing limitations that could constrain the number of charging ports. While this study proposes 10 charging ports for MD charging sites and an additional 10 charging ports for co-located MD/HD charging sites, the actual number would depend on numerous factors requiring further analysis as each potential site is evaluated.

Electricity Usage

To accurately project charging utilization and resulting power requirements for each site will require individual analyses, which are beyond the scope of this study. However, the following discussion provides some insight regarding typical loads, which would almost certainly be below the peak loading potential. The examples below are possible forecasts for electricity usage at the charging sites. Depending on the availability of real estate, in highly dense urban areas, the number of charging ports that could be installed per site may be limited. Some charging sites could have fewer charging ports, which would result in different outcomes when compared with the following discussion.

The average mileage range before MD EVs need to recharge today can be as low as 50 miles, and the average mileage range projected for HD EVs before they need to recharge could be as high as 179 miles (as shown in Table 3). The batteries for MD/HD EVs can vary in size from 50 kilowatt-hours (kWh) to over 550 kWh. Based on the optimal 25 to 80 percent state-of-charge for battery capacity when using public charging infrastructure along the highway corridor, each charging port could see anywhere between 55 and 300 kWh of charging with each recharging event. Using a 350 kW charging port, it could take from 10 to 50 minutes for an MD or HD EV to recharge, depending on the battery size and level of depletion.

Charging profiles were evaluated using the following assumptions:

- Based on the number of MD EVs projected to be traveling along I-5 under the projections made in this study (Table 5), an estimated 440 MD EV trucks are assumed to be traveling on the highway by 2025, growing to 1,660 by 2030.
- The longest round trip an MD/HD EV could make on a single charge while being able to return to the home base would be approximately half of the overall trip. If the EV battery is to remain above the assumed lower limit range of 25 percent state-of-charge, then the longest trip an MD/HD EV could make on a single charge while still being able to return to its home base would be 75 percent of the vehicle's mileage range.
- The average mileage range for MD EVs can be as low as 90 miles and as high as 150 miles. An MD EV with a 90 mile range could travel approximately 68 miles (75 percent of the vehicle's range) on a single round trip (34 miles each way) while staying within the 25 to 80 percent preferred battery operating capacity. The average daily vehicle miles traveled per vehicle segment for MD step vans, cargo vans, construction trucks, and regional trucks can be as high as 87 miles. The estimated number of MD EVs that would use public charging infrastructure as they travel along I-5 for the purpose of this analysis is assumed to be 20 percent.
- Based on the number of HD EVs projected to be traveling along I-5 under the 2030 forecast (Table 5), an estimated 2,490 HD EV trucks are assumed to be on the roads by 2030. As noted earlier, there would be negligible numbers of HD EVs in 2025.
- Previous calculations showed the average mileage range for HD EVs can be as low as 127 miles and as high as 179 miles. An HD EV with a 127 mile range could only travel approximately 95 miles (75 percent of the vehicle's range) on a single round trip (approximately 48 miles each way). The average daily vehicle miles traveled for construction trucks, regional trucks, and long-haul trucks can be as high as 545 miles. The estimated number of HD EVs that would use public charging infrastructure as they travel along I-5 was assumed to be 40 percent, since fewer HD vehicles would return to a home base for recharge and thus they would need to use public charging infrastructure.

Under the 2025 forecast of 440 MD EVs projected to be traveling daily along I-5 in any given section, if 88 of them (20 percent) stopped at a public charging site, this would mean each charging port would provide power for up to nine vehicles per day at an average of 10 minutes per charge (filling up the 55 kWh battery capacity). The highest charging site power consumption in a day for an MD charging site under this forecast would be up to 4,840 kWh, as shown in Table 8.

Table 8. Example 2025 Forecast for kWh Load at an MD Charging Site

Forecast Component	MD Site
Estimated 2025 EVs on the corridor	440
Percentage using a public charging site	20%
Vehicles per day at a site	88
MD recharge capacity maximum (estimated kWh)	55
kWh load per day at a site	4,840

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

By 2030, each co-located MD/HD charging site is proposed to have ten 350 kW charge ports to support MD EVs. Under the 2030 forecast, of the 1,660 MD EVs projected to be traveling daily along the I-5 corridor in any given section, if 332 of them (20 percent) stopped at a public charging site, this would mean each charging port would provide power for up to 33 vehicles per day at an average of 10 minutes per charge (filling up the 55 kWh battery capacity). The highest charging site power consumption in a day for the MD chargers at a co-located MD/HD site under this forecast could be as high as 18,260 kWh.

By 2030, each co-located MD/HD charging site is proposed to have ten 2 MW charging ports to support HD EVs. Under the forecast shown here with 2,490 HD EVs projected to be traveling daily along I-5 in any given section, if 996 of them (40 percent) stopped at a public charging site, this would mean each 2 MW charging port for HD EVs would provide power for up to 100 vehicles per day at an average of 9 minutes per charge (filling up the 300 kWh battery capacity) or 298,800 kWh. Therefore, the highest charging site power consumption in a day for a combined MD/HD charging site could be 317,060 kWh (18,260 kWh for the MD EVs and 298,800 kWh for the HD EVs), as shown in Table 9.

Table 9. Example 2030 Forecast for kWh Load at a Co-Located MD/HD Charging Site

Forecast Component	MD	HD
Estimated 2030 EVs on the corridor	1,660	2,490
Percentage using a public charging site	20%	40%
Vehicles per day at a site	332	996
MD recharge capacity maximum (estimated kWh)	55	300
kWh load per day MD and HD charges	18,260	298,800
kWh total per day at a co-located MD/HD site	317,060	

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

In the forecasts provided here, if all the chargers were utilized at 100 percent of their capacity at the same time, the maximum site peak would be 3.5 MW for the proposed MD charging sites and 23.5 MW for the proposed MD/HD charging sites. This maximum site peak does not take into account diversification for the use of the individual charging ports. Diversification means that charging times will vary, recharging amounts will vary, the number of ports in use at any given time will vary, and so will the speed of charging because of various vehicle designs.

With diversification, it is estimated the peak at the charging sites will be significantly less than the potential maximum. Actual utilization may never reach this estimated full peak load. In addition, managed charging and Distributed Energy Resources solutions such as battery energy storage systems placed at the charging sites could be used to manage loads. Strategically charging a battery energy storage system during off-peak periods and discharging during peak EV charging periods could also effectively reduce peak demand at charging sites, allowing for smaller investments in distribution infrastructure upgrades and reduced electric utility demand charges, with the added benefit of resiliency in the event of an outage.

Deployment Strategy

Two levels of priority deployment were determined and evaluated. As previously discussed, several MD EV models are readily available, and charging technologies exist that can support the MD EV market. For this reason, the MD EVs have the highest priority for deployment.

A total of 27 charging sites for MD EVs have been identified as viable for high-priority deployment along the I-5 corridor. Their proposed locations are approximately every 50 miles, with 16 located in California, five in Oregon, and six in Washington. These site locations are discussed further in the following section and labeled for 2025 deployment.

Models for HD EVs as well as associated charging technologies are currently in various stages of development. Standards are being developed for chargers that would support the large batteries HD EVs will carry. For this study, HD EVs have a secondary priority for deployment. As the charging speed and battery capacity continue to improve, and more models become available, the demand for HD EVs will increase. This level of development is predicted to occur within five to 10 years. Of the 27 sites recommended for MD charging, 14 of those sites have been identified to be colocated with the HD chargers so there would be a charging site to support HD EVs approximately every 100 miles. Although these are labeled for 2030 deployment, electric utilities and developers for these sites will need to track the market for the next couple of years and evaluate when would be the best time to start the planning process for them. This planning is recommended to start well in advance of the desired availability date, given the grid upgrades likely required.

Electric Utility Implications

During interviews with electric utilities, most stated that their infrastructure would be capable of supporting the 3.5 MW load projections for the MD charging locations. Load switching or infrastructure improvements may be required at several locations, but the grid has adequate capacity to supply this load at most of the charging sites identified. Some rural sites would have more difficulty meeting the projected load demand, given that the distribution circuits in these areas are not as robust and would likely need additional infrastructure improvements.

The larger projected 23.5 MW loads for MD/HD charging sites would require more extensive improvements at nearly every site identified. New feeders, generally dedicated to the charging site load, substation transformers, and other improvements, as well as some transmission system improvements at some locations, would be required to feed these large loads. Several electric utilities requested that the developer for these charging sites be proactive in engaging the utility early in the process to discuss load requirements and associated infrastructure improvements. Further, the electric utilities would use the advance notice to also begin interconnection load studies and the permits required to complete the project.

Finally, the 2 MW fast chargers have the potential to severely affect the grid because of the high electrical demand. It would be in the best interest for electric utilities and site hosts to work closely during the planning stages and identify a more accurate estimate for each site peak. With the use of technologies such as managed charging solutions and energy storage, site hosts and electric utilities can minimize the upgrades the electric grid would need, thus helping reduce the investment needed to develop the charging sites.

Prime Locations

The proposed charging site locations (numbered in increments of 50 to represent the approximate mileage distance between them) and the projected loads (based on the assumptions made in this study, with an estimated 10 chargers for MD and 10 for HD in the co-located sites) are presented in Tables 10 and 11. The tables also show the electric utilities involved at each site. Given the proximity of their service territory, possible alternative electric utilities are also shown on the tables. The proposed charging site locations are depicted in Figure 14.

Table 10: Utilities Serving Proposed Charging Site Locations along the I-5 Corridor

Highway I-5 Charging Sites	Max Load (MW)		Primary Electric Utility Service Provider	Alternative Electric Utility Service Provider
	2025 Forecast	2030 Forecast		
HD/MD-0	3.5	23.5	SDG&E	
MD-50	3.5	3.5	SDG&E	
HD/MD-100	3.5	23.5	SCE	
MD-150	3.5	3.5	LADWP	SCE
HD/MD-200	3.5	23.5	PG&E	
MD-250	3.5	3.5	PG&E	
HD/MD-300	3.5	23.5	PG&E	
MD-350	3.5	3.5	PG&E	
HD/MD-400	3.5	23.5	PG&E	
MD-450	3.5	3.5	PG&E	
HD/MD-500	3.5	23.5	SMUD	PG&E
MD-550	3.5	3.5	PG&E	
HD/MD-600	3.5	23.5	PG&E	
MD-650	3.5	3.5	NCPA (Redding)	PG&E
HD/MD-700	3.5	23.5	PP	
MD-750	3.5	3.5	PP	
HD/MD-800	3.5	23.5	PP	
MD-850	3.5	3.5	PP	
HD/MD-900	3.5	23.5	PP	Others
MD-950	3.5	3.5	PP	Others
HD/MD-1000	3.5	23.5	PGE	Others
MD-1050	3.5	3.5	Others	PGE and PP
HD/MD-1100	3.5	23.5	Others	Others
MD-1150	3.5	3.5	PSE	
HD/MD-1200	3.5	23.5	SCL	PSE
MD-1250	3.5	3.5	PSE	Others
HD/MD-1300	3.5	23.5	PSE	

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

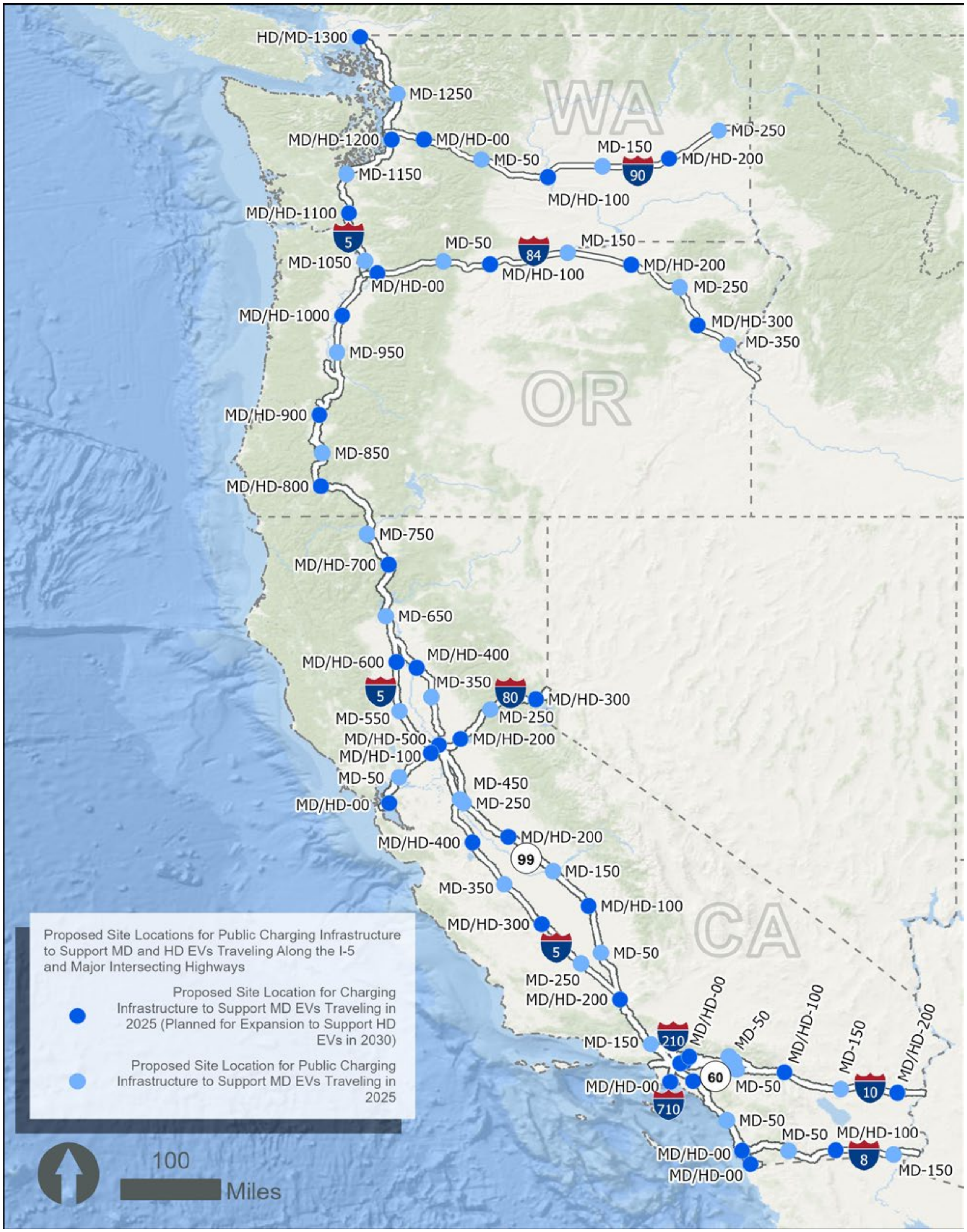
Table 11: Utilities Serving Proposed Charging Site Locations along Arterial Highways

Highway Charging Sites	Max Load (MW)		Primary Electric Utility Service Provider	Alternative Electric Utility Service Provider
	2025 Forecast	2030 Forecast		
Highway I-8				
MD/HD-0	3.5	23.5	SDG&E	
MD-50	3.5	3.5	SDG&E	
MD/HD-100	3.5	23.5	SCPPA (IID)	
MD-150	3.5	3.5	SCPPA (IID)	
Highway I-10				
MD/HD-0	3.5	23.5	SCE	
MD-50	3.5	3.5	SCE	
MD/HD-100	3.5	23.5	SCE	
MD-150	3.5	3.5	SCPPA (IID)	
MD/HD-200	3.5	23.5	SCE	
Highway CA-60				
MD/HD-0	3.5	23.5	SCE	
MD-50	3.5	3.5	SCE	
Highway I-210				
MD/HD-0	3.5	23.5	SCPPA (Azusa)	
MD-50	3.5	3.5	SCE	
Highway I-710				
MD/HD-0	3.5	23.5	SCE	
Highway SR-99				
MD-50	3.5	3.5	PG&E	SCE
MD/HD-100	3.5	23.5	SCE	
MD-150	3.5	3.5	PG&E	
MD/HD-200	3.5	23.5	Others	PG&E
MD-250	3.5	3.5	PG&E	
MD-350	3.5	3.5	PG&E	
MD/HD-400	3.5	23.5	PG&E	

Highway Charging Sites	Max Load (MW)		Primary Electric Utility Service Provider	Alternative Electric Utility Service Provider
	2025 Forecast	2030 Forecast		
Highway I-80				
MD/HD-0	3.5	23.5	PG&E	
MD-50	3.5	3.5	PG&E	
MD/HD-100	3.5	23.5	PG&E	
MD/HD-200	3.5	23.5	NCPA (Roseville)	PG&E
MD-250	3.5	3.5	PG&E	
MD/HD-300	3.5	23.5	NCPA (Truckee)	
Highway I-84				
MD/HD-0	3.5	23.5	PP	
MD-50	3.5	3.5	Others	PP
MD/HD-100	3.5	23.5	PP	
MD-150	3.5	3.5	Others	
MD/HD-200	3.5	23.5	PP	
MD-250	3.5	3.5	Others	
MD/HD-300	3.5	23.5	Others	
MD-350	3.5	3.5	Others	
Highway I-90				
MD/HD-0	3.5	23.5	PSE	
MD-50	3.5	3.5	PSE	PP
MD/HD-100	3.5	23.5	Others	
MD-150	3.5	3.5	Others	
MD/HD-200	3.5	23.5	Others	
MD-250	3.5	3.5	Others	

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

- NCPA (Roseville): Roseville Electric
- NCPA (Truckee): Truckee Donner Public Utility District
- SCPPA (Azusa): Azusa Light & Power
- SCPPA (IID): Imperil Irrigation District



Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure 14: Proposed Charging Site Locations

Appendix B shows detailed maps of the proposed charging locations, including the following additional components:

- 2017 AADT MD/HD truck volume
- truck parking locations
- substations
- electric service territories
- existing DC fast charging sites

Based on the preliminary evaluation and estimates used in this study, interviews were conducted with distribution planning groups from each electric utility with service territory along the I-5 corridor to identify the impact of the electric load needed to support the proposed charging sites identified by the study. Although potential charging sites were identified for the arterial highways, the discussions with the electric utilities focused only on the I-5 corridor. The electric utilities provided valuable information as to which locations were viable for charging and which were not. Electric utilities also shared input regarding their general ability to serve the projected loads. Several locations were modified based on this input.

Summaries of the discussions with each of the stakeholder electric utilities located within the I-5 corridor are provided below. Two of the proposed locations along the I-5 corridor are located within the service territory of electric utilities that were not part of the study.

This study sets the stage to begin dialogue with each electric utility partner in the study to evaluate the next steps required to deploy charging infrastructure along I-5 and major arterial highways. It is not intended to define the absolute correct or final solutions, but rather to serve as a solid starting point for the process of deploying infrastructure that will support the adoption of MD/HD electric trucks along the I-5 corridor.

San Diego Gas & Electric Company (SDG&E)

Two charging sites are located within the SDG&E service territory, beginning at the southern end of the I-5 corridor. A conference call was held with SDG&E personnel to discuss SDG&E's ability to serve the two charging sites.

MD/HD-0. The MD/HD-0 site was originally located on a section of I-5 near the border that is not traveled by MD or HD trucks as they cross the border. The site was moved near the intersection of I-805 and Highway 905, which carries commercial traffic that crosses the US-Mexico border. SDG&E also discussed the potential for a site near the intersection of I-8 and I-805 given the large volume of traffic, which may be considered for a possibly smaller charging site later.

Based on SDG&E's publicly available information, feeders with available capacity are located in the area of I-805 and Highway 905 and have capacity to serve the MD charging site load of 3.5 MW. Adding up to 20 MW of additional load to feed a future HD charging site will take more significant infrastructure upgrades, which SDG&E stated will require approximately three years to plan, permit, and construct.

MD-50. The MD-50 site was originally located on a section of I-5 along the Camp Pendleton military base, just north of Oceanside. Based on discussions, the charging site was relocated near the intersection of I-5 and Highway 76.

Based on SDG&E's publicly available information, feeders with available capacity are available in the area and likely capable of serving the MD charging site load of 3.5 MW.

Southern California Edison (SCE)

One charging site is located within the SCE service territory, and a second charging site is near the SCE service territory boundary. A conference call was held with SCE personnel to discuss SCE's ability to serve the two charging sites.

MD/HD-100. The MD/HD-100 site is located near the intersection of I-5 and Highway 22. There is available capacity in the vicinity to serve the MD charging site load of 3.5 MW. Adding up to 20 MW of additional load to feed the future HD charging loads at this site will take more significant infrastructure upgrades and will require additional planning.

MD-150. The MD-150 site is located near the intersection of I-5 and I-210. The area closest to SCE service territory is east along I-210 and it is in a dense residential area that would make it difficult to serve the 3.5 MW load. This site would better be served by the Los Angeles Department of Water and Power (LADWP).

Los Angeles Department of Water and Power (LADWP)

One charging site is located in the LADWP service territory. A conference call was held with LADWP personnel to discuss LADWP's ability to serve the charging site.

MD-150. The MD-150 site is located near the intersection of I-5 and I-210. LADWP stated that several feeders are available in the area and they currently have the capacity to serve the 3.5 MW load. LADWP also noted that the area is already industrial and would likely be a good option for trucking access.

Southern California Public Power Authority (SCPPA)

Two charging sites are located near, but not within, the service territories of two electric utilities represented by SCPPA. After further discussions with the other electric utilities and confirmation that these two charging sites would be located in their service territories, no additional discussions were needed with SCPPA's electric utilities since it was determined that they had no viable locations.

Pacific Gas and Electric (PG&E)

Eight charging sites are located within the PG&E service territory, many in remote areas of northern California. One site (HD/MD-500) was originally located in PG&E service territory, but it was relocated to the Sacramento Municipal Utility District (SMUD) service territory. A second substation located in the City of Redding is also in close proximity to PG&E service territory. A conference call was held with PG&E personnel to discuss PG&E's ability to serve the charging sites. PG&E noted that loads greater than 25 MW would require a transmission service at every site and they would also have different tariff options.

MD/HD-200. The MD/HD-200 site is located south of the intersection of I-5 and Highway 99. Currently there are feeders with available capacity to serve the MD charging site load of 3.5 MW but would require distribution feeder improvements at the site. Adding up to 20 MW of additional load to feed the future HD charging loads at this site would require substation improvements or a new substation as well as further distribution feeder improvements.

MD-250. The MD-250 site is located south of the intersection of I-5 and West Laredo Highway. Currently there are feeders in the area, but upgrades to them would be needed in order to increase capacity to serve the MD charging site load of 3.5 MW load.

MD/HD-300. The MD/HD-300 site is located east of the intersection of I-5 and Highway 269. An existing truck stop is near the location. PG&E stated that it does not currently have available capacity to serve the MD charging site load of 3.5 MW. Two substations are in the area, and one is approximately two miles away; however, improvements would be required at both substations as well as the feeders to the charging site. Adding up to 20 MW of additional load to feed the future HD charging loads at this site would likely require a new substation and it could be placed near the truck stop and the transmission line.

MD-350. The MD-350 site is located south of the intersection of I-5 and Panoche Road. The existing substation near the area has available capacity and that feeders to this area have recently been upgraded so they have capacity to serve the MD charging site load of 3.5 MW.

MD/HD-400. The MD/HD-400 site is located east of the intersection of I-5 and Highway 140. In order to serve the MD charging site load of 3.5 MW the existing feeders in the area would likely need to be rebuilt. The existing substation close to the HD charging site would likely require significant upgrade and a new substation would also be needed in order to support the 20 MW of projected load.

MD-450. The MD-450 site is located along I-5 near French Camp. There are currently multiple substations and feeders in the area that could serve the MD charging site load of 3.5 MW. The area is growing quickly, and this available capacity could change in the near future.

MD/HD-500. The MD/HD-500 site was originally located between Woodland and the Sacramento Metropolitan Airport. The Woodland area has limited capacity at this time and that the area is growing rapidly.

This site was also discussed with SMUD, and that discussion is included below.

MD-550. The MD-550 site is located along I-5 near Williams. The nearby substation in the area has limited capacity to serve the proposed MD charging site load of 3.5 MW. There is a probability that a new distribution feeder would be required.

MD/HD-600. The MD/HD-600 site is located south of Corning. The substation in the city currently has capacity although a new feeder would likely be required to serve the 3.5 MW load for the proposed MD charging site. Two distribution circuits would likely be required to support the future HD charging site load of 20 MW.

MD-650. The MD-650 site is located along I-5 south of Redding and is located in the City of Redding near PG&E service territory. There is a nearby substation within PG&E service territory with limited capacity to support the MD charging site load of 3.5 MW. A second substation located approximately eight miles to the south has adequate capacity to support this proposed new load.

Sacramento Municipal Utility District (SMUD)

One charging site was originally located just west of the SMUD service territory, so SMUD was contacted to determine whether moving the site within the territory was a viable option. A conference call was completed with SMUD personnel to discuss SMUD's ability to serve the charging site.

MD/HD-500. The MD/HD-500 site was originally located between Woodland and the Sacramento Metropolitan Airport, just west of the Sacramento city limits. The site was relocated to be within the edge of SMUD service territory. The recent development in the area have resulted in a new substation being built and the feeders have added capacity to support the proposed MD charging site load of 3.5 MW. Additional analysis would be needed in the future when considering a 20 MW load for a HD charging site.

Northern California Power Agency (NCPA)

One charging site is located within the electric utility boundaries of the City of Redding, which is represented by NCPA. NCPA and the City were contacted by email to discuss whether these electric utilities would like to evaluate these locations.

MD-650. The MD-650 site is located along I-5 south of Redding and near the service boundary with PG&E. In the vicinity of Bonnyview and Churn Creek Road, there are several feeders with the capacity to adequately serve the proposed MD charging site 3.5 MW load. Loads over 1.5 MW in size would be served with a primary service, so the transformer and MD equipment down line of the transformer would need to be supplied by the developer of the charging site.

Access into the downtown area is difficult for large trucks and a charging site in that area may not be a viable alternative.

Pacific Power

Six charging sites are located within the Pacific Power service territory, many in remote areas of northern California and Oregon. A conference call was completed with Pacific Power personnel to discuss Pacific Power's potential charging sites. In order to better serve MD/HD EVs traveling along I-5, Pacific Power recommended the consideration of additional charging sites around mountain passes. This may require the installation of additional charging sites within certain segments of the corridor and/or the relocation of charging sites to allow for vehicles to charge before crossing the mountain pass.

MD/HD-700. The MD/HD-700 site is located between Dunsmuir and Mount Shasta. The area has limited physical access and electric utility infrastructure and may be better relocated a small distance to the north or south along I-5 in Pacific Power's service territory where there may be additional capacity to serve the 3.5 MW load. Additional discussions will need to take place to assess the best location to support a future HD charging site with 20 MW of additional load.

MD-750. The MD-750 site is located near the intersection of I-5 and Copco Road, southwest of Hornbrook, Oregon. The current location may require system upgrades to support the 3.5 MW load for the proposed MD charging site, the extent to which would require some additional analysis. However, due to the high mountain passes, the addition of two smaller locations (one each side of the mountain pass) in this area may be a better solution to developing charging infrastructure for this location.

MD/HD-800. The MD/HD-800 site was originally located between Rogue River and Gold Hill. The site had limited physical access and electric utility infrastructure so it was relocated within Pacific Power's service area near the Rogue River. There are two substations currently at Rogue River: one is served by a 115 kilovolt transmission line and is expandable to serve the proposed 3.5 MW additional load for the MD charging site and the future 20 MW of load for the HD charging site.

MD-850. The MD-850 site is located near Canyonville, exit 99. Pacific Power services Canyonville through a 115 kilovolt transmission line with adequate capacity. A distribution circuit feed to the vicinity of the area may require some rebuild to support added 3.5 MW load for the MD charging site.

MD/HD-900. The MD/HD-900 site was originally located north of the intersection of I-5 and Highway 389, east of Yoncalla. The site was moved to near Rice Hill in Pacific Power's service territory, close to a large truck stop. Additional planning discussions will need to take place to accommodate the proposed 3.5 MW load for the MD charging site as well as the future 20 MW load for the HD charging site.

MD-950. The MD-950 site was originally located approximately five miles north of Coburg. Pacific Power serves the industrial area along the interstate in Coburg. The site was relocated approximately 11 miles north, near Brownsville, where there are two substations that could be upgraded to provide service to a charging site.

MD-1050. The MD-1050 site is located near the intersection of I-5 and I-205, north of Portland. This study looked at possibly relocating this site into Portland and serving from Pacific Power or Portland General Electric (PGE). Pacific Power serves the northeast Portland area east of I-5, including part of the I-205 area which acts as a truck bypass route around Portland. Access to large areas for an MD charging site in the Portland area are challenging, so this site was left in its original proposed location.

Portland General Electric (PGE)

One charging site is located within the PGE service territory. One additional site is located near PGE's service territory in Portland. A conference call was held with PGE personnel to discuss PGE's ability to serve the two charging sites.

MD/HD-1000. The MD/HD-1000 site is located north of the intersection of I-5 and Highway 22, near Four Corners. Serving the 3.5 MW load for the MD charging site should not be a problem in this area since the substation that is close to it has the capacity needed to support this additional load. The existing transmission line have capacity for additional load, but a 20 MW load addition to support the proposed HD charging site would likely require upgrades to the transmission line system.

MD-1050. The MD-1050 site is located near the intersection of I-5 and I-205, north of Portland. The site is within the Clark County Public Utility District service territory, and this study looked at possibly relocating this site into Portland and serving from PGE. Although PGE could serve an MD charging site with a 3.5 MW load near Columbia Boulevard, this area is near downtown Portland and it would likely be difficult for trucks to get access. Clark County Public Utility District was not contacted during this study.

Puget Sound Energy (PSE)

Three charging sites are located within PSE's service territory. One additional site is located near PSE's service territory near the I-5 and I-405 intersection. The areas proposed by the study located in PSE's service territory are close to highway exits. They are served with feeder level conductors and the substations in those areas generally have capacity to support 3.5 MW load for MD charging sites. Areas not close to major arterial streets would likely require system upgrades.

MD-1150. The MD-1150 site is located near the intersection of I-5 and Tumwater Boulevard, near Tumwater. At this site, not all the circuits in close proximity have sufficient capacity to serve the additional 3.5 MW of load for the MD charging site. It is possible that load can be shifted from one circuit to another although additional system planning studies would be needed to determine if this is an option.

MD/HD-1200. The MD/HD-1200 site was originally located near the intersection of I-5 and I-405, which is at the boundary of the SCL and PSE service territories. This specific area is highly developed with commercial businesses and, therefore, it would likely not be a viable location for future expansion. This site was relocated to approximately 1.5 miles north to the intersection of Highway 599, where it is a viable location in Seattle City Light's (SCL's) service territory.

MD-1250. The MD-1250 site is located near the intersection of I-5 and Highway 532. The distribution circuits in the vicinity of this proposed location have capacity for an additional 3.5 MW of load needed to serve the MD charging site.

MD/HD-1300. The MD/HD-1300 site is located south of the intersection of I-5 and Highway 543, as Highway 543 is the freight truck crossing location of the Canadian border. The distribution circuits in the vicinity of this proposed location have capacity for an additional 3.5 MW of load needed to serve the MD charging site. Adding up to 20 MW of additional load to feed a HD charging site would likely require shifting load between circuits or new facilities. Additional system planning studies would be needed to define circuit capacity in the area.

Seattle City Light (SCL)

One charging site is located within SCL's service territory. A conference call was held with SCL personnel to discuss SCL's ability to serve the site.

MD/HD-1200. The MD/HD-1200 site was originally located near the intersection of I-5 and I-405, which is at the boundary of the SCL and PSE service territories. This specific area is highly developed with commercial businesses and would not likely be a viable location for future expansion. SCL stated that the 3.5 MW for a MD charging site could be served well, but for the 20 MW load for the MD/HD charging site, SCL would need several new feeders and possibly a new substation, given the size of the load.

The site was relocated to the intersection of I-5 and Highway 599 (approximately 1.5 miles north of the original site) because this area is more industrial (with trucking companies and fueling stations) and would better support the additional load. There are also other EV chargers for light duty vehicles located or planned in the area, including King County Metro as well as a pilot test for an EV trucking company. Given the potential for the additional large electrical loads in the area and the challenges in crossing I-5 with additional distribution feeders, SCL is doing an analysis for a potential new substation located on the western side of the interstate that would likely be used to serve the new load in the area and support a future 20 MW load for the HD charging site.

Projected Costs for the Proposed Charging Sites

Public MD/HD charging sites pose a unique set of challenges, given the size of the vehicles, overhead space, turning radii, charging technologies, and load requirements. This section provides a high-level planning cost estimate considering the following elements:

Site locations

- Easy access to the I-5 corridor is available within a reasonable distance (one mile).
- Existing truck stops along I-5 are ideal locations for consideration given these properties could be retrofitted without the need to develop additional land, thus most likely reducing costs.
- New sites would require more work to permit, build, interconnect to the electric utilities and would ultimately drive up costs.
- Greater distance to the power source means more infrastructure will be needed and the cost will escalate accordingly.
- Proper real estate will be needed to accommodate MD/HD vehicles. Charging sites for Class 7 and 8 trucks will require enough space to enable the trucks to get in and out of the property safely. Existing gas stations or parking locations designed for trucks will help reduce the initial site preparation and installation cost.

Type of site

- Existing site: Existing property large enough to provide adequate parking spacing and maneuverability for MD trucks to come in and out. This site would also require electric utility upgrades to accommodate the new load added to the site.
- Greenfield site: Existing property large enough to provide adequate spacing and maneuverability for HD trucks to come in and out. This site would also be large enough for a customer dedicated substation needed to accommodate the new load added to the site.

Assumptions and considerations

- EV supply equipment infrastructure: 350 kW chargers were considered for the MD charging sites and 2 MW chargers were considered for the HD charging sites. Since the High Power Charging for Commercial Vehicles standard is still under development, no costs are available today for a 2 MW charger. An estimate of $600,000 for a 2 MW charger was used, taking into account the average $600 per kW cost for the 350 kW chargers available in the market and the assumption that production costs for chargers will continue to drop as production volume and competition in this space increases.
- Property upgrades include the new "behind the meter" electrical equipment such as chargers, switchgears, load centers, disconnect switches, and cables as well as permits, design, materials, and construction.
- Electric utility upgrades include conductors, breakers, step-down transformers, and metering cabinets. It would also account for a new customer dedicated substation for the HD charging sites. The estimate does not account for distribution circuits that need to be built underground due to urban areas with city ordinances pertaining to electric utility upgrades.
- Greenfield substations usually require lengthy and complex environmental review processes that can result in significant permitting costs. The estimate assumes a new substation would be close to an existing transmission line with capacity for the new substation, and the project would be exempt under General Order 131-D from the California Public Utilities Commission as part of a larger project for which the final environmental document (environmental impact report or negative declaration) finds no significant unavoidable environmental impacts caused by the proposed line or substation.

Table 12 summarizes the estimated costs for the two types of potential charging sites.

Table 12: Estimated Costs per Charging Site

Equipment and Work Description	Unit Cost	Existing Site		Greenfield Site	
		Qty	Total	Qty	Total
MD Charging Site					
Property Upgrades (behind the meter)					
350 kW Charger	$210,000	10	$2,100,000		
Permits, Design, Materials, and Construction (when installing 10 chargers per site)	$85,000	10	$850,000		
Utility Upgrades					
OH Feeder (per ft)	$120	1,000	$120,000		
Breaker/Padmount Switch	$50,000	1	$50,000		
Step-Down Transformer	$120,000	1	$120,000		
Meter	$20,000	1	$20,000		
Installation cost	$100,000	1	$100,000		
		Grand Total	$3,360,000		
HD Charging Site					
Property Upgrades (behind the meter)					
2 MW Charger	$600,000			10	$6,000,000
Permits, Design, Materials, and Construction (when installing 10 chargers per site)	$130,000			10	$1,300,000
Utility Upgrades					
Dedicated Customer Substation and Subtransmission Interconnection (20 MW)	$10,000,000			1	$10,000,000
				Grand Total	$17,300,000

Source: Analysis by HDR, CALSTART, S Curve Strategies, Ross Strategic

The estimates for charging site costs developed in this report are intended to provide a high-level overview of the different elements that can affect the deployment of this infrastructure. A large number of components can significantly affect these costs. Permits, distance from the electric utility interconnection, and capacity of the grid are among some of the critical components that can affect the overall cost of a particular charging site. Additional coordination will need to occur to identify how the costs would be allocated for the electric utility upgrades.

To successfully manage the costs associated with the installation of charging sites along I-5 in support of MD/HD electric trucks, robust planning and closely monitored execution will need to take place. Coordination between site owners, developers, and electric utilities would also be another important component to help ensure planning, design, permitting, and construction costs are well-managed (while also helping to avoid potential delays). The use of design standards, managed charging strategies, proper equipment selection, and robust project execution strategy can also be important factors to reduce costs.

6. Conclusions

This study identified locations that could be ideal for the installation of public charging infrastructure to support MD/HD electric trucks traveling along the I-5 corridor and connecting corridors. Future programs implemented by the electric utilities can use these recommended locations as a reference and specifically encourage development of charging facilities in those areas. The study did not provide exact addresses because several layers of negotiations are needed to determine specific locations, including property ownership, developer interest, funding, permits, and necessary roadway improvements or modifications.

Property owners, third-party charging facility operators, and other stakeholders who will be involved in developing and deploying MD/HD charging facilities can support the business decisions required by using the analyses and findings of this report. Although this study provides initial feedback from electric utilities and the potential upgrades that would be needed, each location will need a full business case analysis for the multiple stakeholders involved to reach agreement on the needed MD/HD charging infrastructure investment.

As MD/HD EVs start to emerge, the approach developed in this study can help locate charging infrastructure where it is needed most for vehicles on the road, while also encouraging more truck operators to adopt EVs. It also helps demonstrate the potential for higher utilization of the charging facilities, which is critical to operating an EV charging site profitably. A location that works for both truck operators and the electric utility supplying the energy is far more likely to be successful than a location selected for less relevant reasons.

Another important planning aspect identified in this study is the timing of adoption for MD (Class 3 to 6) versus HD (Class 7 to 8) electric trucks. By necessity, this study applied some assumptions (described in Chapter 5, *Proposed Charging Site Locations Along the I-5 Corridor*) regarding the number and power of charging sites, and the split use and availability of MD and HD electric trucks. The general assumption was all MD sites would have 10 ports, providing 350 kW of power each, which means 3.5 MW for an MD facility. Generally, this level of power is within the capacity of the electric utilities and the current grid infrastructure, pointing to the ability to move forward with MD facilities that could also serve LD cars because the chargers would use the same CCS connectors.

A critical point, however, is the recognition that charging facilities for MD trucks must be designed differently than for LD cars. The existing LD charging facilities are largely unsuitable for trucks of any size. The fact that cars could use the MD chargers is an additional benefit for higher utilization, a benefit that may have to be managed to give priority to trucks over cars. Other design considerations may include:

- charge port spacing to allow larger vehicles
- turning radius limitations of larger trucks
- allowing for backing into the stall, or pulling through forward
- overhead spacing and accommodation of Americans with Disabilities Act requirements

For HD truck charging, the assumptions of the study included the deployment of 10 ports per site, with each delivering 2 MW. Each HD charging facility would, therefore, have a 20 MW peak load. Since the HD sites are proposed to be shared with MD sites, the overall peak load for each of these MD/HD sites would be 23.5 MW. Serving a 23.5 MW peak load is above the capacity of virtually all current electric distribution infrastructure and would require extensive improvements, most likely at the subtransmission level, at nearly every site identified. These improvements are achievable, but development times are elongated usually taking three to five years for planning, permitting, and construction. Coincidentally, this development timeline aligns with the expected arrival of larger numbers of HD electric trucks in roughly 2024 to 2025. That alignment means a roadblock to adoption of HD electric trucks can be avoided if steps are taken to develop infrastructure capacity as soon as possible.

Using this report as a point of departure, collaboration with electric truck OEMs, fleet operators, and the electric utilities can accelerate planning of infrastructure to serve HD trucks, which will then accelerate adoption of those trucks in the market.

Included in those collaborative efforts would be a deeper assessment for each of the sites regarding how many charge ports are needed and what the expected growth rate and needed future capacity would be. The technology tradeoffs between corded and inductive charging can also be discussed. Truck stop operators—such as Love's Travel Stops, Pilot Flying J, TA-Petro, and others—can be essential partners and may also be engaged during the planning stages for building out the MD/HD electric truck infrastructure. Their facilities will likely have large power demands as electric trucks gain market share. Some may not be ideally located from an electric utility perspective, but already are well located from a truck operations perspective.

The methodologies applied for this study can also be replicated for other highways, cities, regions, and districts. The partner electric utilities can offer to support analyses of other corridors or areas that are of interest to stakeholders in their regions who are involved in adopting MD/HD electric trucks. In this way, this study can further advance MD/HD infrastructure and adoption of electric trucks well beyond the I-5 corridor. The approach considers advancements in technology, the use of databases, understanding of traffic volumes, and optimization of recommended locations for both fleets and electric utilities, rather than just one or the other.

The recommended locations from the study could be part of larger electric utility or state-funded programs. Locations for other charging sites outside of this corridor could be operated by third parties, and capturing the outcomes can help guide policy and future development. Electric utilities can submit requests to the state public utility commissions showing there is a need for a unified regional plan for MD/HD charging deployments. Public utility commission-funded studies and projects of this sort would be valuable to the acceleration of adoption and to building a sustainable economic ecosystem for EV charging.

The following sections summarize the key findings of the study, challenges and opportunities related to MD/HD electric truck infrastructure, and recommendations for moving forward.

Key Findings

Growth in EV Use. The last five years have witnessed extensive growth in light-duty (passenger) EVs, driven by several factors, including improvements in battery technology. These advances in battery technology are also helping MD electric trucks reach cost parity—in terms of TCO—with conventionally fueled trucks. The advancements in battery technology have increased range and helped develop cases for MD EVs while at the same time demonstrating the feasibility of widespread adoption of HD electric trucks in the future. By 2030, it is estimated that MD and HD electric trucks could make up over 8 percent of all trucks on the road in California, Oregon, and Washington. Chapter 3, *Electric Truck Market Projections*, provides more information regarding the future electric truck market.

Policies and Programs. This study identified more existing MD and HD truck electrification policies and programs in California compared to Oregon and Washington, where policies and programs have primarily focused on light-duty EVs. However, the policy context is changing. Oregon and Washington recently passed legislation that enables electric utilities to develop transportation electrification plans and creates grant and assistance programs for electrified transit. Oregon set a new statewide goal to transition its state-owned motor vehicle fleet to electric by 2035. Clean fuel policies in all three West Coast states continue to drive transportation electrification. Continued government support—through policies, regulations, and incentives—will be essential to advance the adoption of electric trucks by fleet operators.

Options for Expanding Infrastructure Programs. State, federal, and private programs that provide funding for charging infrastructure can help accelerate EV adoption. To date, electric utility infrastructure programs that support MD/HD EVs have primarily focused on fleets that charge at a single location (usually their home base). Expanding these programs to support charging for fleets that travel along corridors and rely on public fueling stations could further accelerate electric truck adoption.

Perspectives of Fleet Operators. Interviewed fleet operators (see the *West Coast Clean Transit Corridor Initiative, I-5 Corridor, Background Research Technical Memorandum*) identified the need for publicly available charging infrastructure in the three West Coast states to support their operations. They noted less investment in charging infrastructure in Oregon and Washington to date. Operators with limited funding but with an interest in deploying electric trucks stated that better access to public charging would accelerate deployment of EVs because their trucks could use public sites. Their electric trucks could use the public sites, allowing the fleets to avoid significant capital costs involved with installing charging sites on their own property. This will help drive the adoption of electric trucks.

Standardization of Infrastructure. A network of publicly available charging sites can help promote standardization of electric charging infrastructure for electric trucks. Just as drivers of conventional trucks today utilize standardized diesel fueling equipment at truck stops and gas stations, a standardized system of electric charging equipment for electric trucks would help drivers make the transition to EVs more easily. Standard charging equipment would also allow fleets to plan their routes, knowing how long each stop would take and how far their vehicles could travel.

Range of Electric Trucks. The MD trucks projected to be on the road during the next five years will have an average range of approximately 90 to 120 miles. The HD electric trucks expected to be on the road during the next 10 years would have a much longer range: between 230 and 325 miles, on average. With a goal of keeping the electric truck batteries at an optimal charge of between 25 and 80 percent, the recommended distance between stops for charging for MD electric trucks is 50 miles, and for HD electric trucks is approximately 100 miles.

Proposed Charging Site Locations and Electric Loads. This study identified conceptual locations for 27 charging sites to support MD electric trucks along Interstate 5 for a 2025 forecast. The sites would be spaced approximately 50 miles apart. Each would be equipped with up to ten 350 kW charging ports, for up to a 3.5 MW peak load.

As part of the 2030 forecast, which could develop sooner based on market conditions, 14 of the 27 MD charging sites would be expanded to accommodate HD electric trucks. These sites would be every-other MD site and thus spaced approximately 100 miles apart. Combined MD/HD charging sites would be equipped with up to an additional ten 2 MW charging ports (using the High Power Charging for Commercial Vehicles standard), for a maximum 23.5 MW peak load. This co-location approach would minimize the need for additional grid upgrades, reduce permit processing times, leverage land availability, and minimize costs.

For both MD and combined MD/HD sites, managed charging techniques or distributed energy resource solutions such as battery energy storage systems could be used to reduce peak load.

Electric Utility Capacity. Most electric utilities in California, Oregon, and Washington have enough capacity in urban areas along the Interstate 5 corridor to support interconnections with the proposed MD charging sites. In rural areas, capacity constraints would be encountered for some electric utilities in the three West Coast states. The potential need to install new distribution circuits in rural areas could significantly increase the cost of a charging site interconnection, and would most likely require additional time and planning. In all locations, most loads over 10 megawatts would require extensive upgrades to the electric grid and, most likely, a new customer-dedicated substation. Therefore, there is a high probability the proposed HD charging sites would require a new substation and a new line interconnection. Load capacity in the grid changes frequently over time, and future load interconnections for electric truck charging infrastructure will require additional current-status coordination with electric utilities.

Challenges

Site Infrastructure Cost Uncertainty. The costs of building charging sites for electric trucks can be challenging to predict given the numerous variables, such as equipment selection, site location, distance from the electric utility interconnection, electric circuit capacity and associated upgrades, permits, and labor costs. Consequently, individual assessments that require in-person site visits are necessary on a site-by-site basis, making accurate system-wide assumptions difficult and time-consuming.

Public Funding Focuses on Vehicles. Government incentives designed to accelerate early EV deployment such as vouchers or grants, have mainly focused on vehicle cost or private infrastructure and not public infrastructure. Even though some grants provide incentives to invest in charging infrastructure, they are not multi-jurisdictional and available in all the states that a highway corridor crosses.

Timing of Infrastructure Upgrades. The proposed charging sites for electric trucks could take significant time to plan, permit, design, and construct presenting a chicken-egg dilemma to prepare infrastructure for future EV adoption. The proposed charging sites for MD electric trucks under the 2025 forecast could each take between one and two years to plan and build. The proposed charging sites to serve HD electric trucks under the 2030 forecast could each take between three and five years to plan and build.

Lack of Knowledge Regarding Electric Trucks. The background research conducted for this study (see the *West Coast Clean Transit Corridor Initiative, I-5 Corridor, Background Research Technical Memorandum*) found that fleet operators have difficulty understanding the range of electric trucks currently available and which trucks would work best for them. Fleet operators also struggle to identify the total cost of ownership for electric trucks.

Real Estate Constraints for Charging Sites in Urban Areas. Constraints in the availability of real estate for potential charging site locations in urban areas could pose a challenge. Although most industrial zones have the capacity for additional load interconnections, these areas tend to be densely developed, with limited large areas that would allow ingress and egress of electric trucks for charging. Most existing truck stops are not generally located in metropolitan areas, and identifying real estate in highly dense urban areas will be a challenge to be overcome with proper planning.

Opportunities

Electric Utilities as Drivers of Electric Truck Adoption. By taking a lead role in transportation electrification efforts on the West Coast, electric utilities have the opportunity to be important proponents of electric truck adoption—and the related benefits of cleaner air and reduced greenhouse gas emissions. Stakeholders such as fleet operators and electric truck manufacturers are very interested in infrastructure along Interstate 5 and want to be engaged, and electric utilities could play a leadership role in this clean transit initiative.

Building on Existing EV Programs. Several electric utilities in California—Los Angeles Department of Water & Power, PG&E, SDG&E, and SCE—have programs aimed at supporting the adoption of electric trucks. Other electric utilities in California, Oregon, and Washington may implement similar programs to move forward with the goals set for the Interstate 5 corridor.

Partnerships. Establishing partnerships between electric utilities, electric truck manufacturers, charging equipment providers, fleets, and state agencies can encourage technology growth and adoption. Such partnerships will be essential for the successful implementation of infrastructure improvements. A high-profile corridor with public charging infrastructure, such as Interstate 5, can be a catalyst for fleets to make larger investments in electric trucks. Truck stop operators—such as Love's Travel Stops, Pilot Flying J, TA-Petro, and others—can be essential partners to engage during the planning stages for building out the charging sites identified in the study.

Recommendations for Moving Forward

As infrastructure providers, market facilitators, and trusted advisors, electric utilities are uniquely positioned to leverage this report's key findings and build on opportunities to overcome the challenges identified above. This report supports the proposal to develop 27 charging sites located 50 miles apart along Interstate 5 to support MD electric trucks by 2025, with the ability to expand 14 of those sites to accommodate HD electric trucks by 2030.

Three areas of recommendations focus on electric system planning, building stakeholder collaboration, and the electric utility role in positive EV business cases. The ten next-step actions detailed below are general across all three western states, and across all electric utilities in the study. Each state and each electric utility have their own regulatory environments, business goals and planning processes, which means the implementation of these steps will vary by state and electric utility. None of the recommendations are intended to be directed at any particular state or electric utility.

1) Begin long-term system planning and detailed site evaluations for development of corridor charging sites.

Begin a proactive approach to electric grid planning needs, irrespective of ownership models and exact site locations, to avoid electric utility lead times from becoming a barrier to charging deployment. *(Additional discussion may be found in Chapter 3, Electric Truck Market Projections, and in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*

Prioritize deployment of MD charging sites close to the Interstate 5 corridor while also planning for future expansion of those sites to accommodate HD charging. *(Additional discussion may be found in Chapter 3, Electric Truck Market Projections, and in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*

Leverage results from this study to identify specific sites and begin conducting interconnection studies, right-of-way analyses, examination of real estate records for ownership and zoning, and specific site development cost estimates. *(Additional discussion may be found in Chapter 4, Truck Network Along the I-5 Corridor, Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor, and in the background research technical memorandum in Chapter 4, Truck Market Overview.)*

2) Leverage the electric utility role as an Energy Advisor to enhance collaboration and engagement across a broad range of stakeholders.

Collaborate across the broad range of industry stakeholders through the creation of working groups, task forces, and joint pilot programs to plan infrastructure, determine use cases and charging patterns, and identify priority regions and locations for deployment. *(Additional discussion may be found in the background research technical memorandum in Chapter 3, Stakeholder Engagement.)*

Serve as a trusted infrastructure provider by developing a charging site design guideline document to educate site hosts on site design, safety standards, and charging station configuration to help lower site development costs. *(Additional discussion may be found in the background research technical memorandum in Chapter 2, Overview of Electric Vehicle Technology and Investment, Chapter 3, Stakeholder Engagement, Chapter 5, Electric Truck Charger Market Overview, and Chapter 6, Existing and Planned Electric Truck Charging Infrastructure.)*

3) Leverage electric utilities' expertise to develop ways of improving the experiences of site customers, fleet owners, and drivers, and build positive business cases for medium- and heavy-duty EVs.

Support the creation of robust, dependable, and long-term funding of incentive programs for electric truck technology. *(Additional discussion may be found in Chapter 2, Regulatory and Political Landscape, and in the background research technical memorandum in Chapter 6, Existing and Planned Electric Truck Charging Infrastructure.)*

Work closely with commercial customers to develop electrification program designs to help accelerate MD/HD EV adoption. *(Additional discussion may be found in the background research technical memorandum in Chapter 2, Overview of Electric Vehicle Technology and Investment.)*

Develop informational materials to help educate fleet operators on the grid regarding vehicle total cost of ownership tools as a means for fleet operators to gain a better understanding of how electric trucks would work for them. *(Additional discussion may be found in the background research technical memorandum in Chapter 3, Stakeholder Engagement.)*

Investigate the business case for potential ways to manage site peak loads (i.e., managed charging and Distributed Energy Resource solutions) and reduce costs for charging sites. *(Additional discussion may be found in Chapter 5, Proposed Charging Site Locations Along the I-5 Corridor.)*

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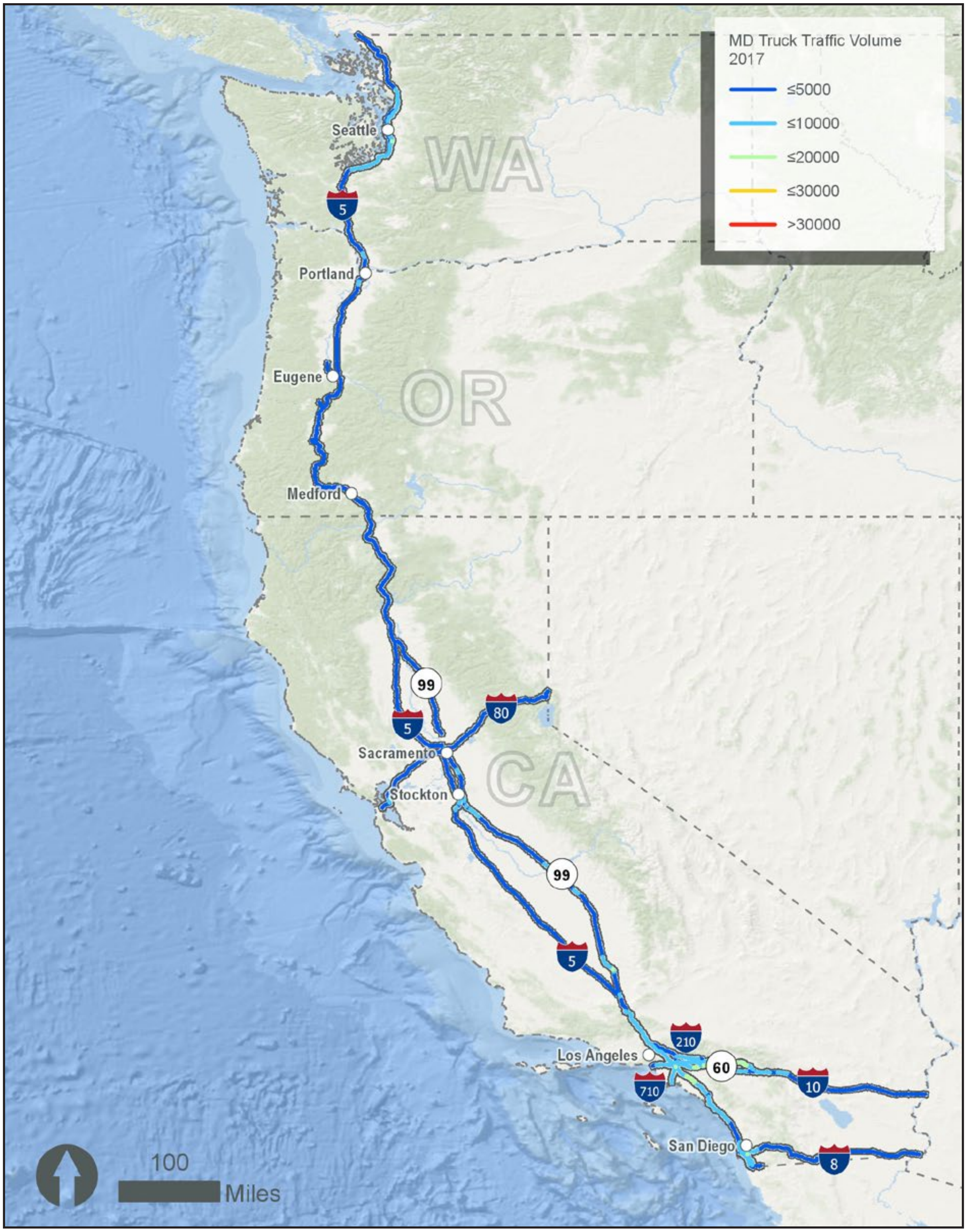
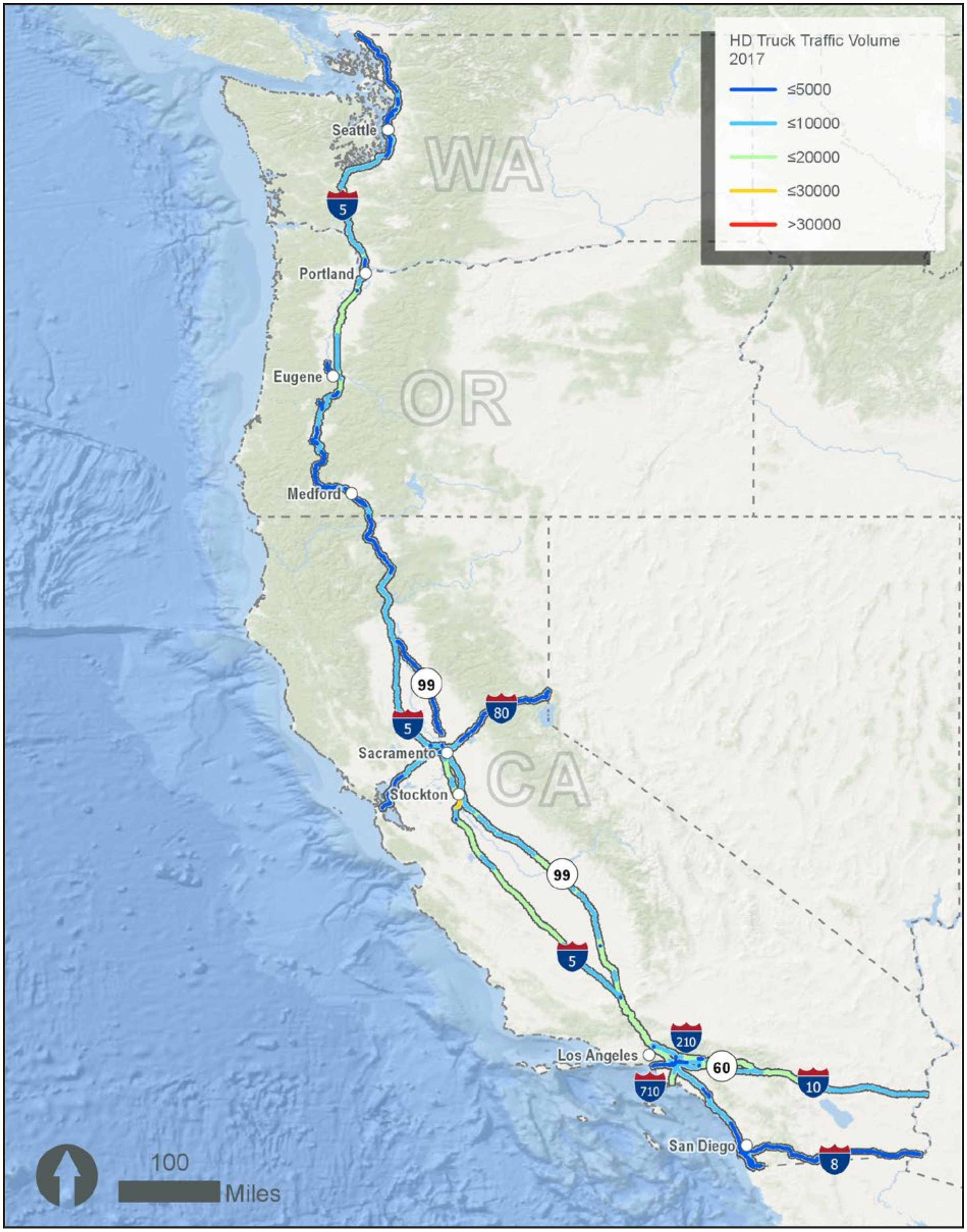
Appendix A. Truck Network Supporting Documentation



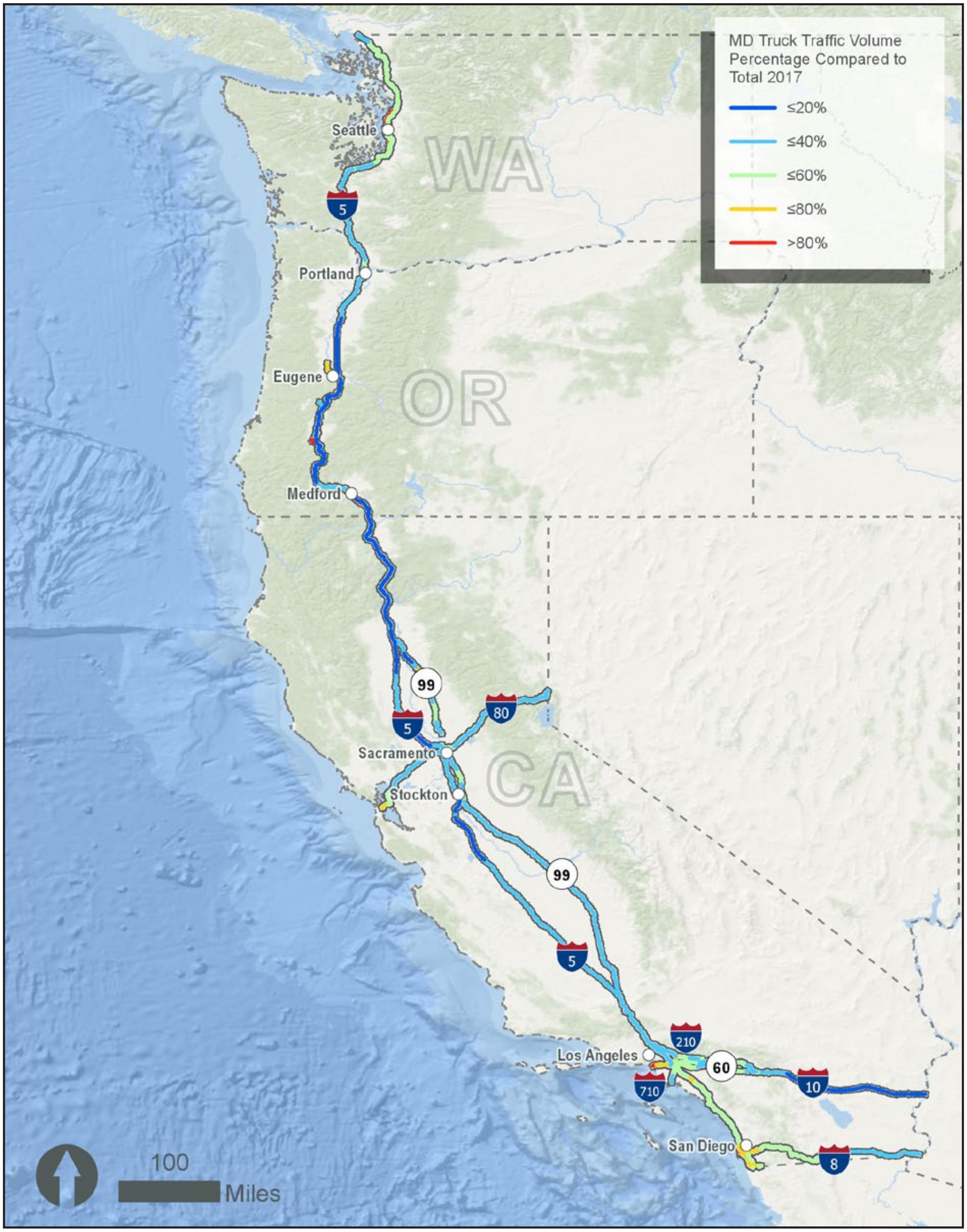
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-1: Existing (2017) MD Trucks Annual Average Daily Traffic (AADT)



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-2: Existing (2017) HD Trucks AADT

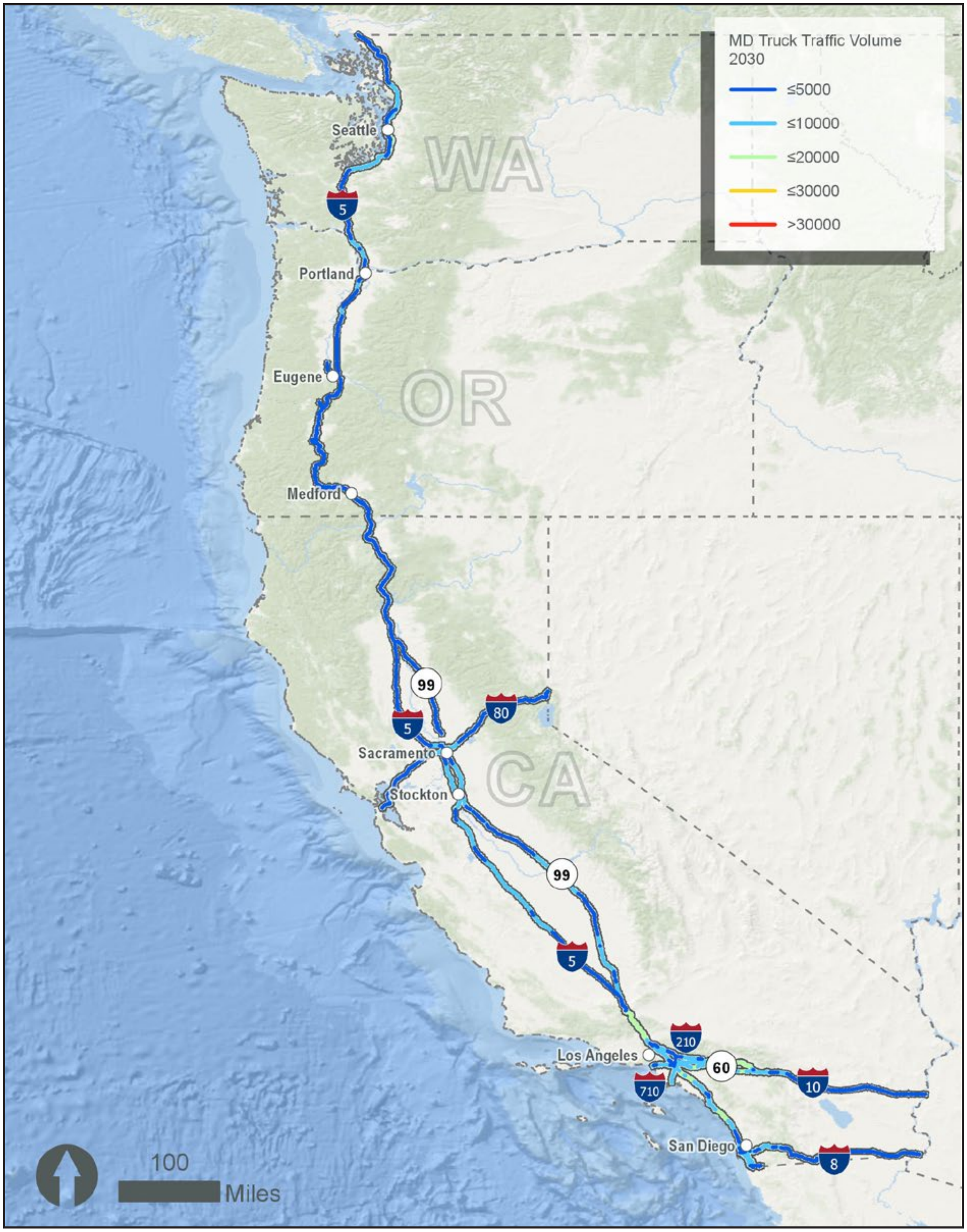


Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-3: Existing (2017) MD Trucks AADT Percentage Compared with Total MD/HD

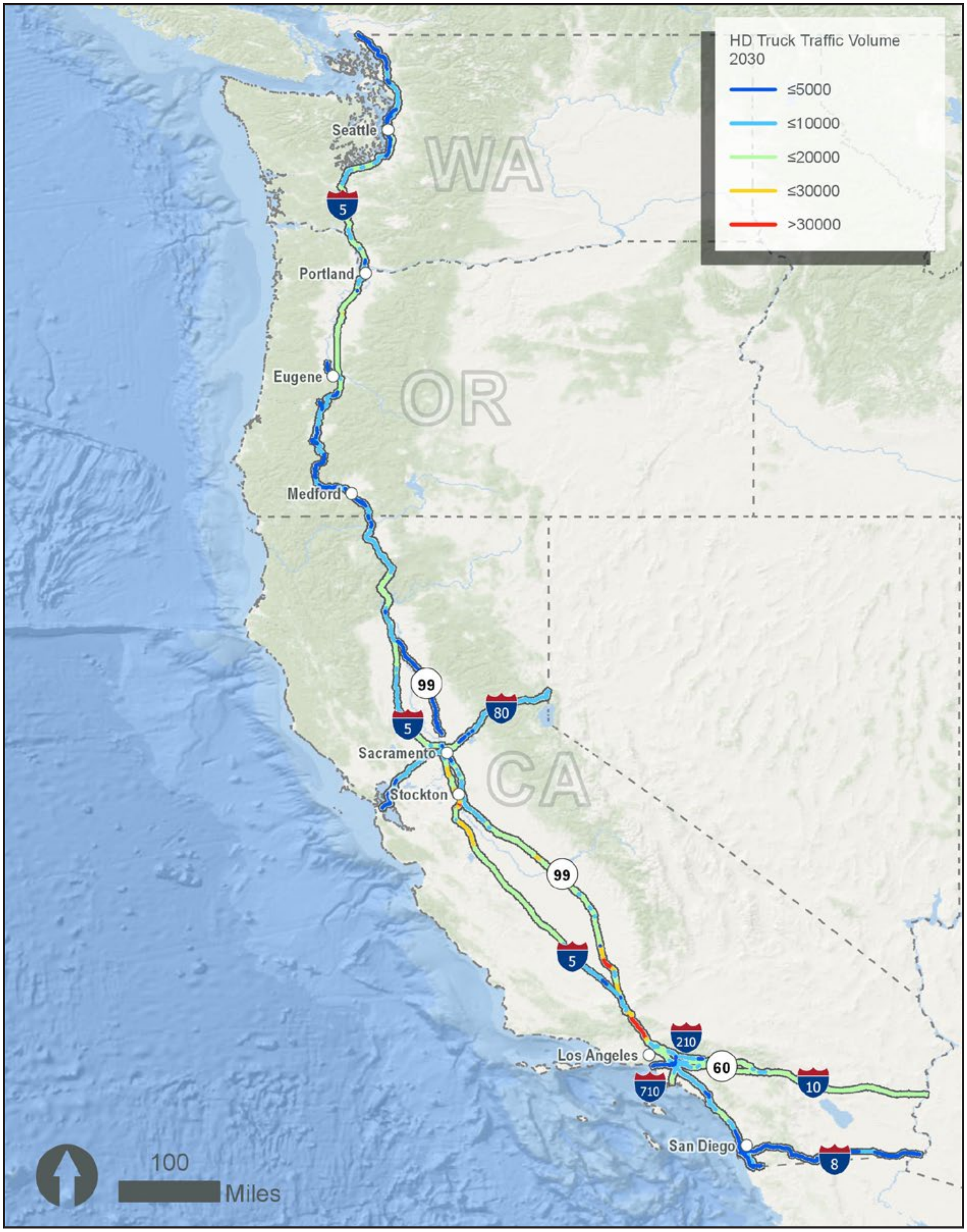
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-4: Existing (2017) HD Trucks AADT Percentage Compared with Total MD/HD



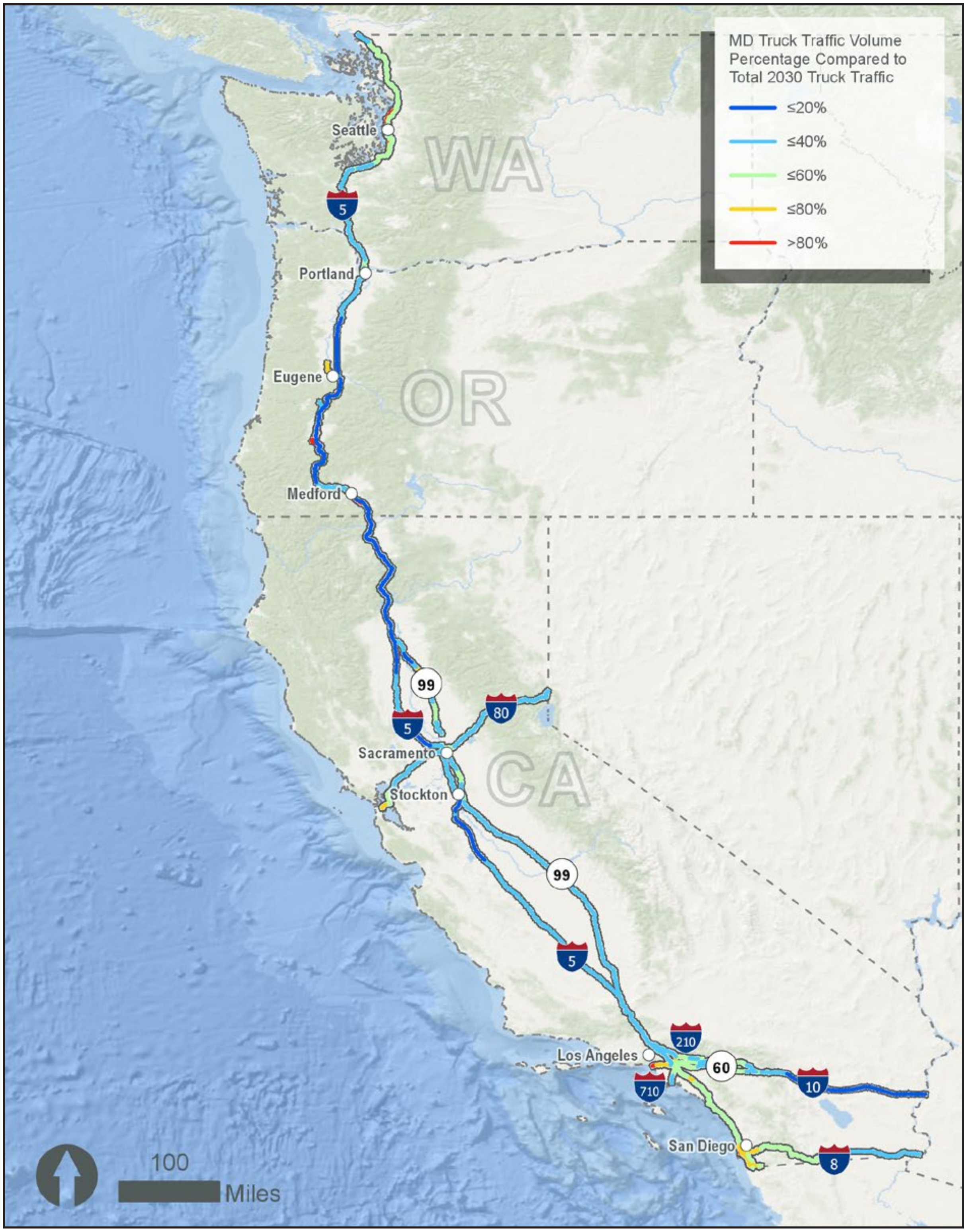
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-5: Projected (2030) MD Truck AADT



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-6: Projected (2030) HD Truck AADT



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-7: Projected (2030) MD Truck AADT Percentage Compared with Total MD/HD

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-8: Projected (2030) HD Truck AADT Percentage Compared with Total MD/HD

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-9: Existing (2017) MD/HD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-10: Existing (2017) MD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-11: Existing (2017) HD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-12: Projected (2030) MD/HD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-13: Projected (2030) MD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-14: Projected (2030) HD Truck AADT in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-15: Existing (2017) MD Truck AADT Percentage Compared with Total MD/HD in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

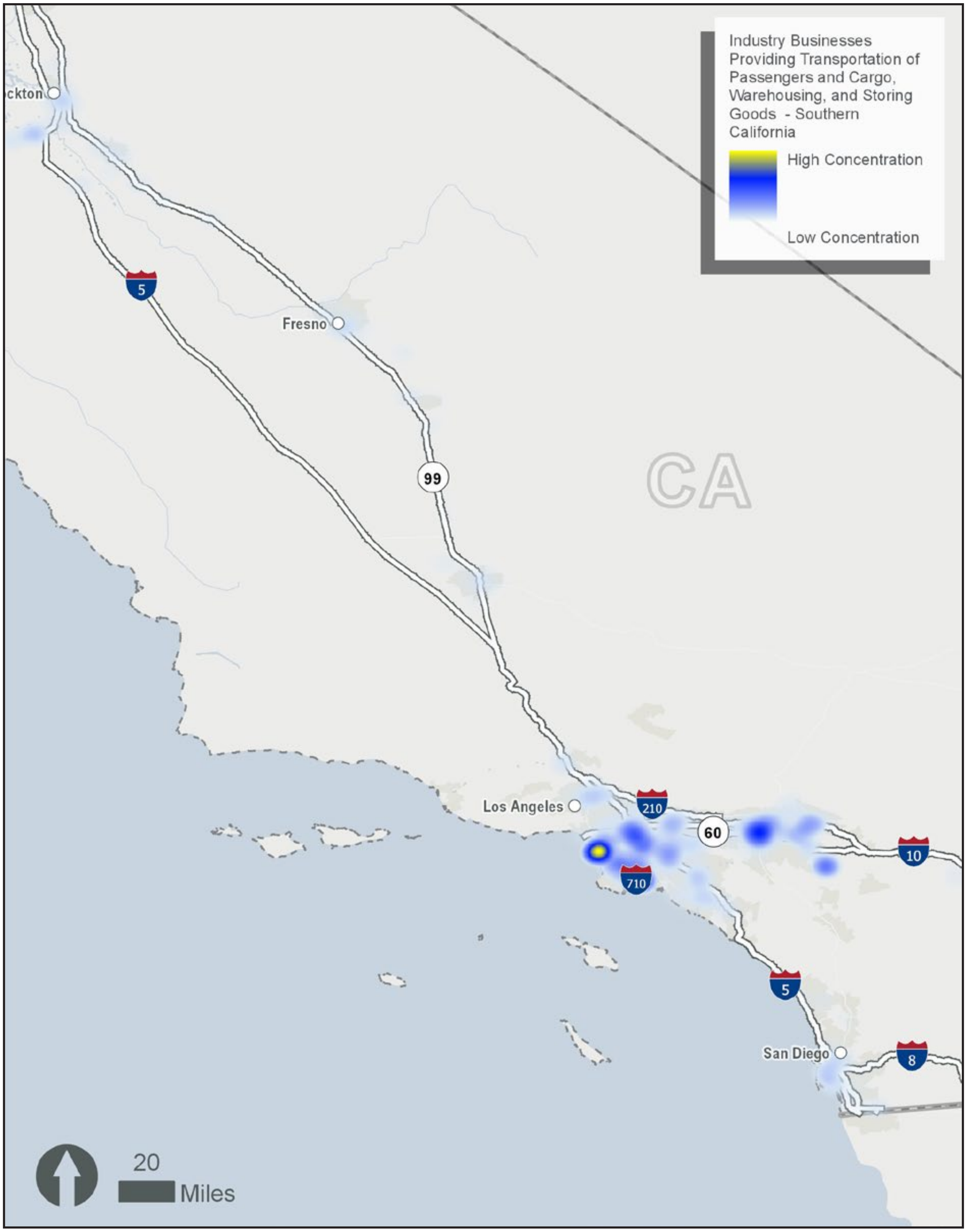
Figure A-16: Existing (2017) HD Truck AADT Percentage Compared with Total MD/HD in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-17: Projected (2030) MD Truck AADT Percentage Compared with Total MD/HD in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-18: Projected (2030) HD Truck AADT Percentage Compared with Total MD/HD in Southern California

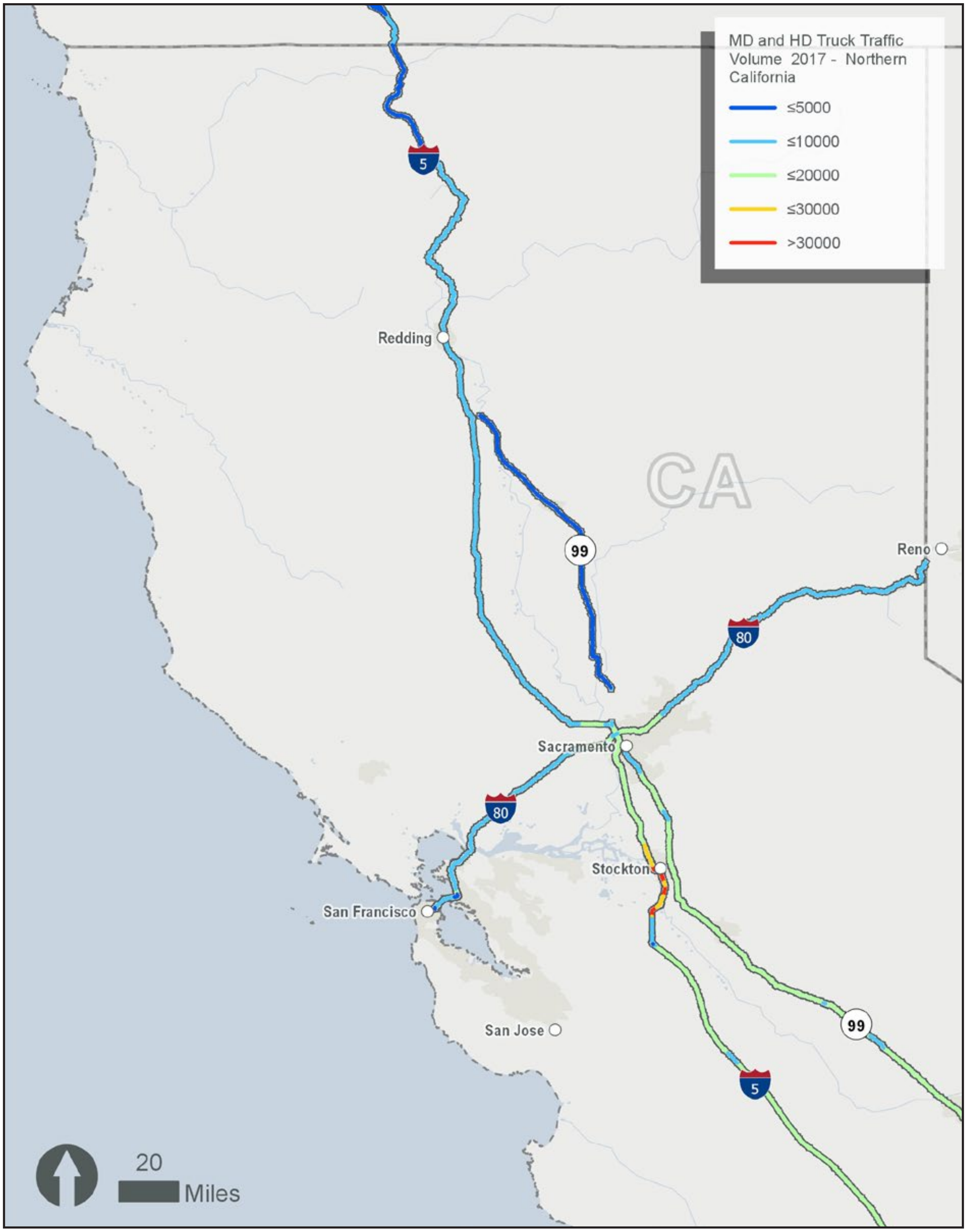


Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-19: Truck-Related Industries Concentration in Southern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-20: Truck Parking Locations in Southern California



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-21: Existing (2017) MD/HD Truck AADT in Northern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-22: Existing (2017) MD Truck AADT in Northern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

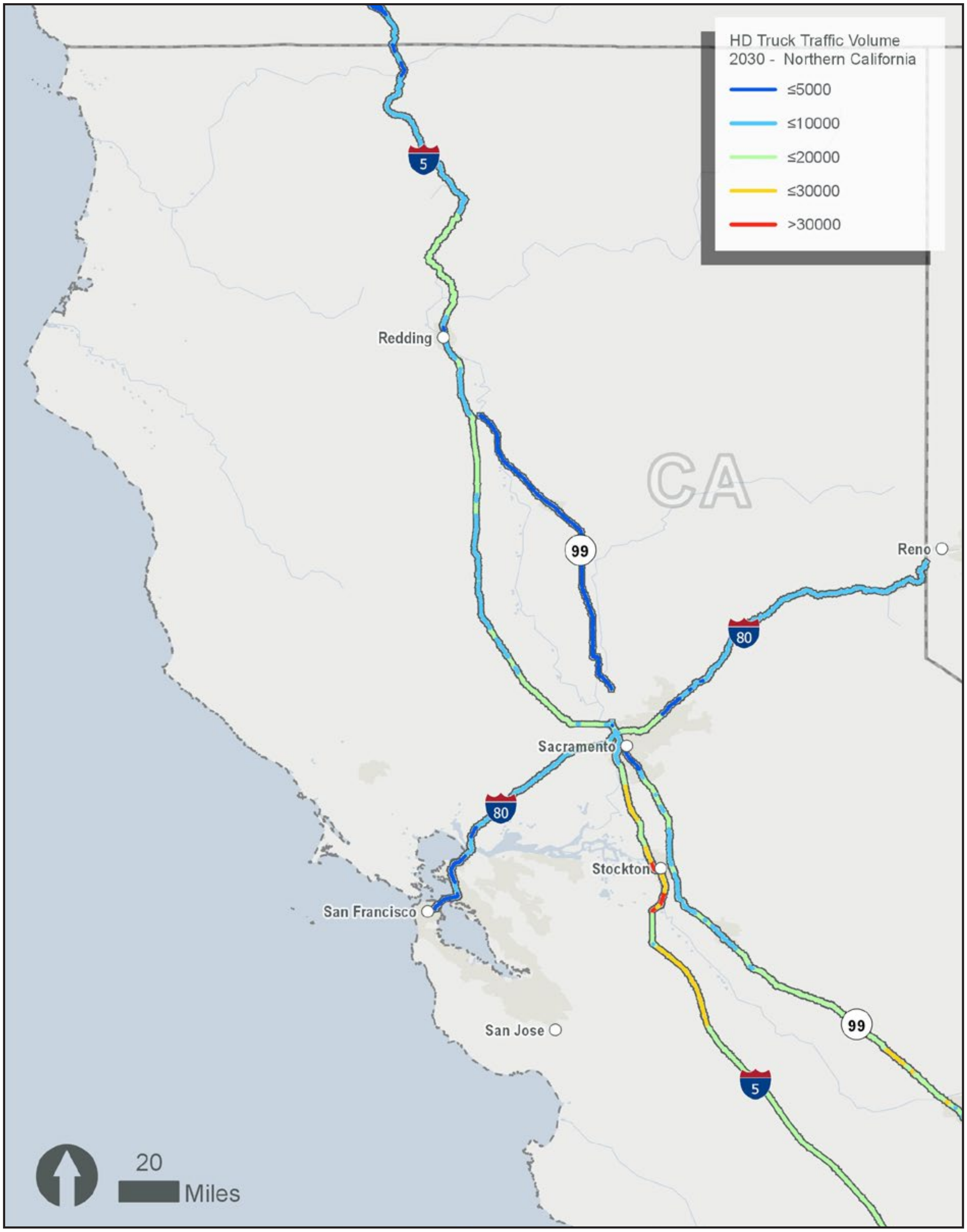
Figure A-23: Existing (2017) HD Truck AADT in Northern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-24: Projected (2030) MD/HD Truck AADT in Northern California

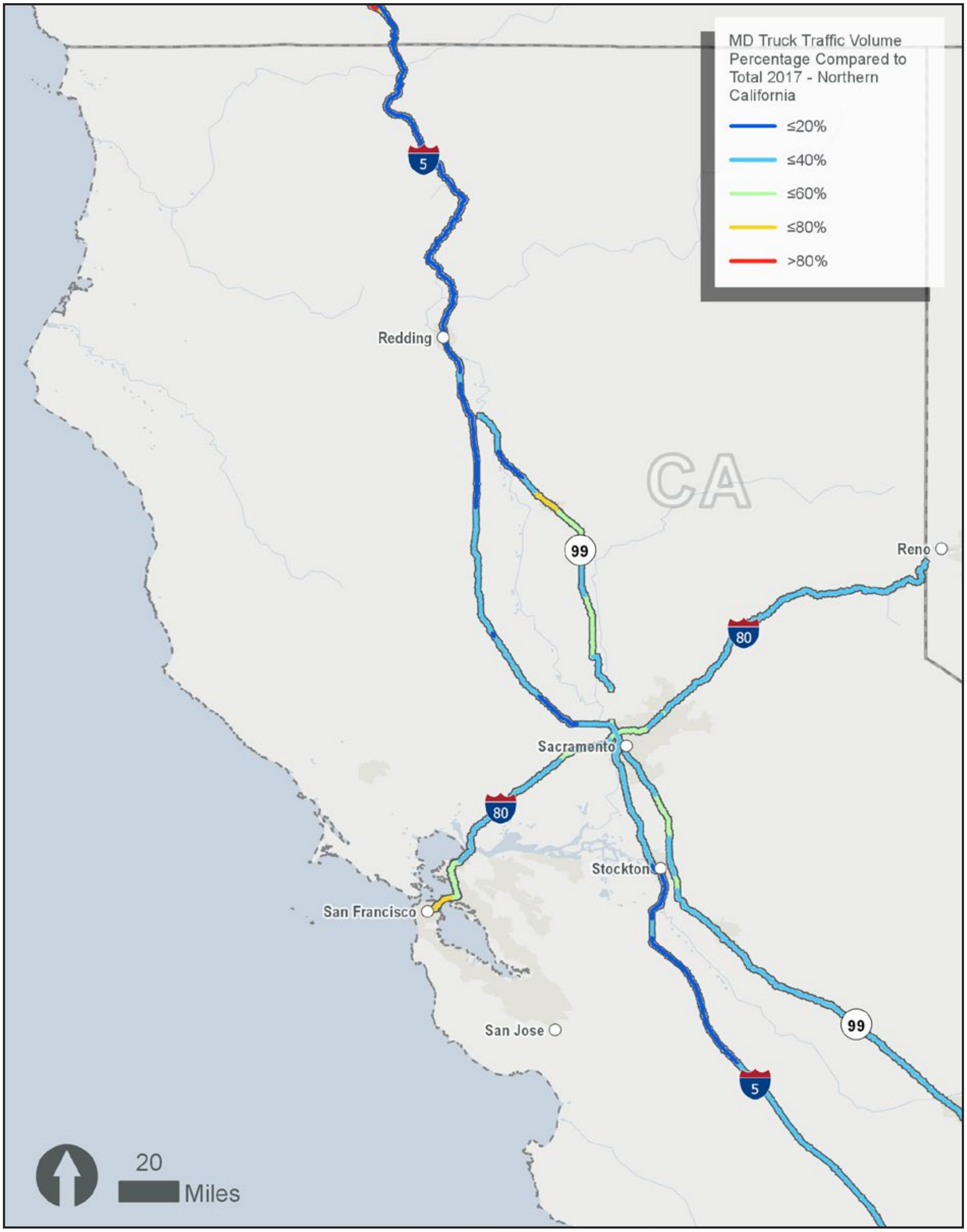
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-25: Projected (2030) MD Truck AADT in Northern California



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-26: Projected (2030) HD Truck AADT in Northern California

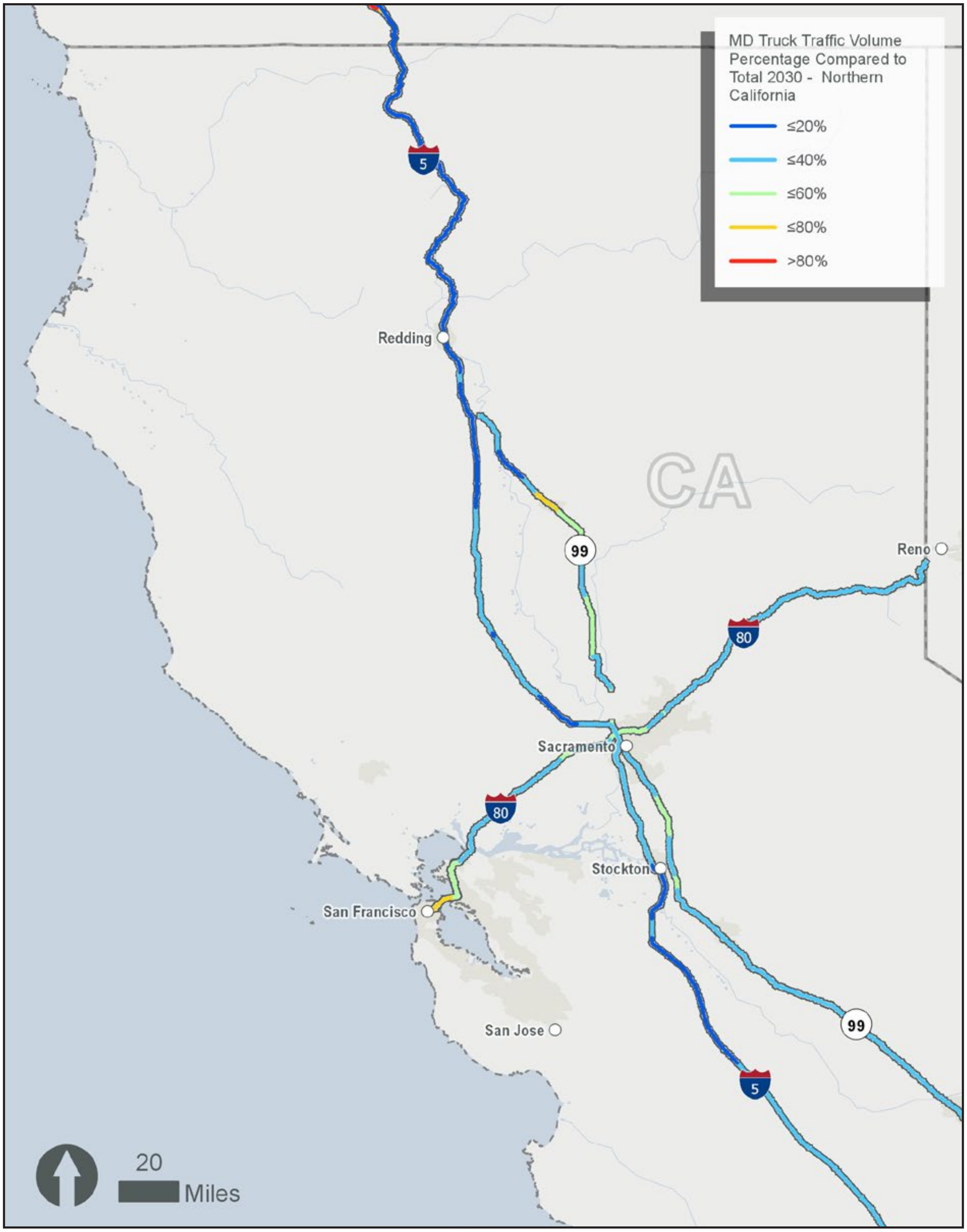


Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-27: Existing (2017) MD Truck AADT Percentage Compared with Total MD/HD in Northern California

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-28: Existing (2017) HD Truck AADT Percentage Compared with Total MD/HD in Northern California

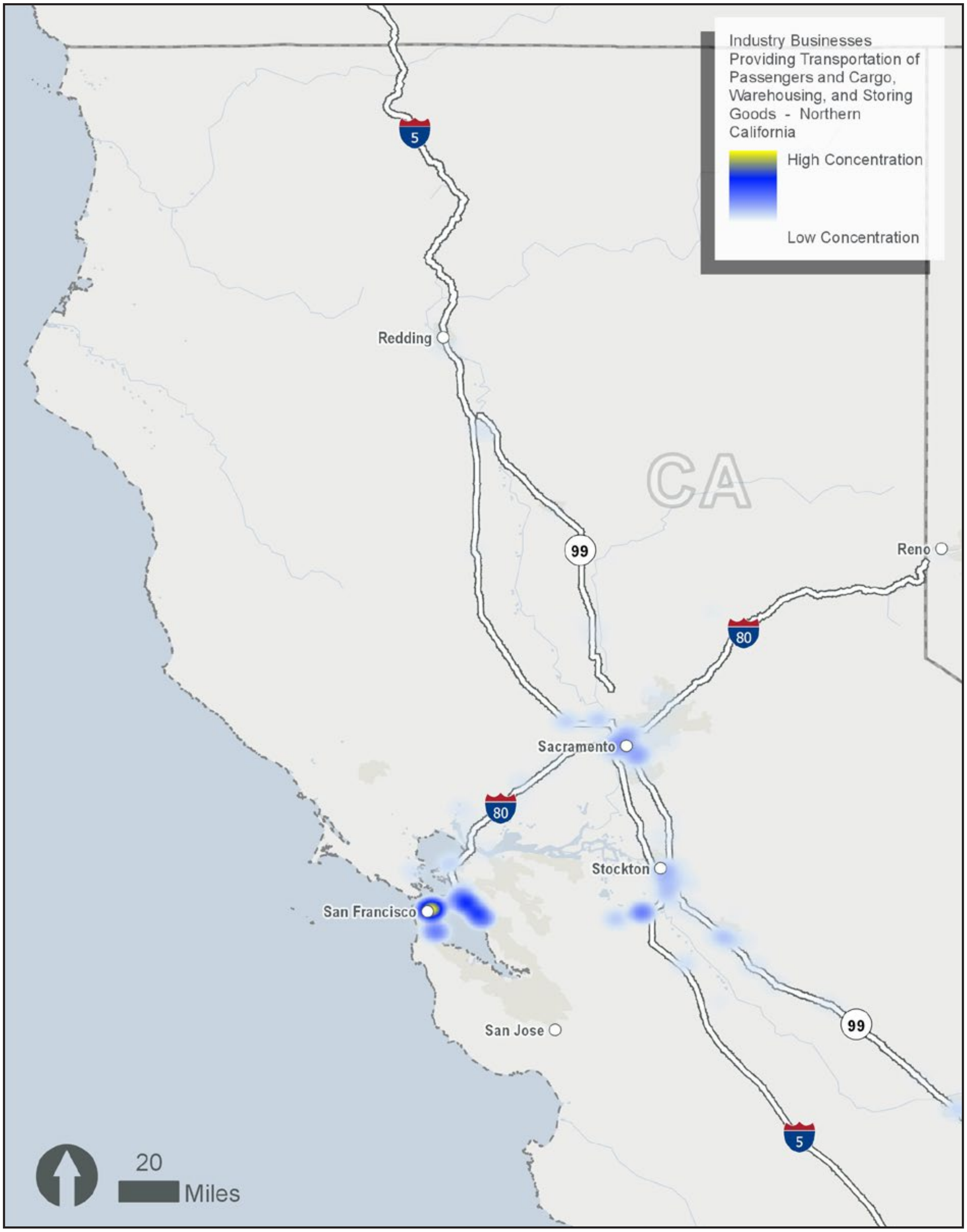


Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-29: Projected (2030) MD Truck AADT Percentage Compared with Total MD/HD in Northern California

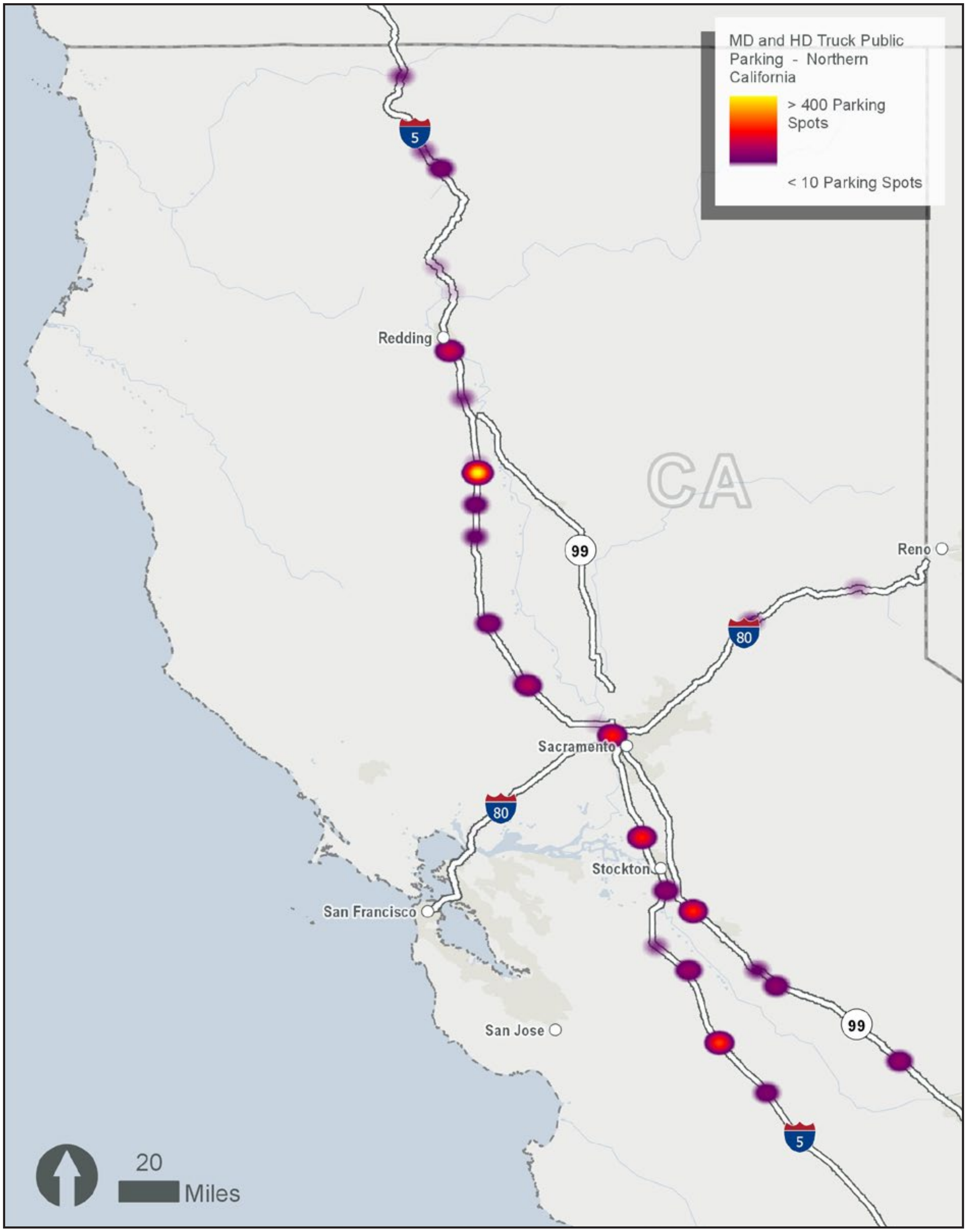
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-30: Projected (2030) HD Truck AADT Percentage Compared with Total MD/HD in Northern California



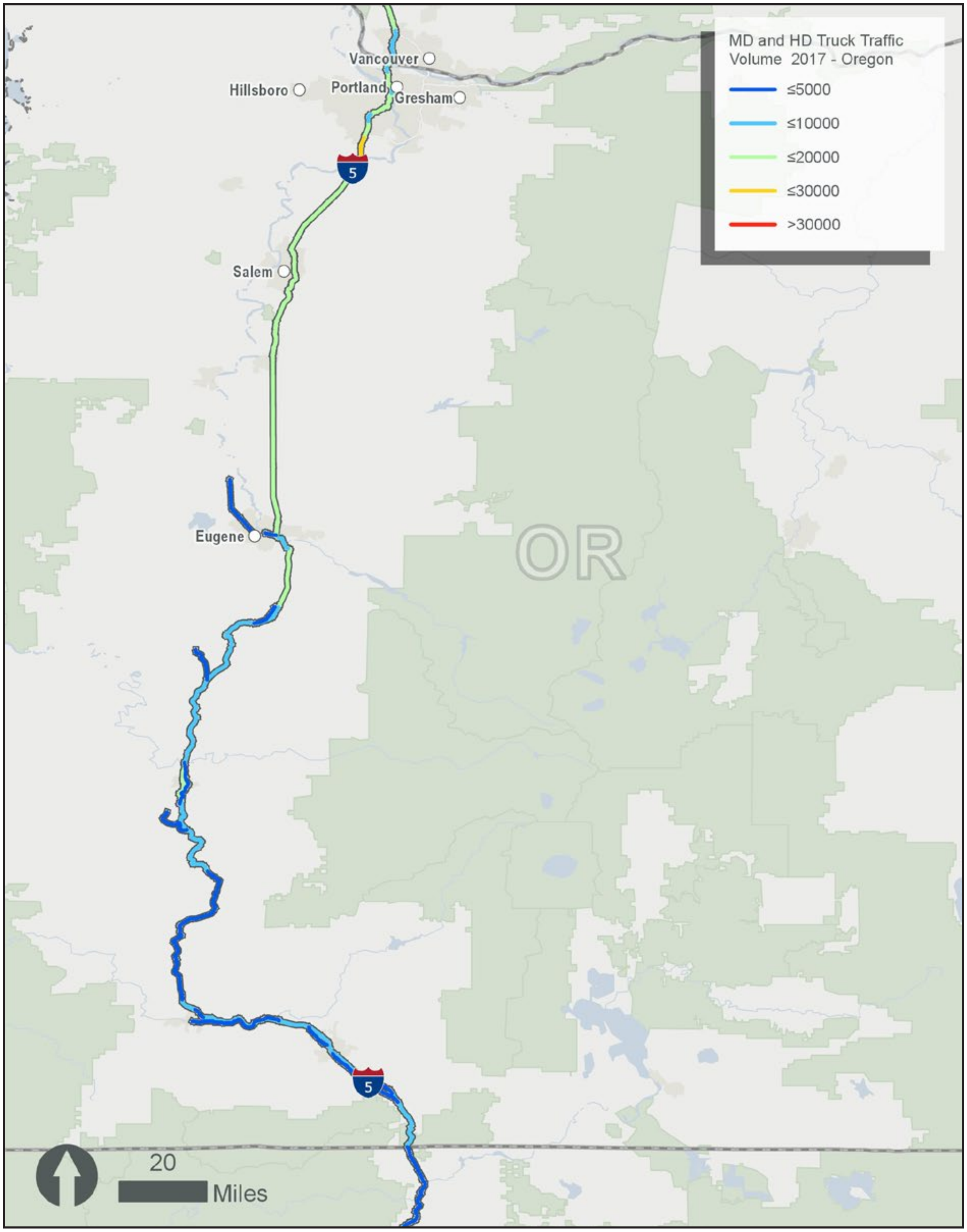
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-31: Truck-Related Industries Concentration in Northern California



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-32: Truck Parking Locations in Northern California



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-33: Existing (2017) MD/HD Truck AADT in Oregon

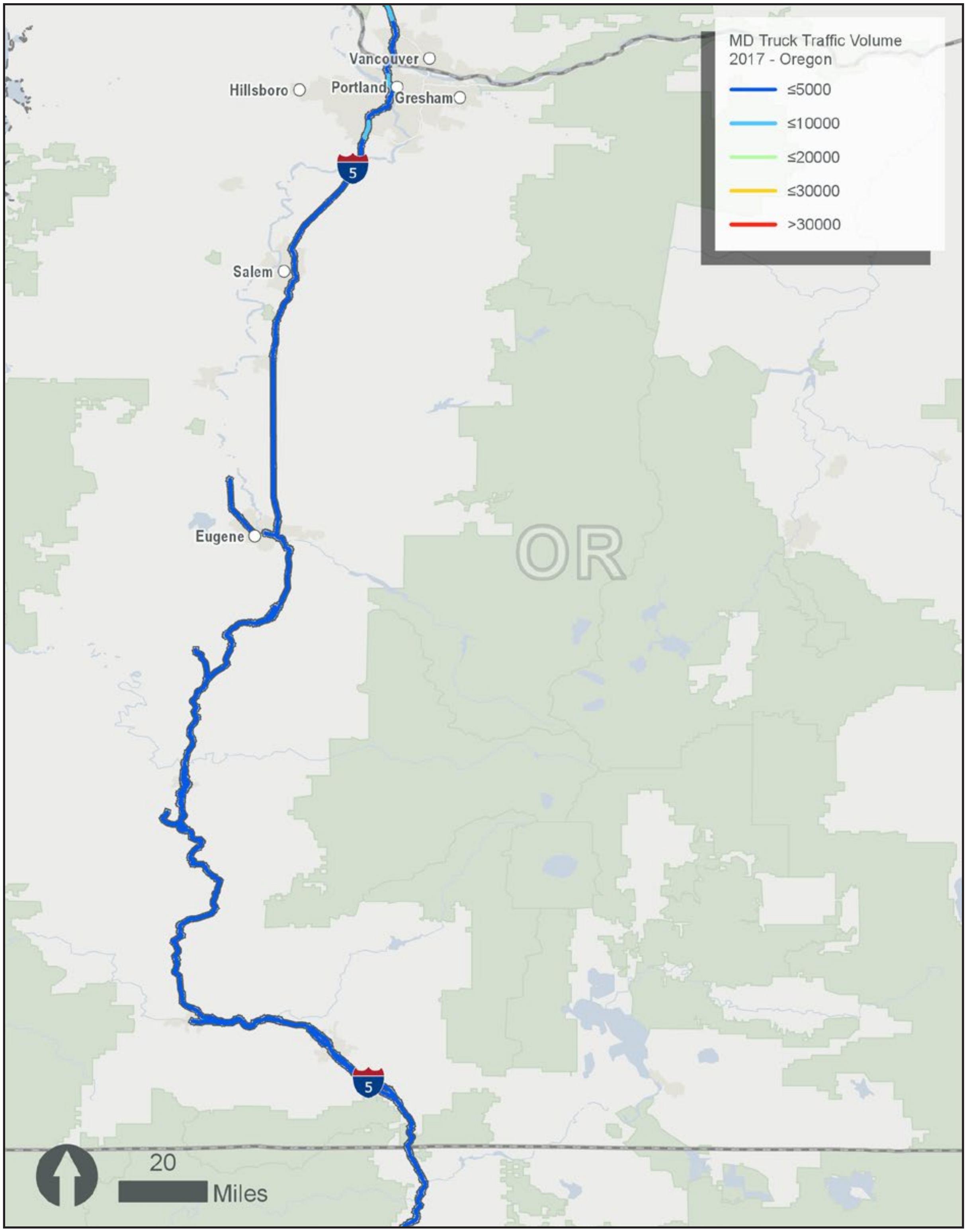


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Figure A-34: Existing (2017) MD Truck AADT in Oregon

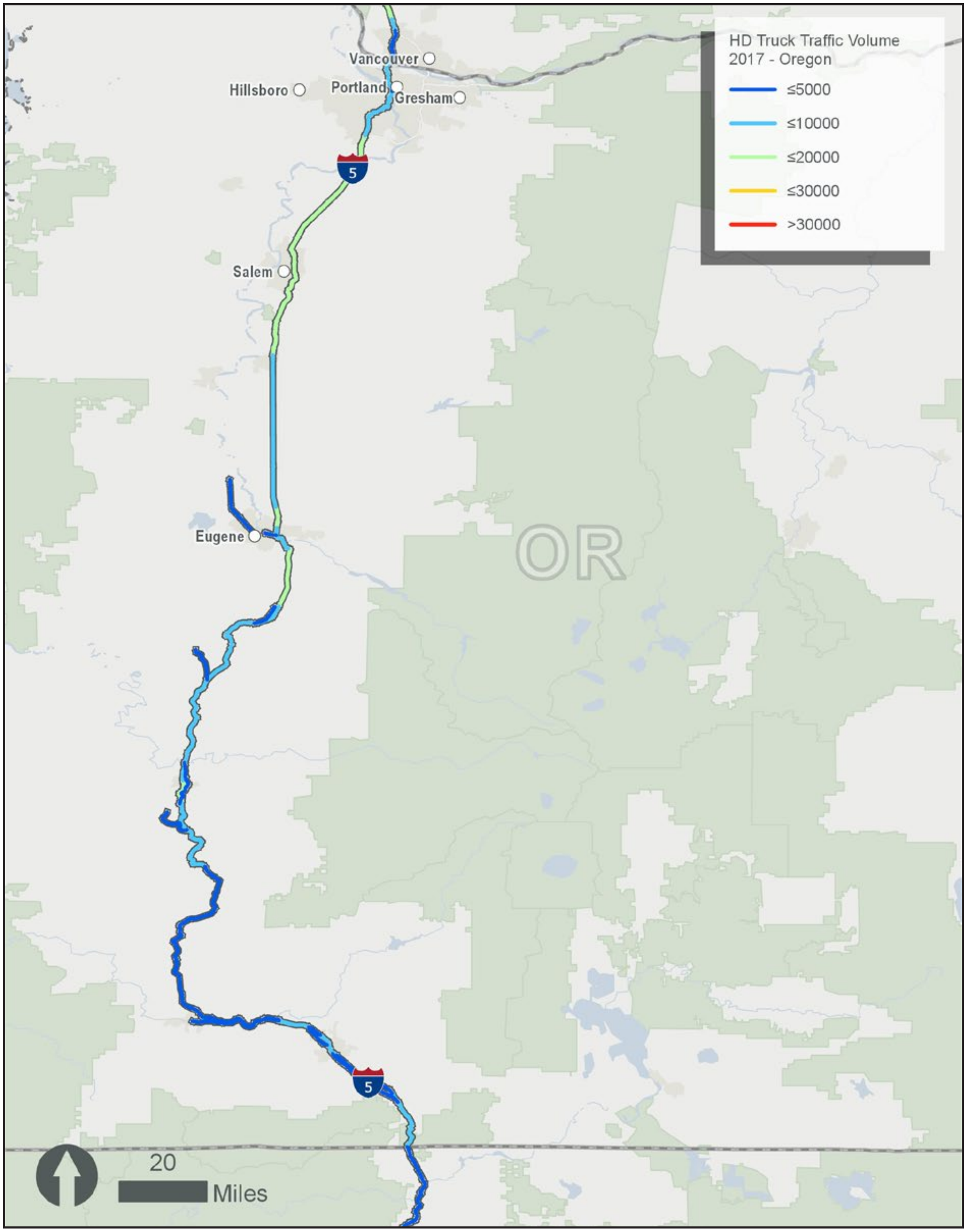

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Figure A-35: Existing (2017) HD Truck AADT in Oregon

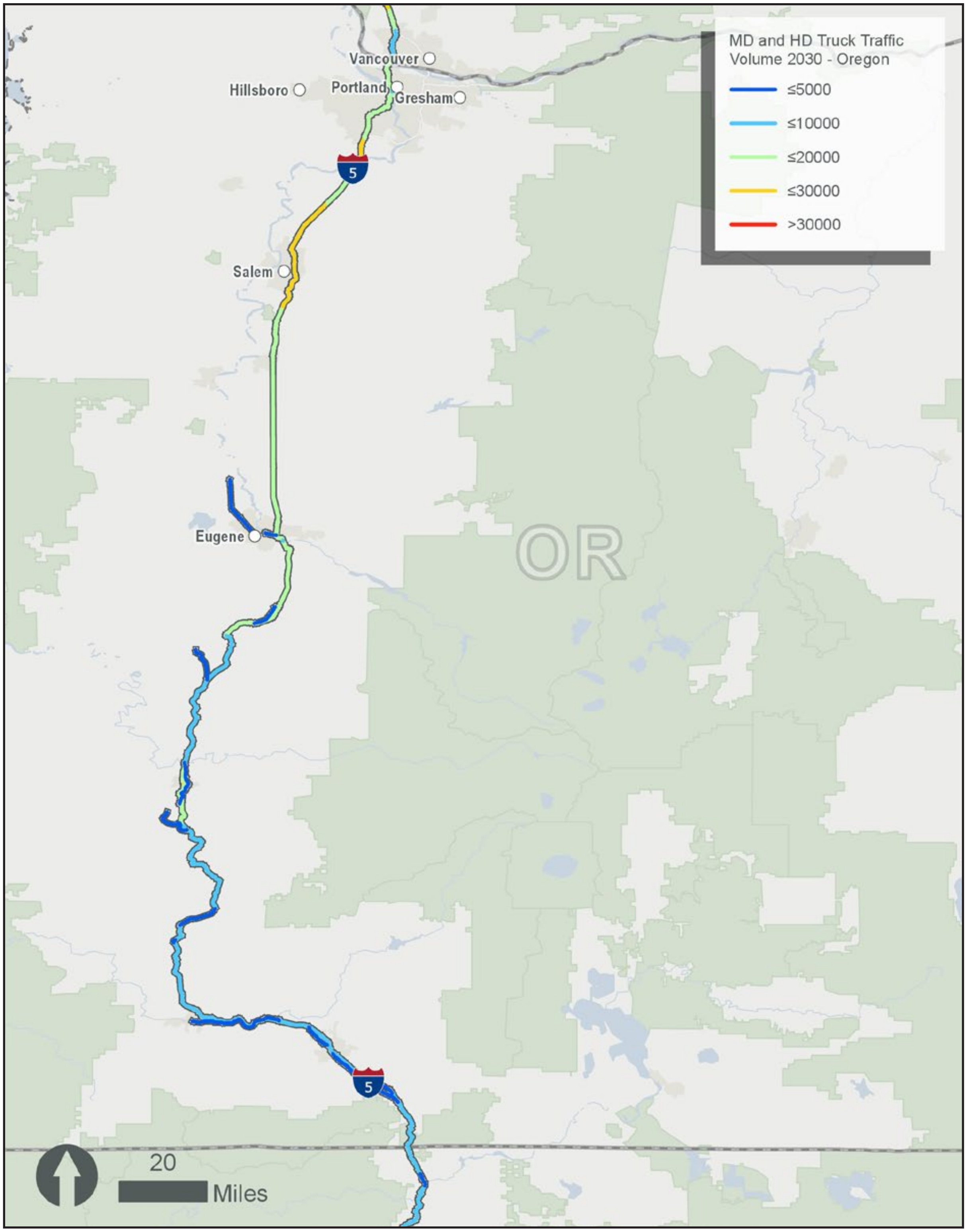

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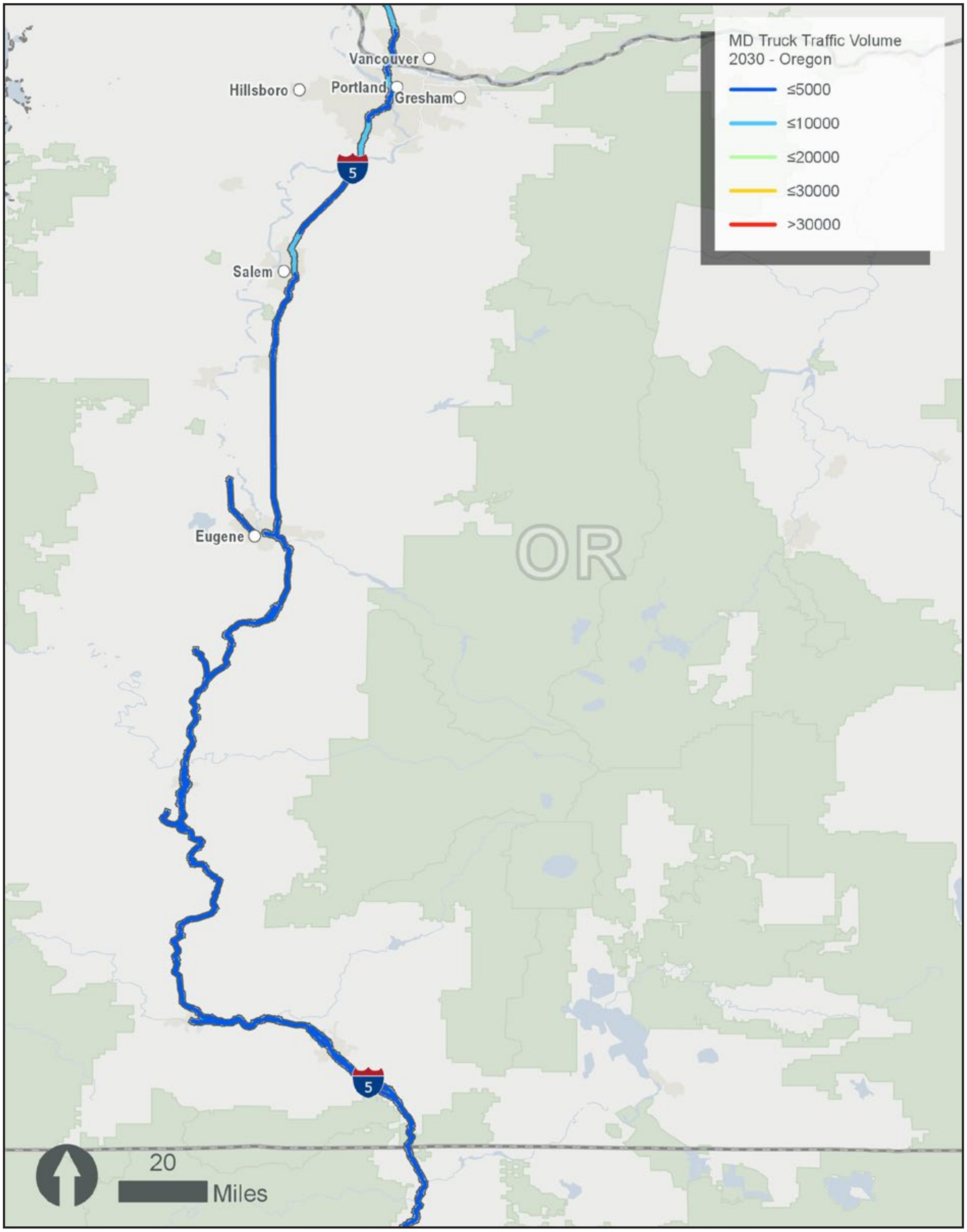
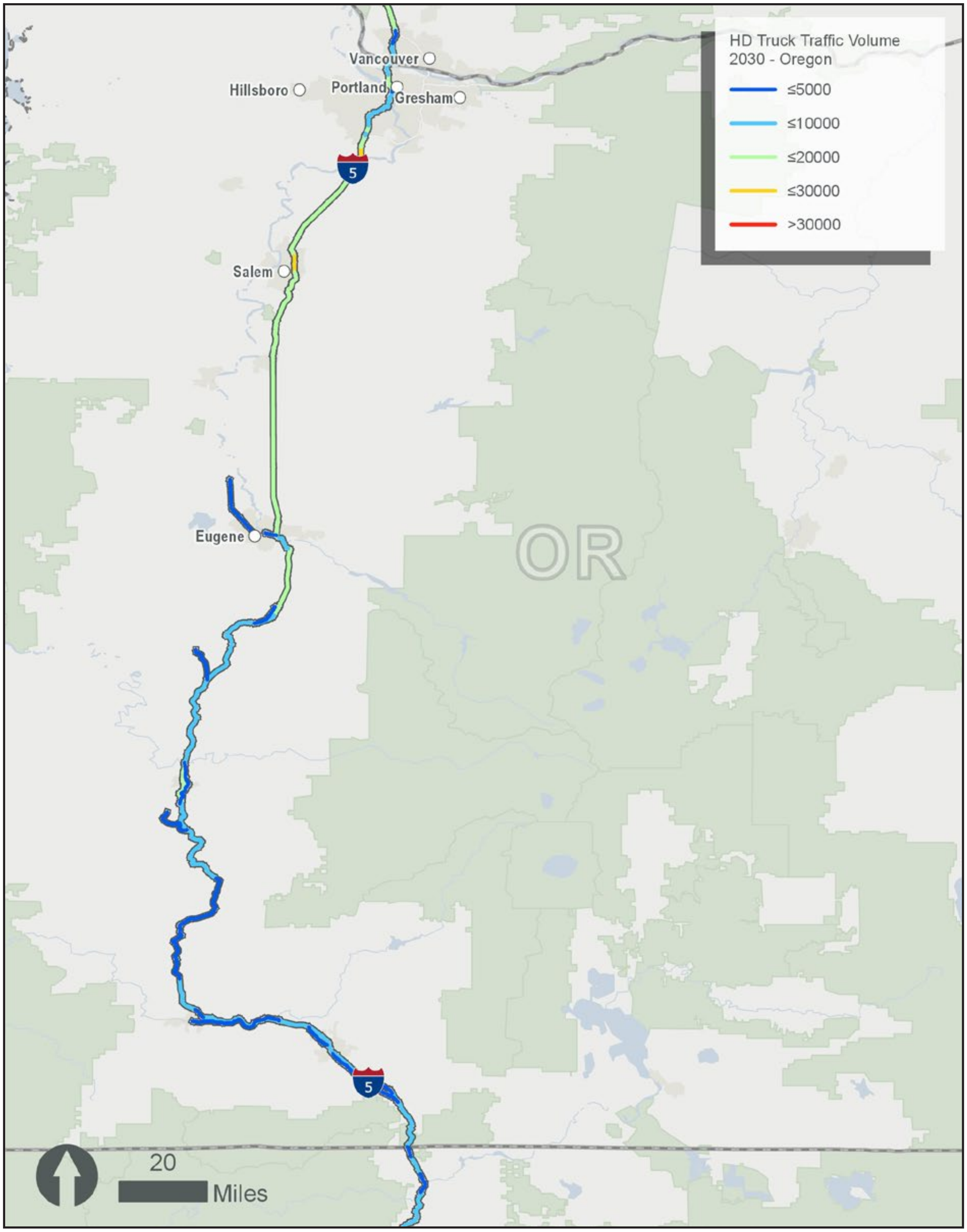
Figure A-36: Projected (2030) MD/HD Truck AADT in Oregon



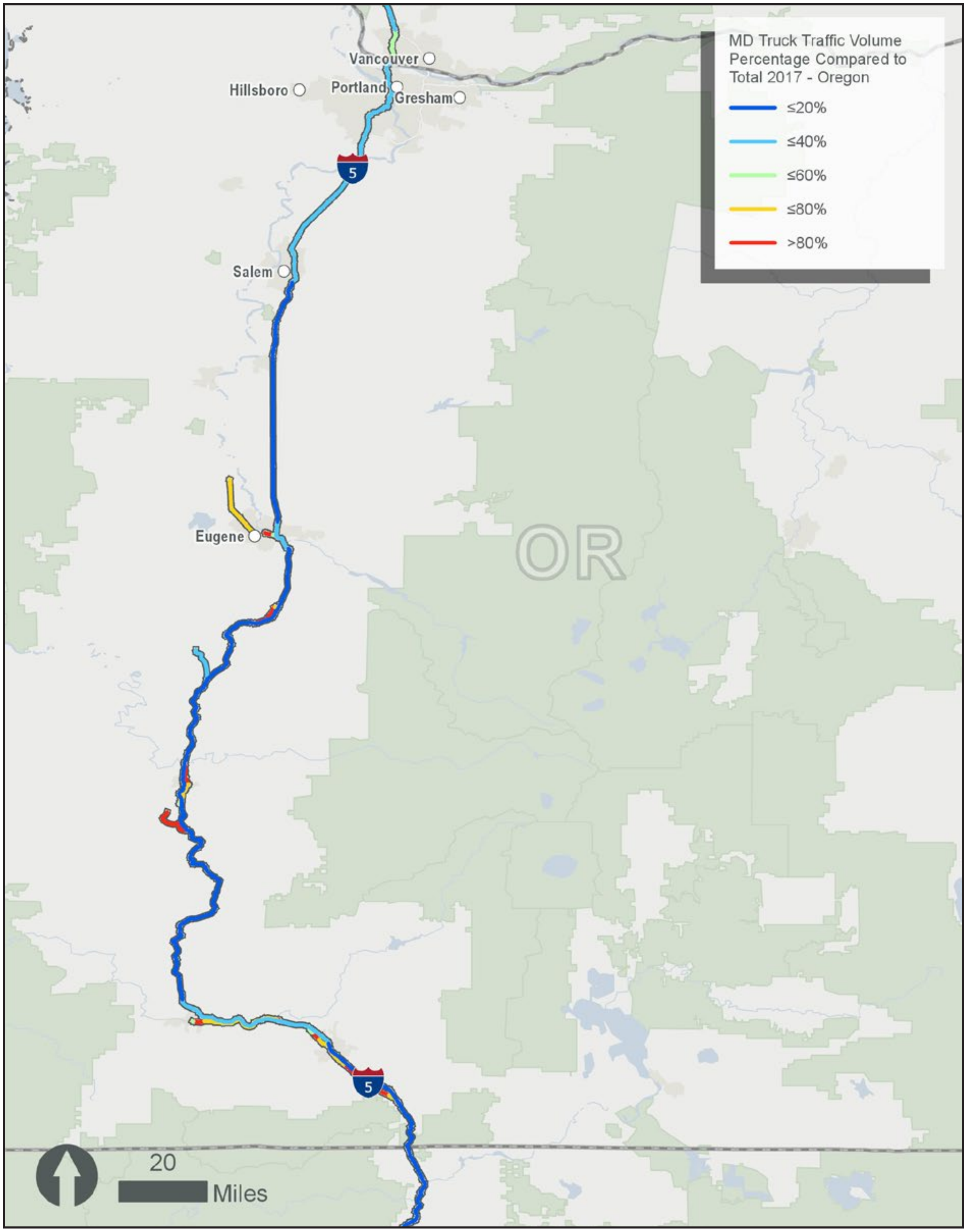
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-37: Projected (2030) MD Truck AADT in Oregon



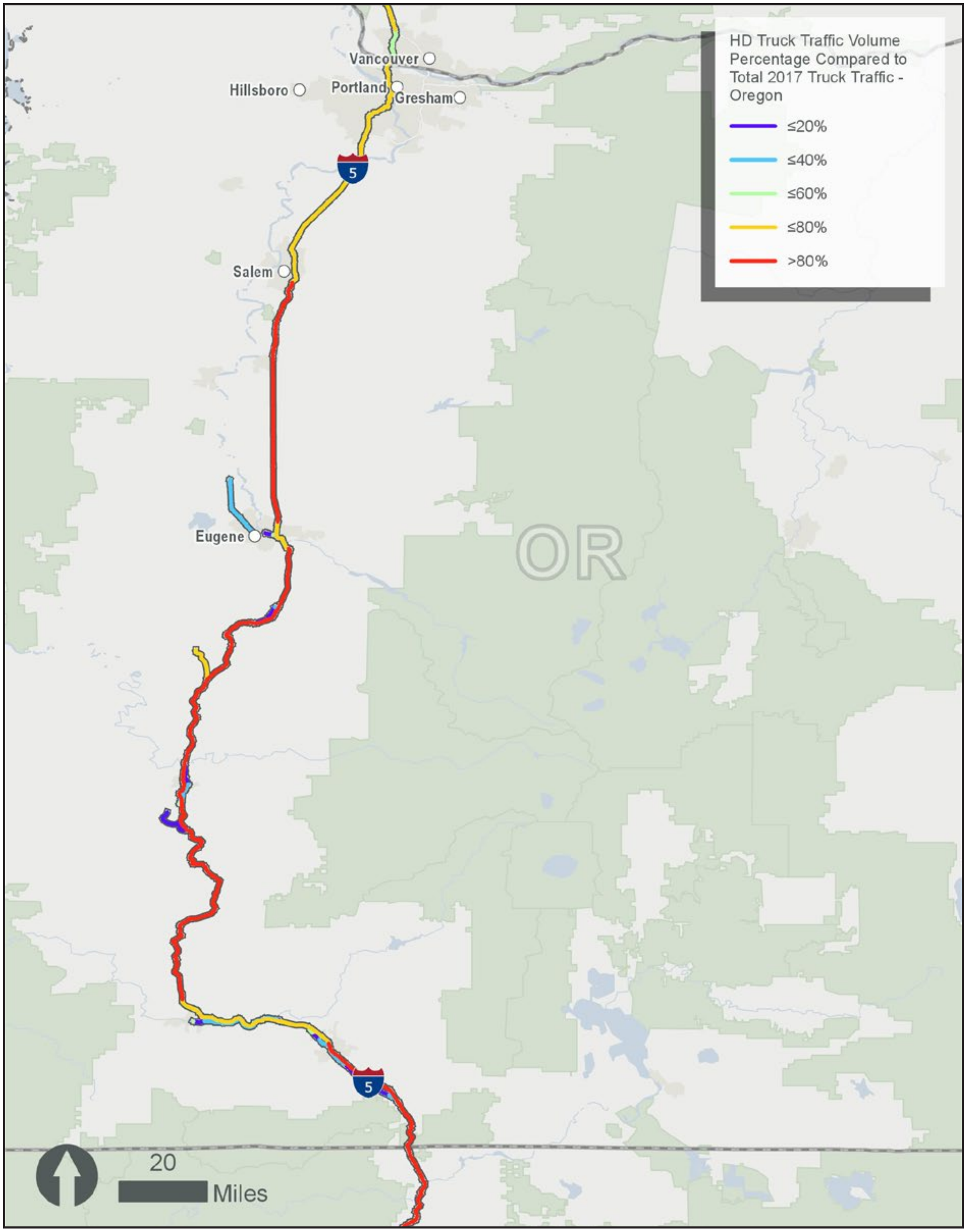
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-38: Projected (2030) HD Truck AADT in Oregon



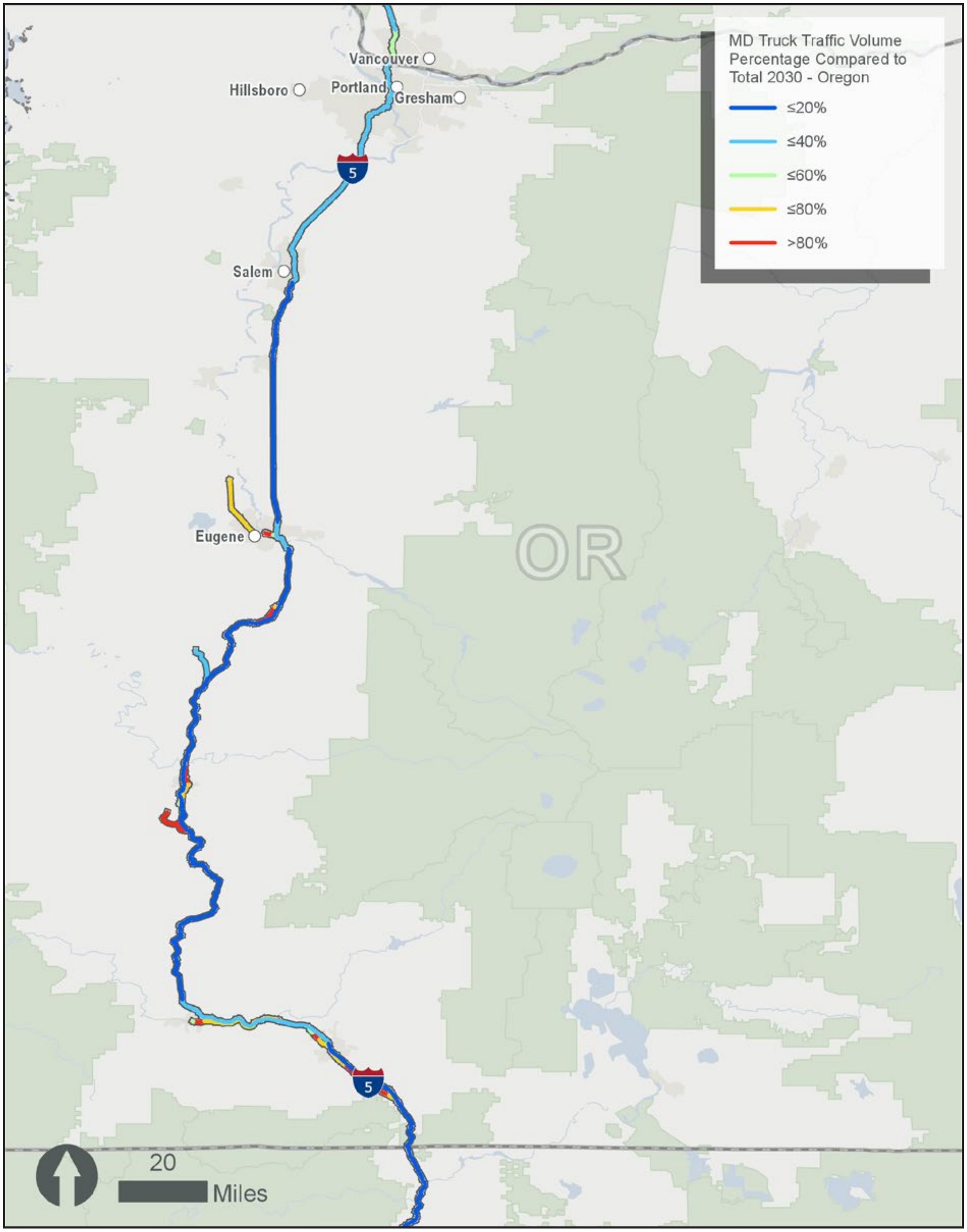
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-39: Existing (2017) MD Truck AADT Percentage Compared with Total MD/HD in Oregon



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-40: Existing (2017) HD Truck AADT Percentage Compared with Total MD/HD in Oregon



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-41: Projected (2030) MD Truck AADT Percentage Compared with Total MD/HD in Oregon

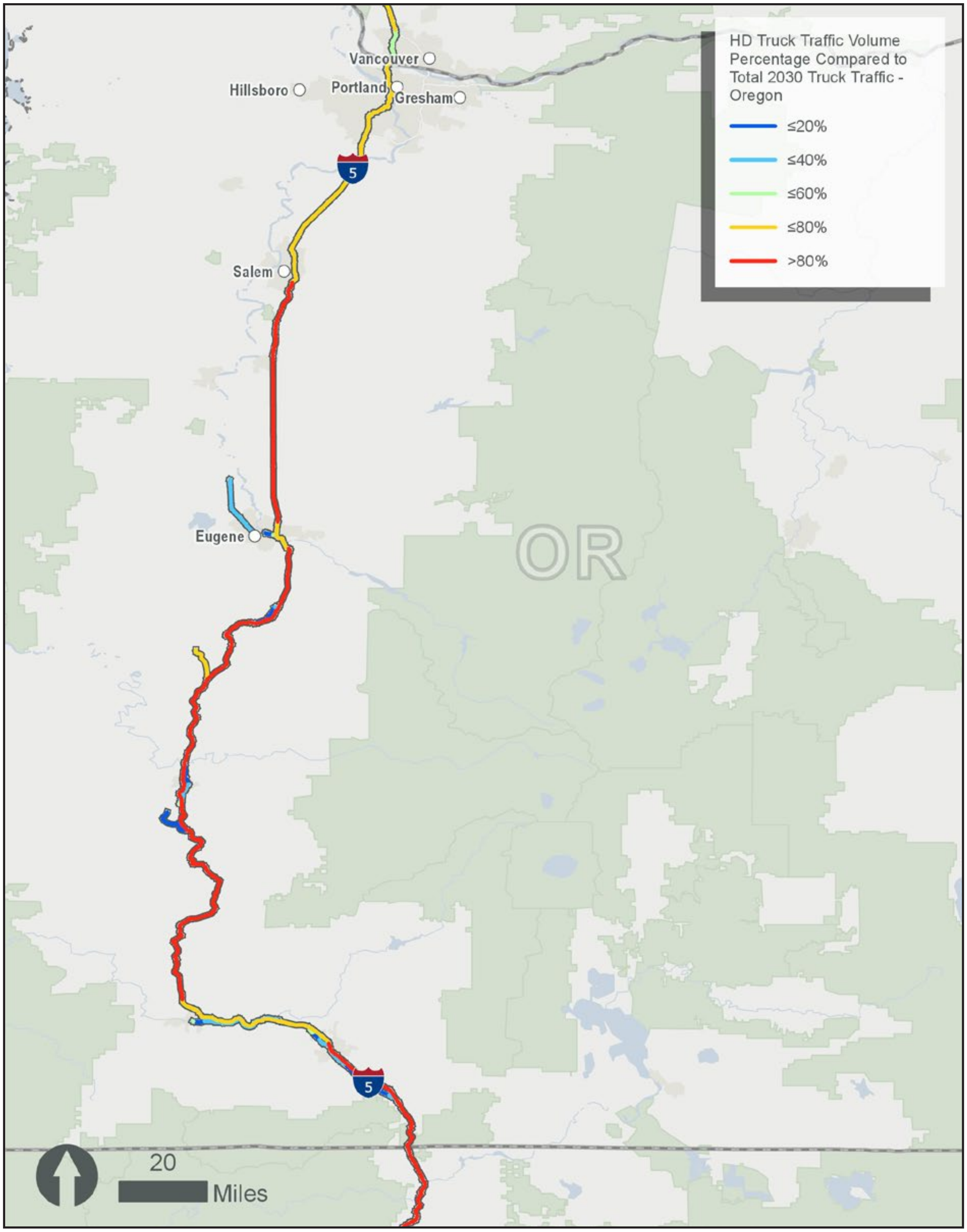


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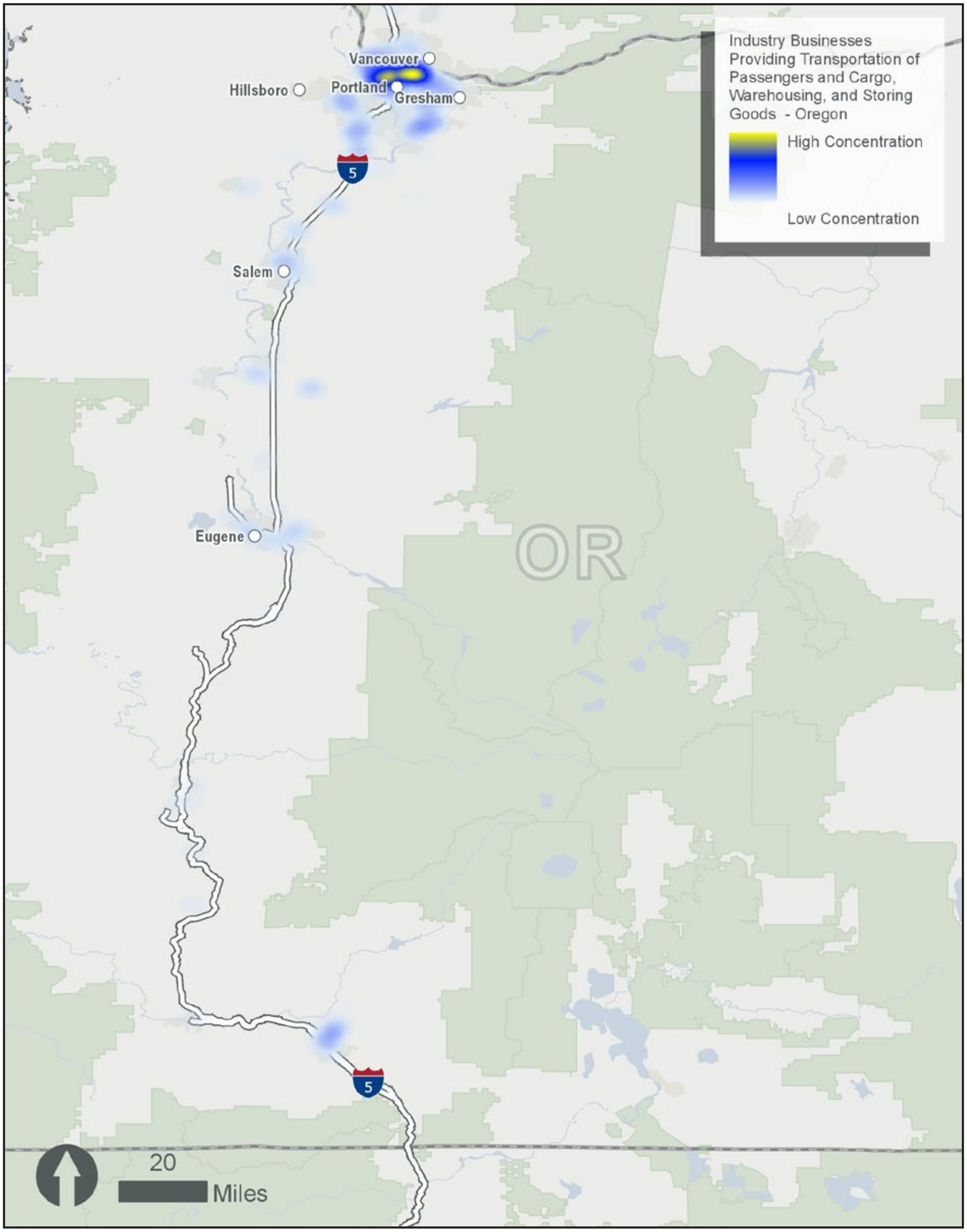
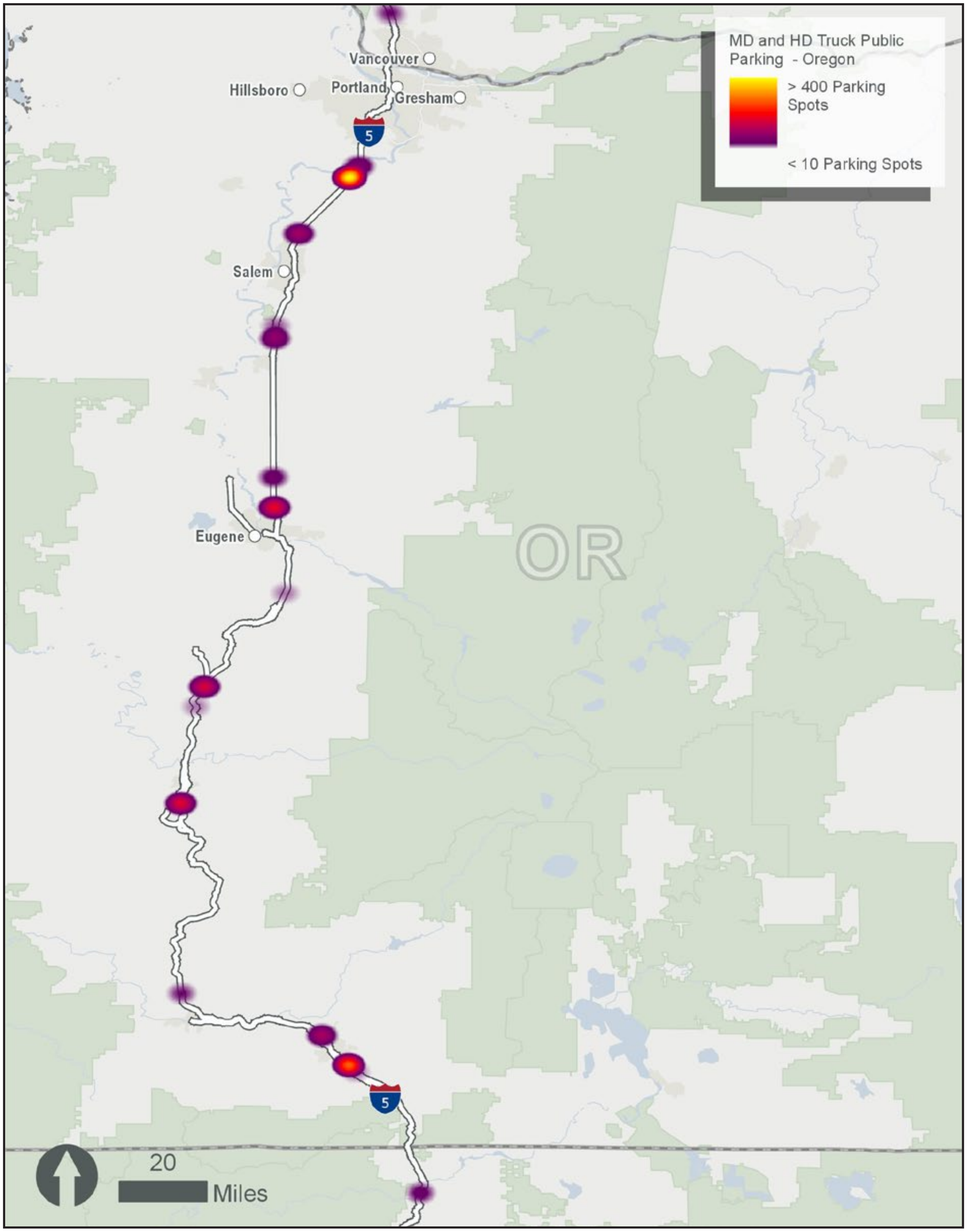
Figure A-42: Projected (2030) HD Truck AADT Percentage Compared with Total MD/HD in Oregon



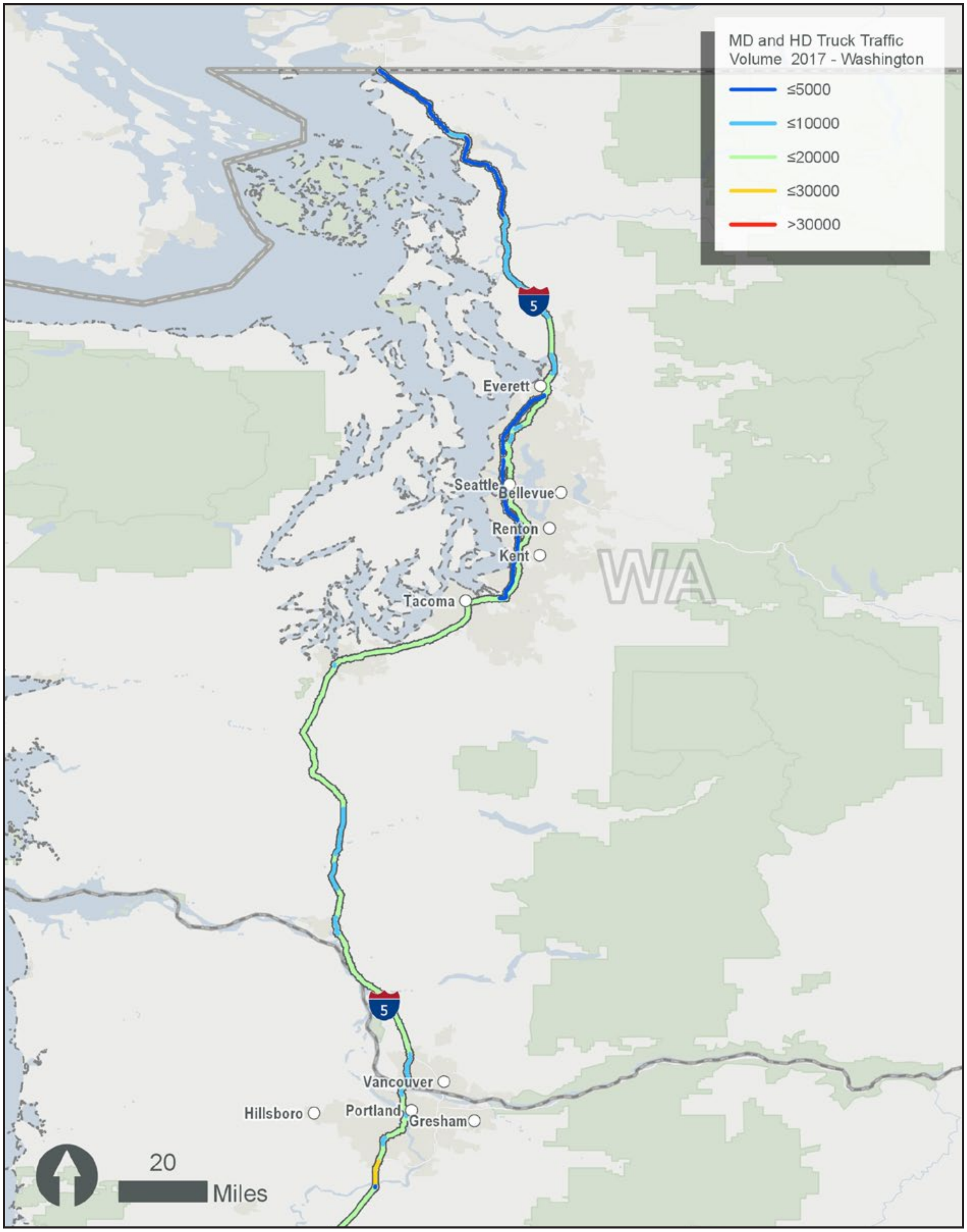
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-43: Truck-Related Industries Concentration in Oregon



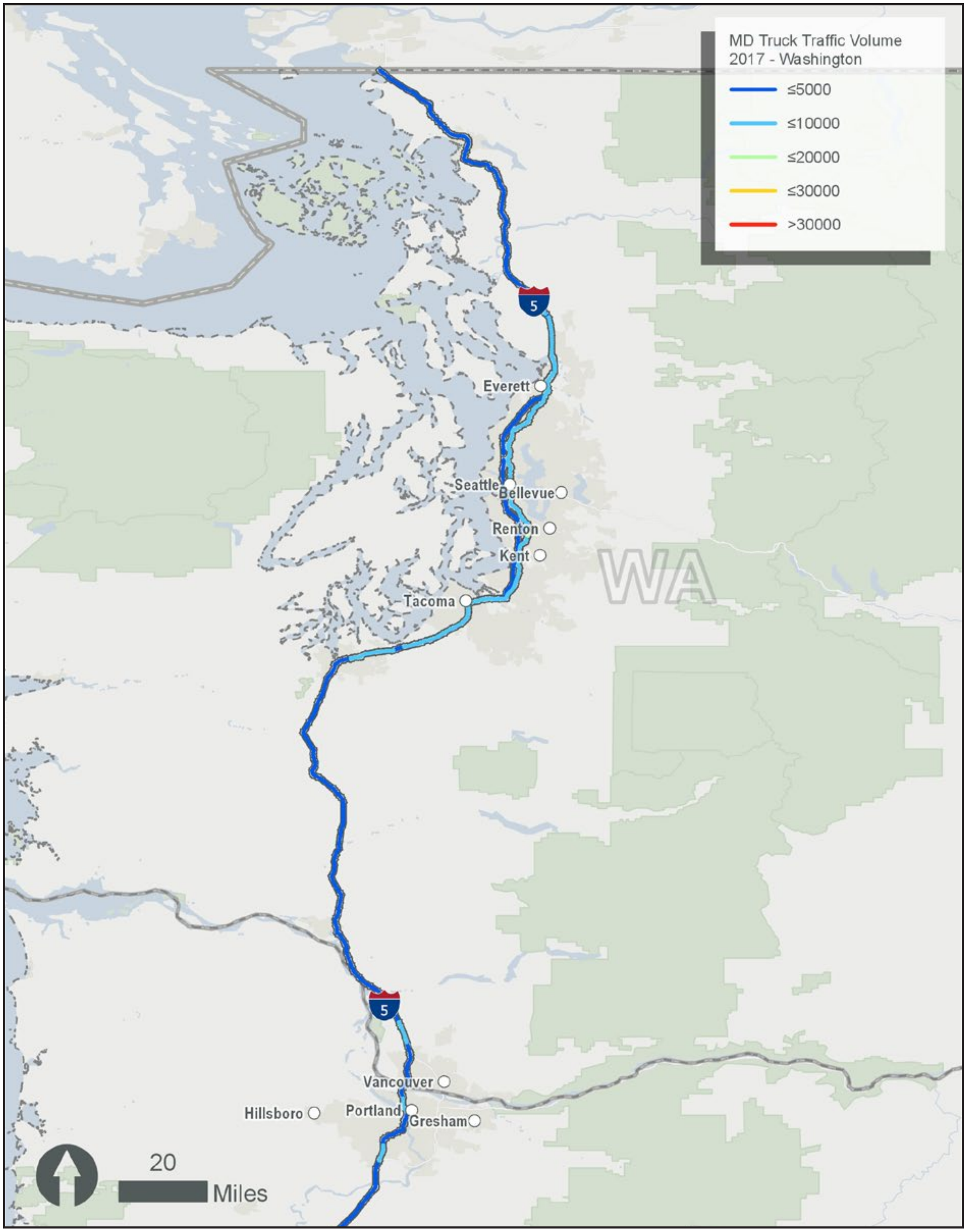
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-44: Truck Parking Locations in Oregon



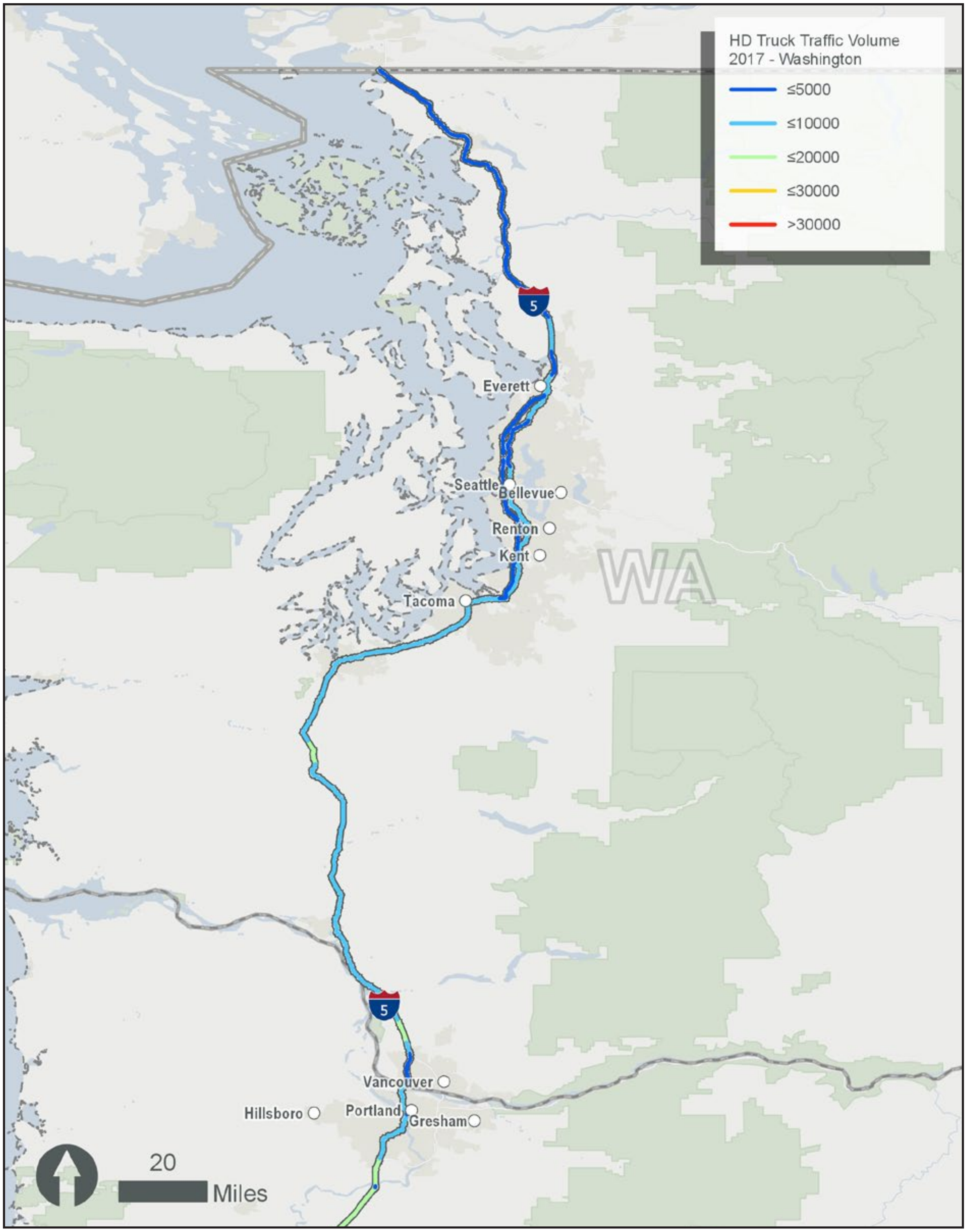
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-45: Existing (2017) MD/HD Truck AADT in Washington



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-46: Existing (2017) MD Truck AADT in Washington



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-47: Existing (2017) HD Truck AADT in Washington

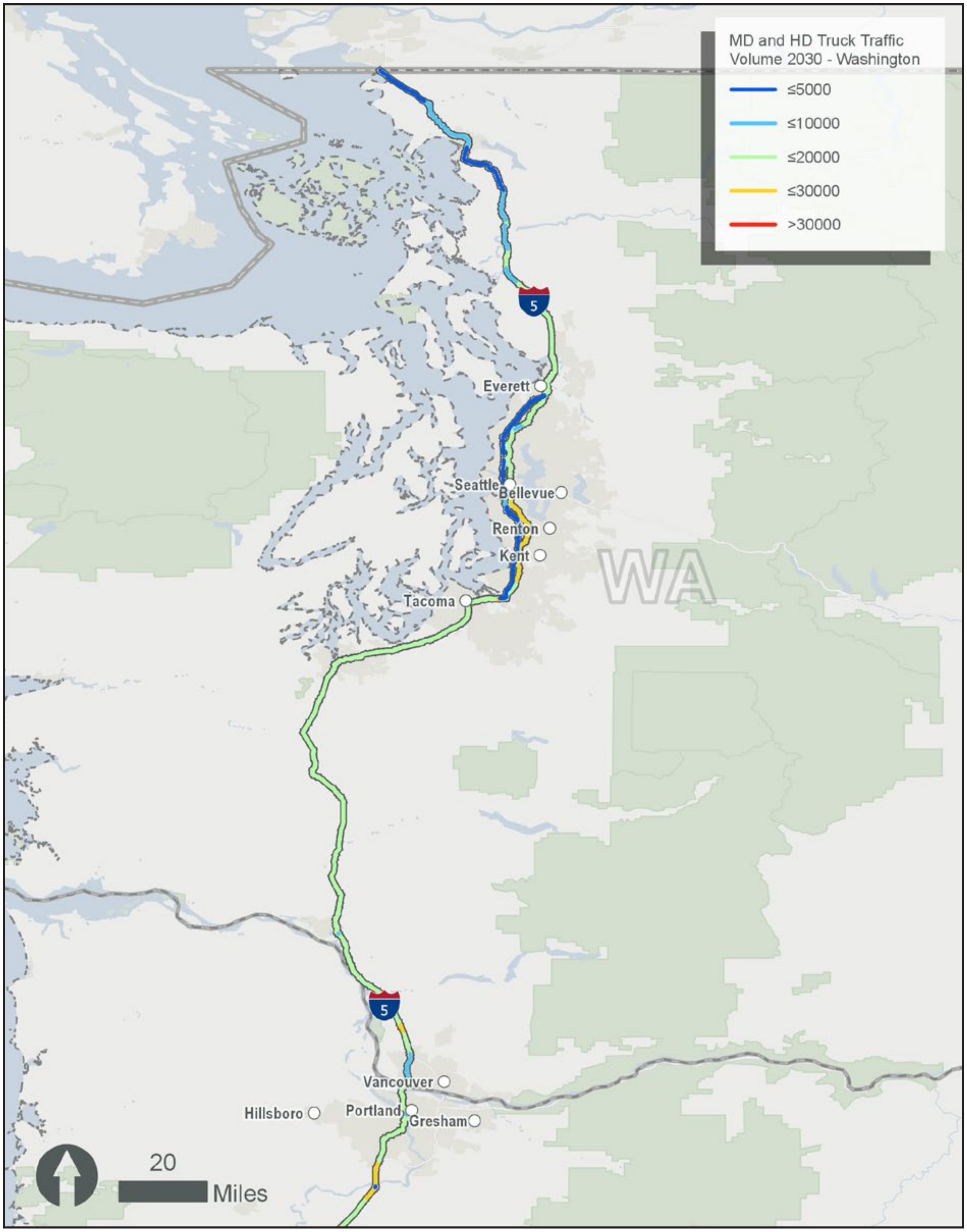


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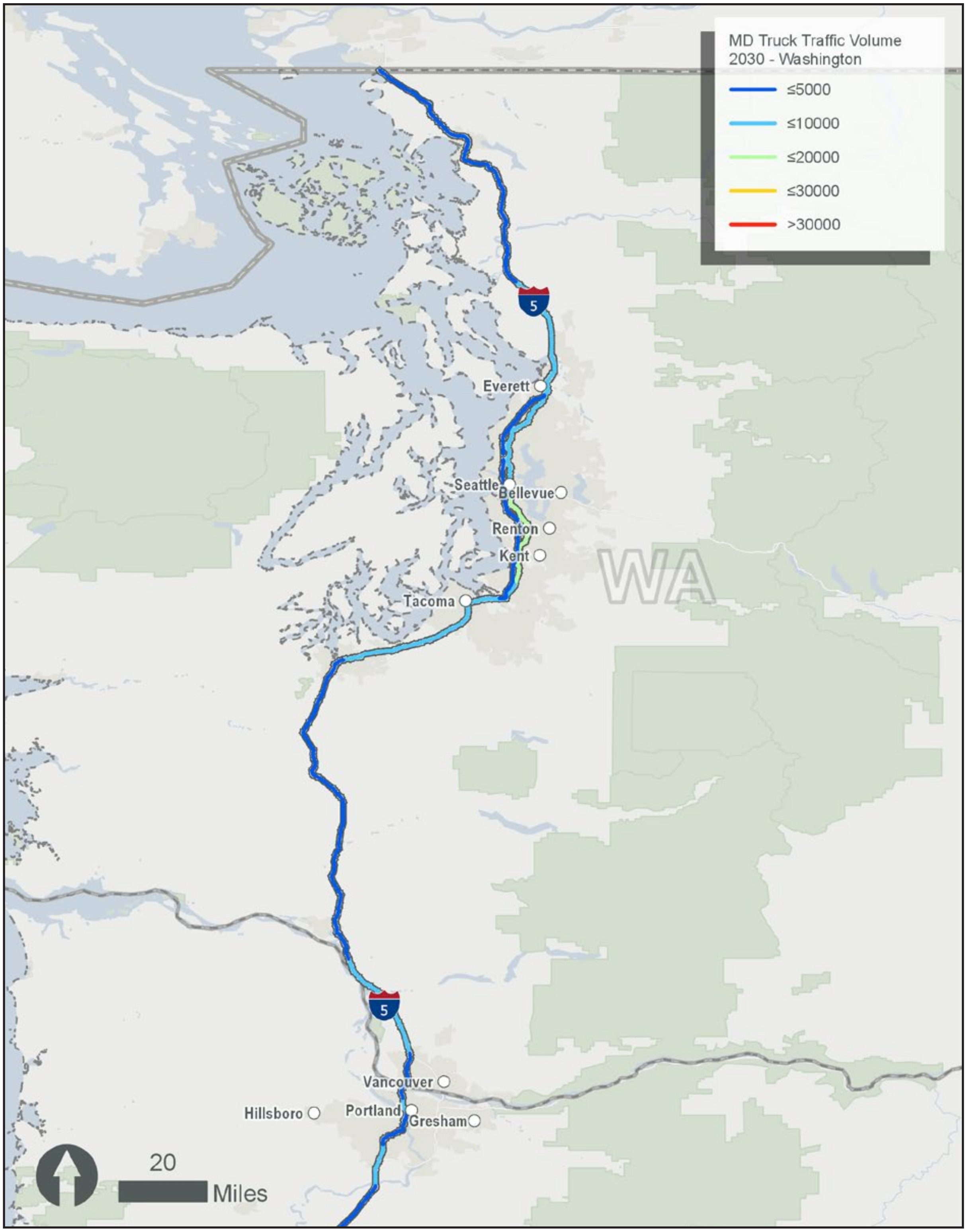
Figure A-48: Projected (2030) MD/HD Truck AADT in Washington



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-49: Projected (2030) MD Truck AADT in Washington

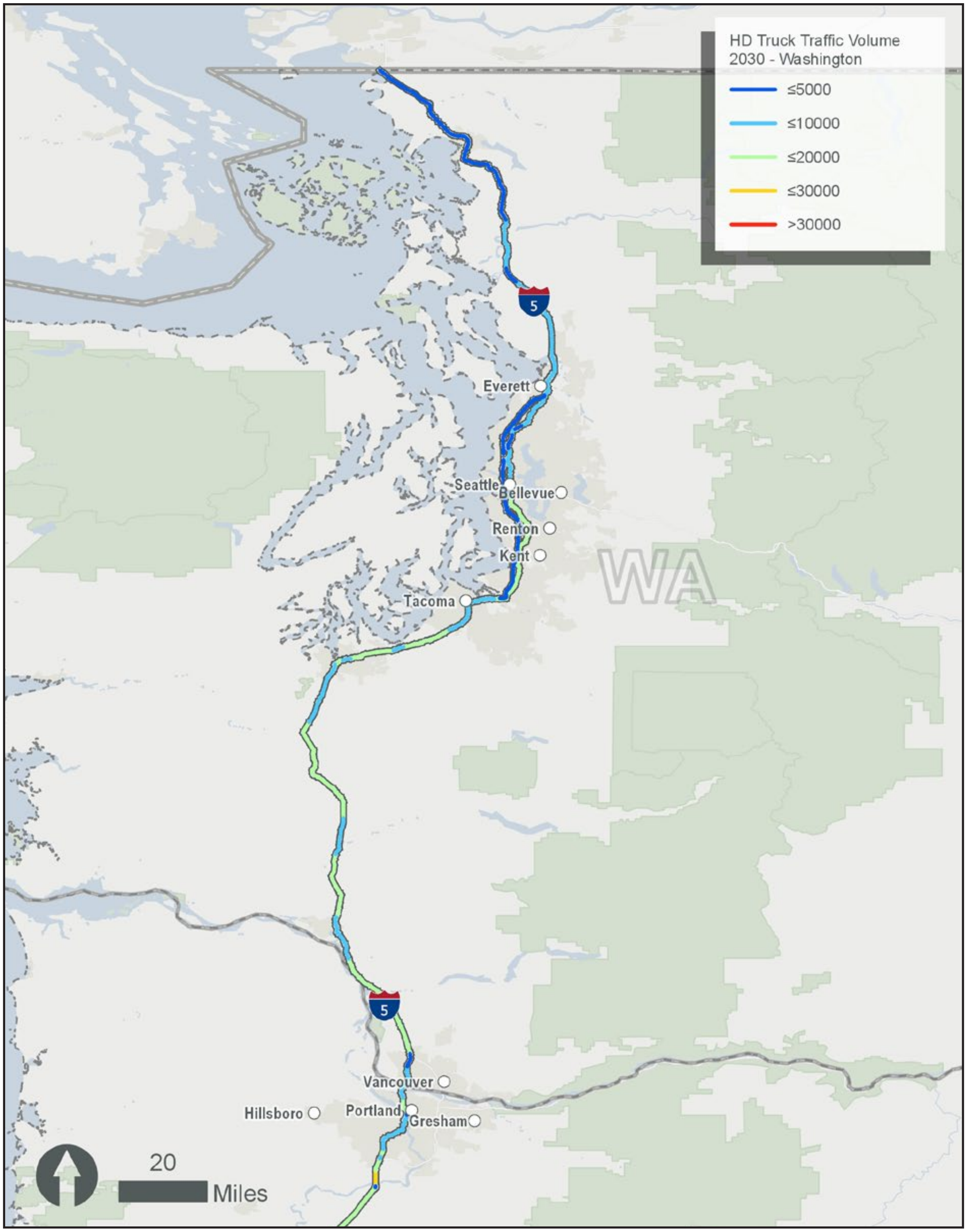


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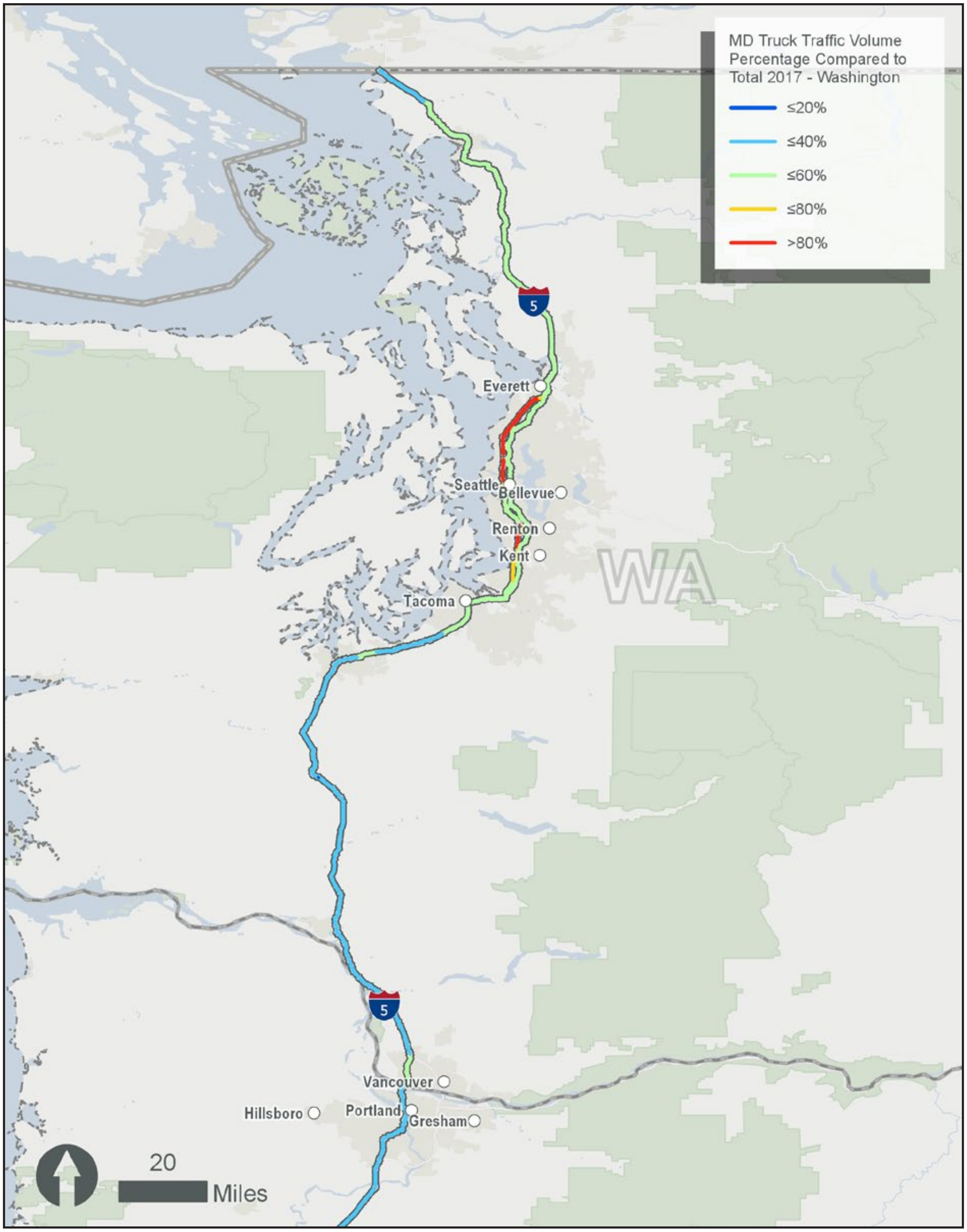
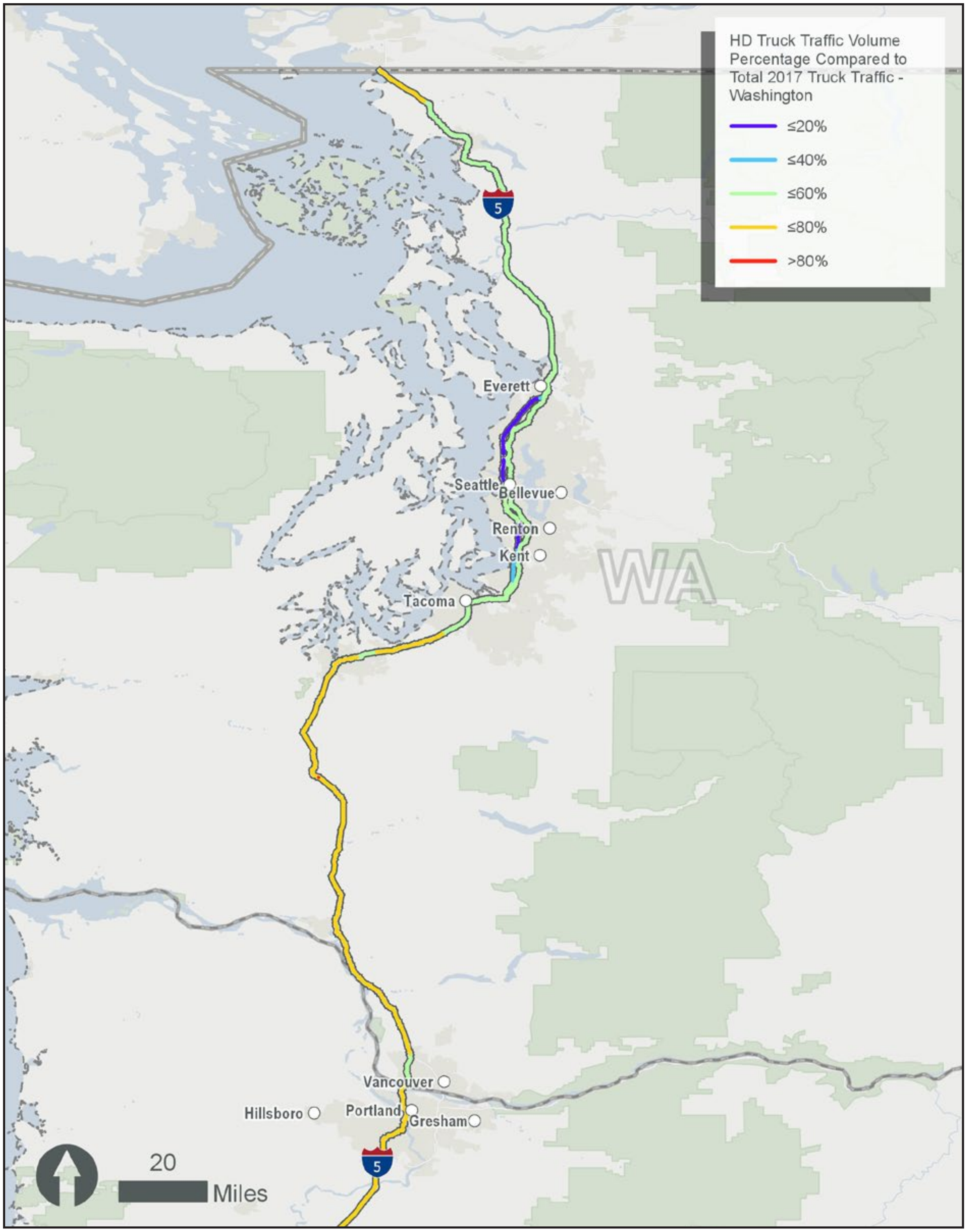
Figure A-50: Projected (2030) HD Truck AADT in Washington



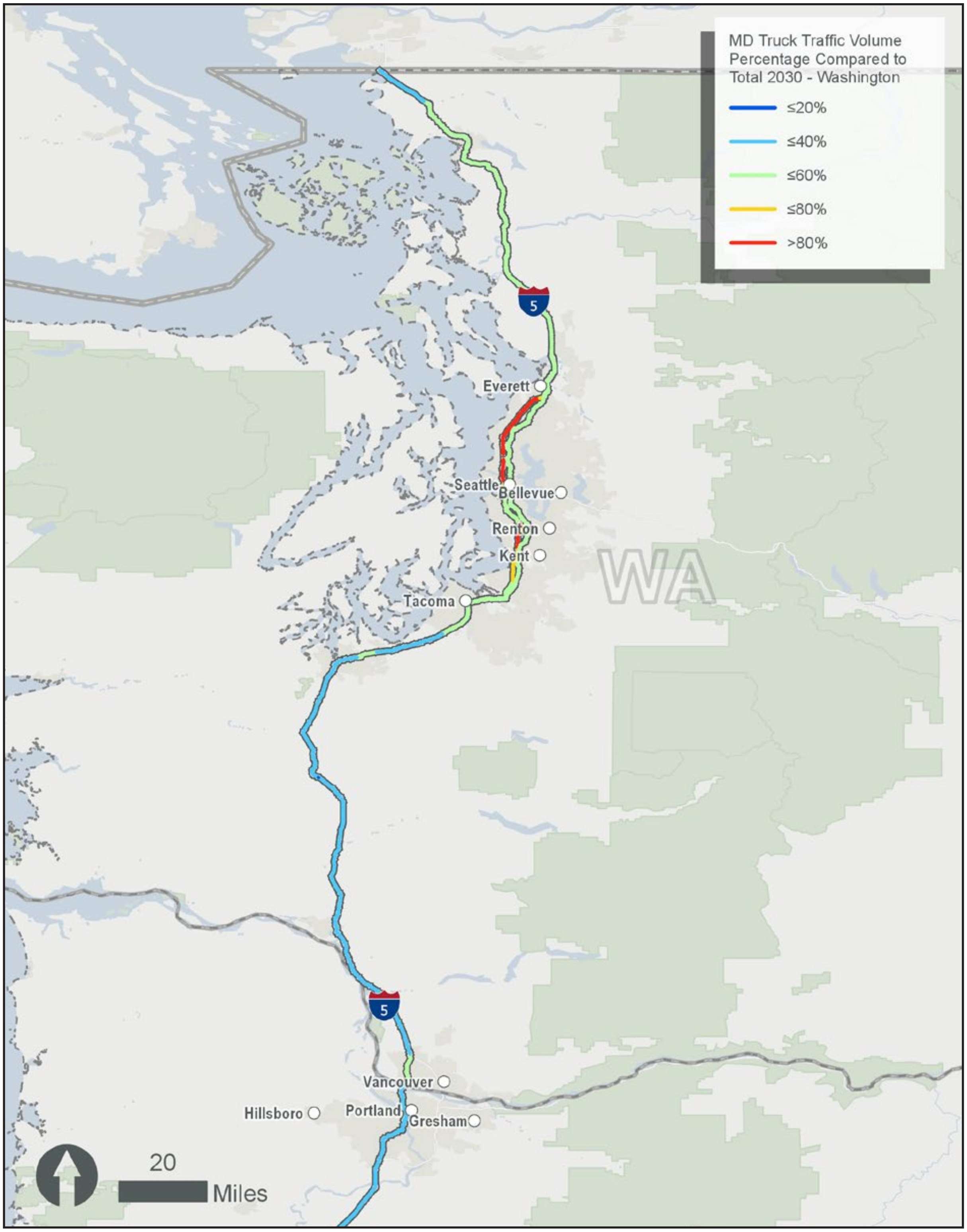
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-51: Existing (2017) MD Truck AADT Percentage Compared with Total MD/HD in Washington



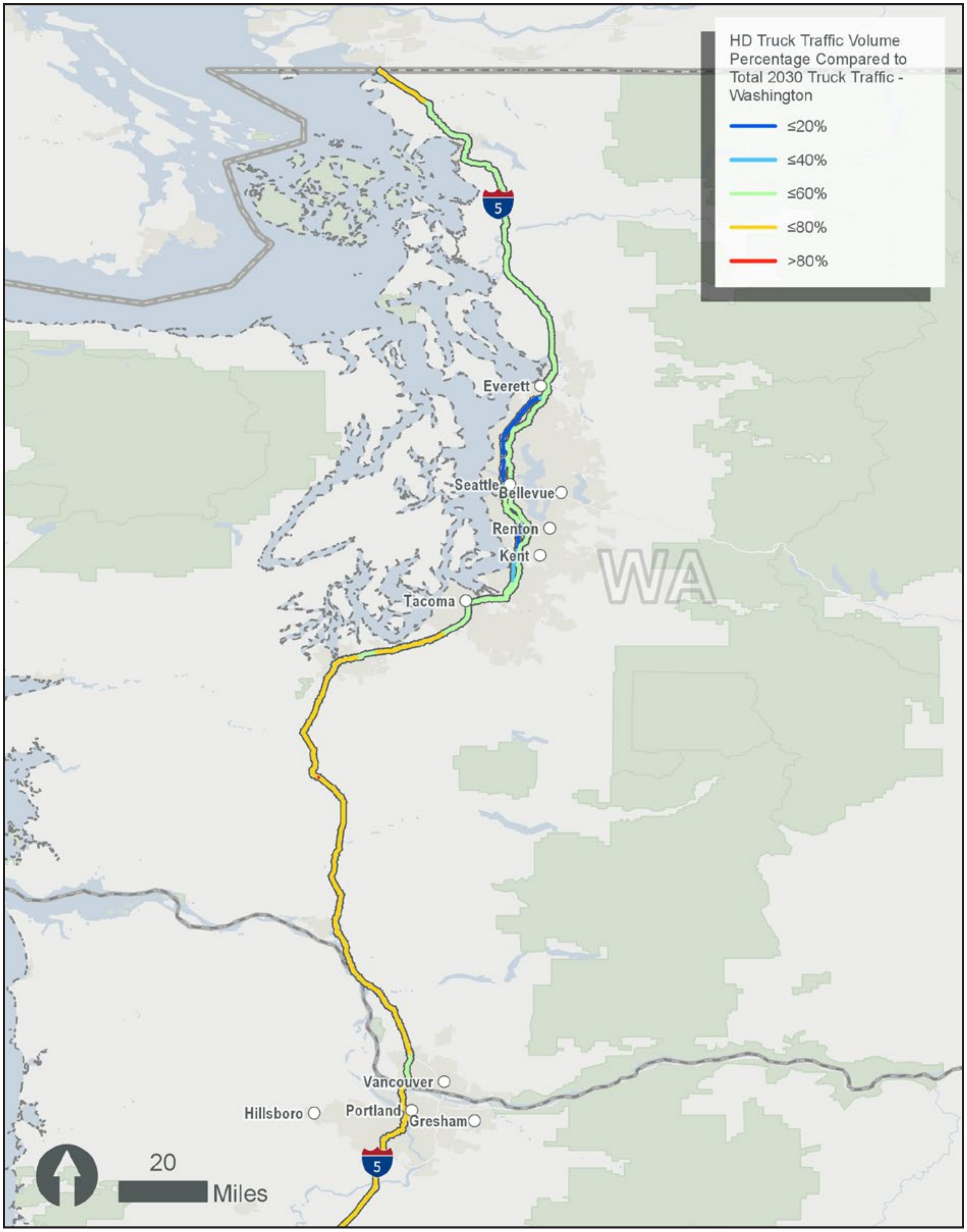
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-52: Existing (2017) HD Truck AADT Percentage Compared with Total MD/HD in Washington



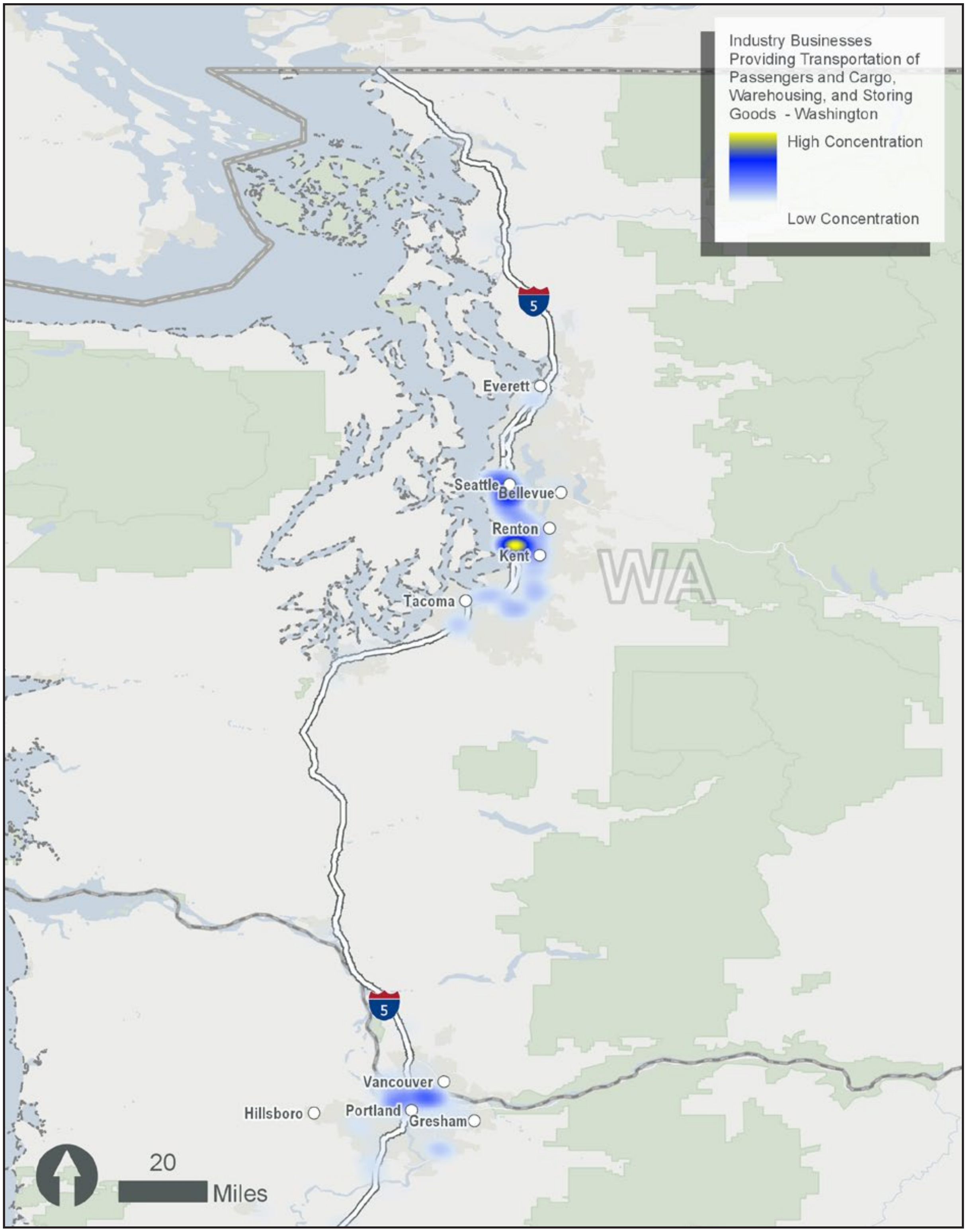
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-53: Projected (2030) MD Truck AADT Percentage Compared with Total MD/HD in Washington



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-54: Projected (2030) HD Truck AADT Percentage Compared with Total MD/HD in Washington



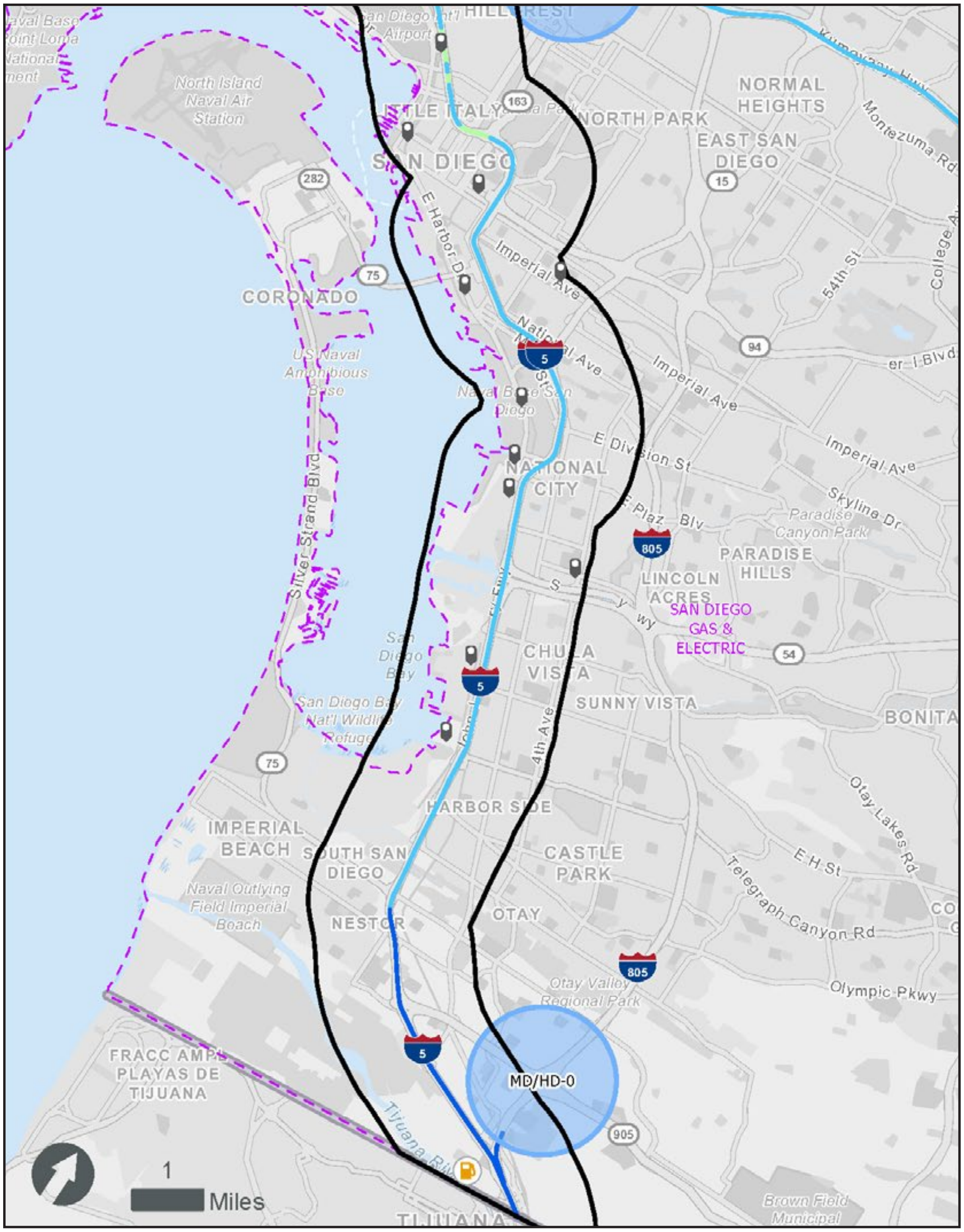
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-55: Truck-Related Industries Concentration in Washington

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure A-56: Truck Parking Locations in Washington

Appendix B. Proposed Charging Site Locations



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

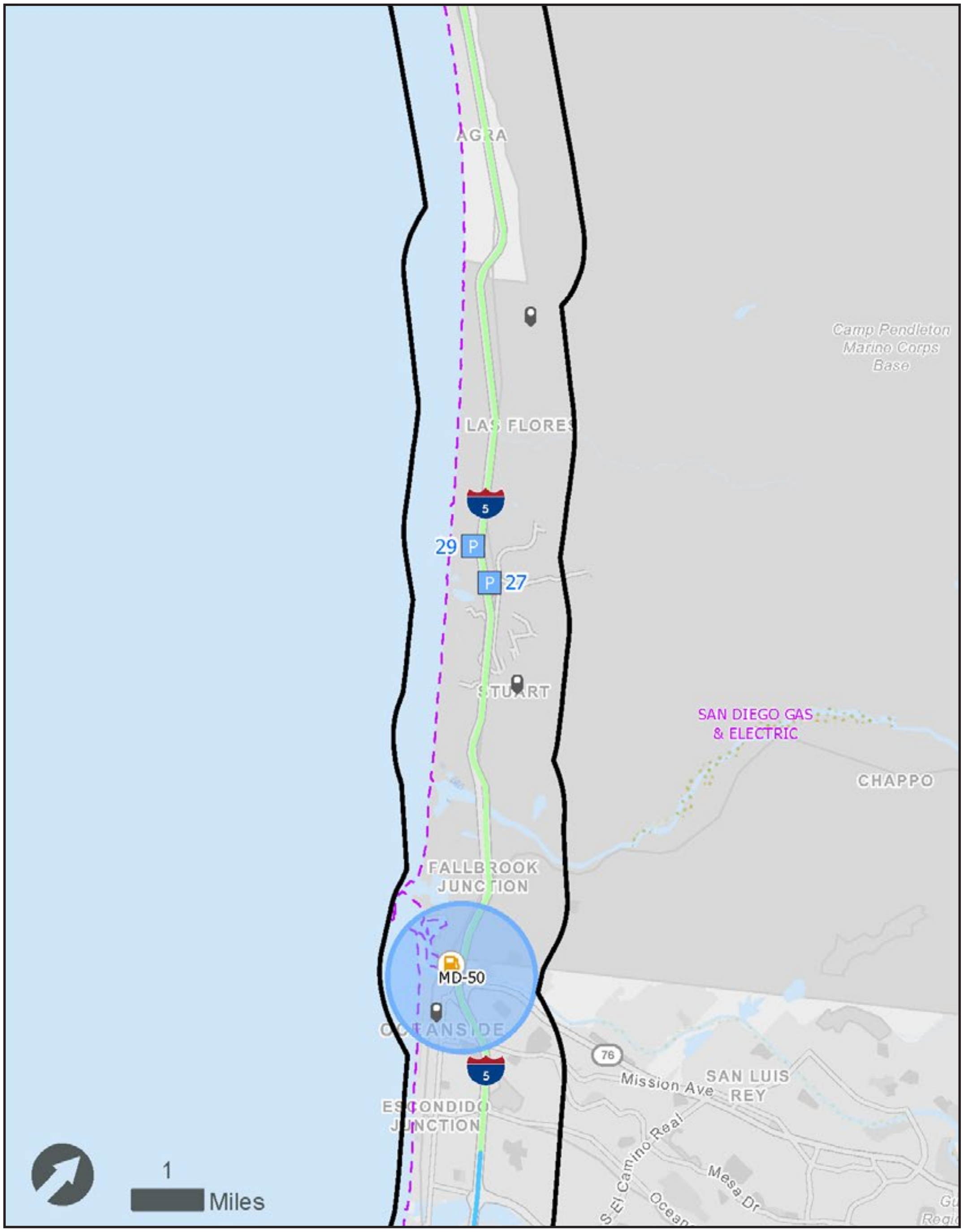
Truck Volume 2017

- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
SAN DIEGO GAS & ELECTRIC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-1: I-5 Proposed Charging Location MD/HD-0



- WCCTCI Study Area Potential
- Charging Location Truck Parking
- Location
- Substation
- Electric Retail Service Territories
- Existing DC Fast Charging Public Stations

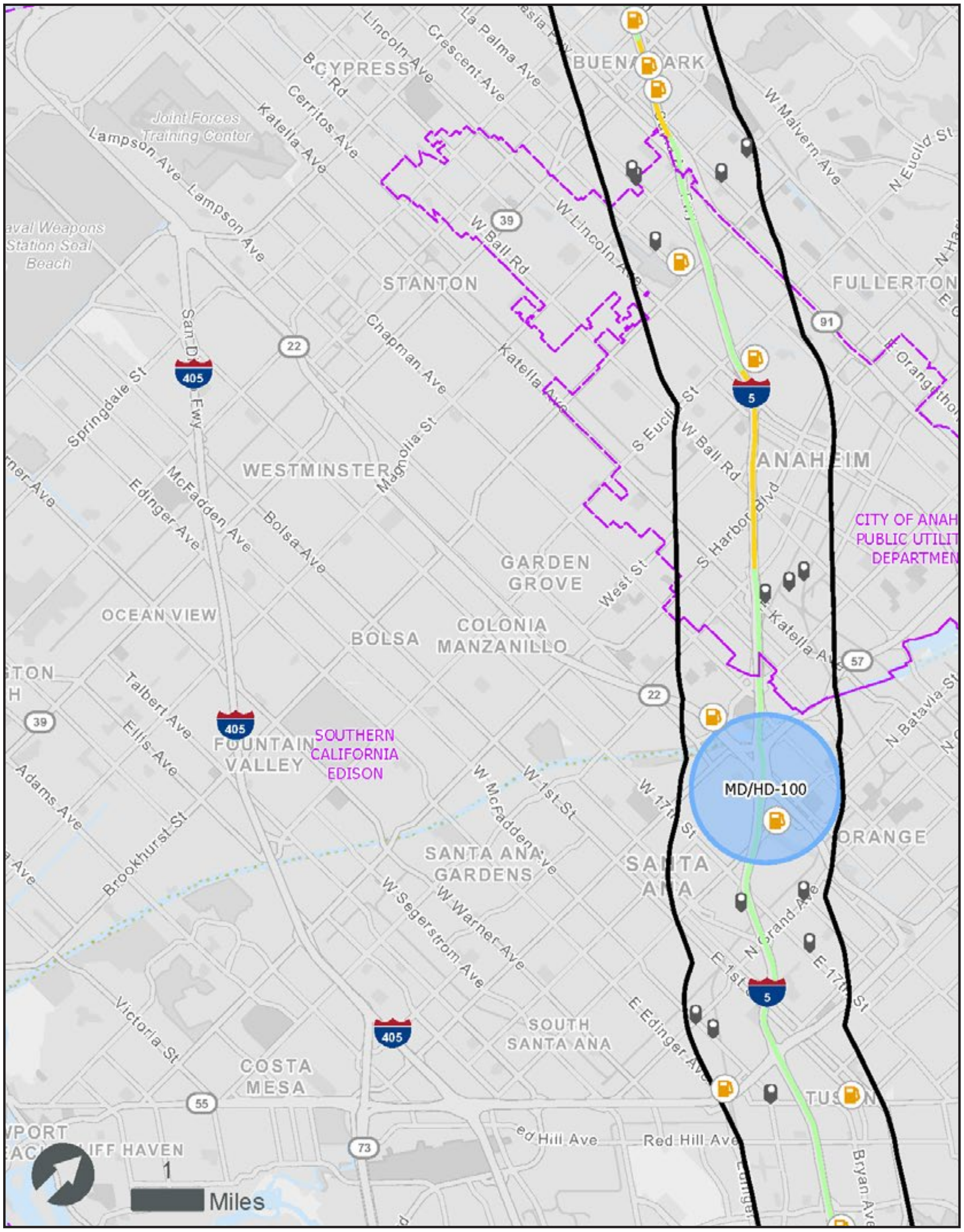
Truck Volume 2017

- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
SAN DIEGO GAS & ELECTRIC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-2: I-5 Proposed Charging Location MD-50



▭	WCCTCI Study Area Potential
▭	Charging Location Truck Parking
P	Location
	Substation
⬚	Electric Retail Service Territories
	Existing DC Fast Charging Public Stations

Truck Volume 2017

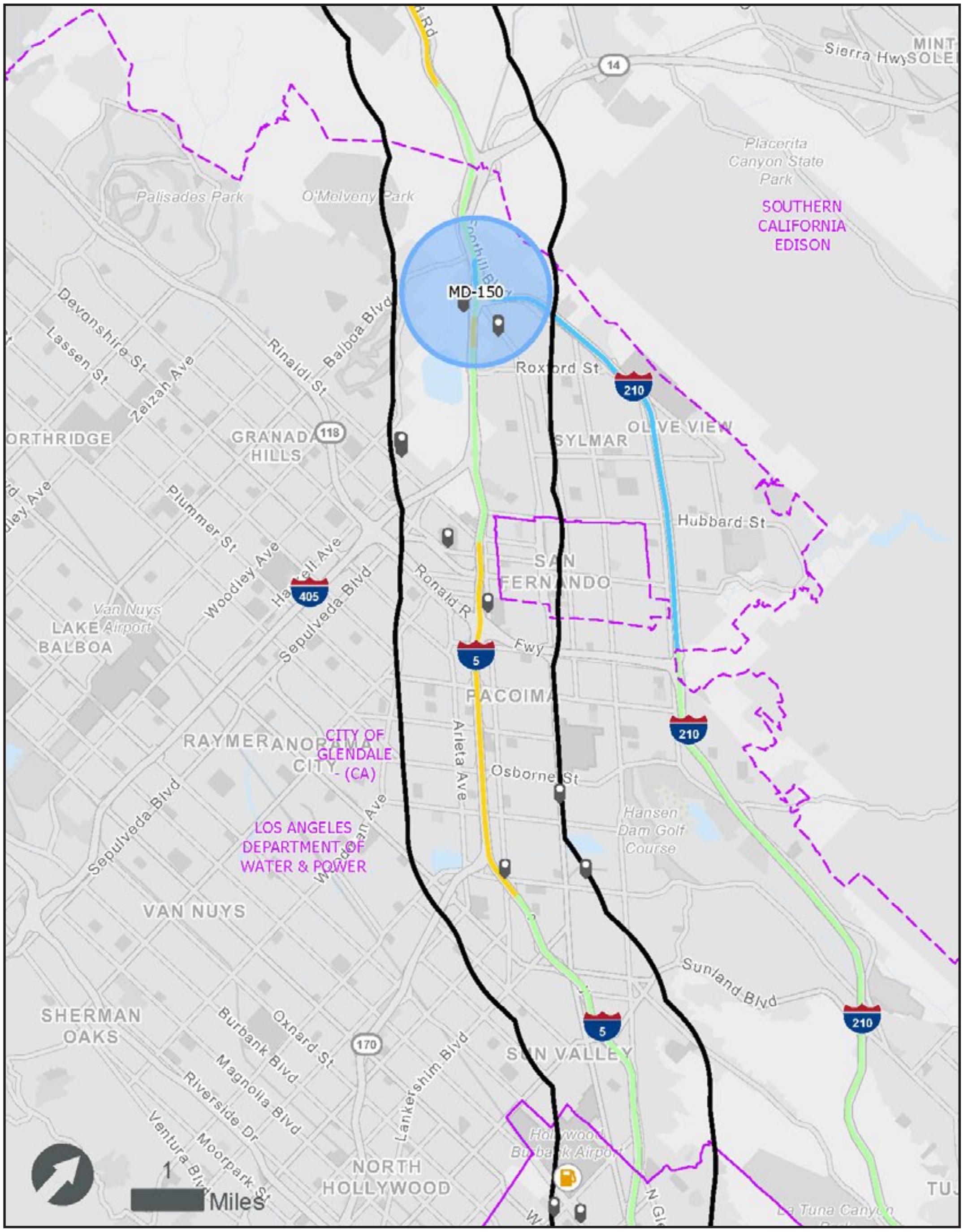
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON , CITY OF ANAHEIM PUBLIC UTILITIES DEPARTMENT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-3: I-5 Proposed Charging Location MD/HD-100



- WCCTCI Study Area Potential
- Charging Location Truck Parking
- Location
- Substation
- Electric Retail Service Territories
- Existing DC Fast Charging Public Stations

Truck Volume 2017

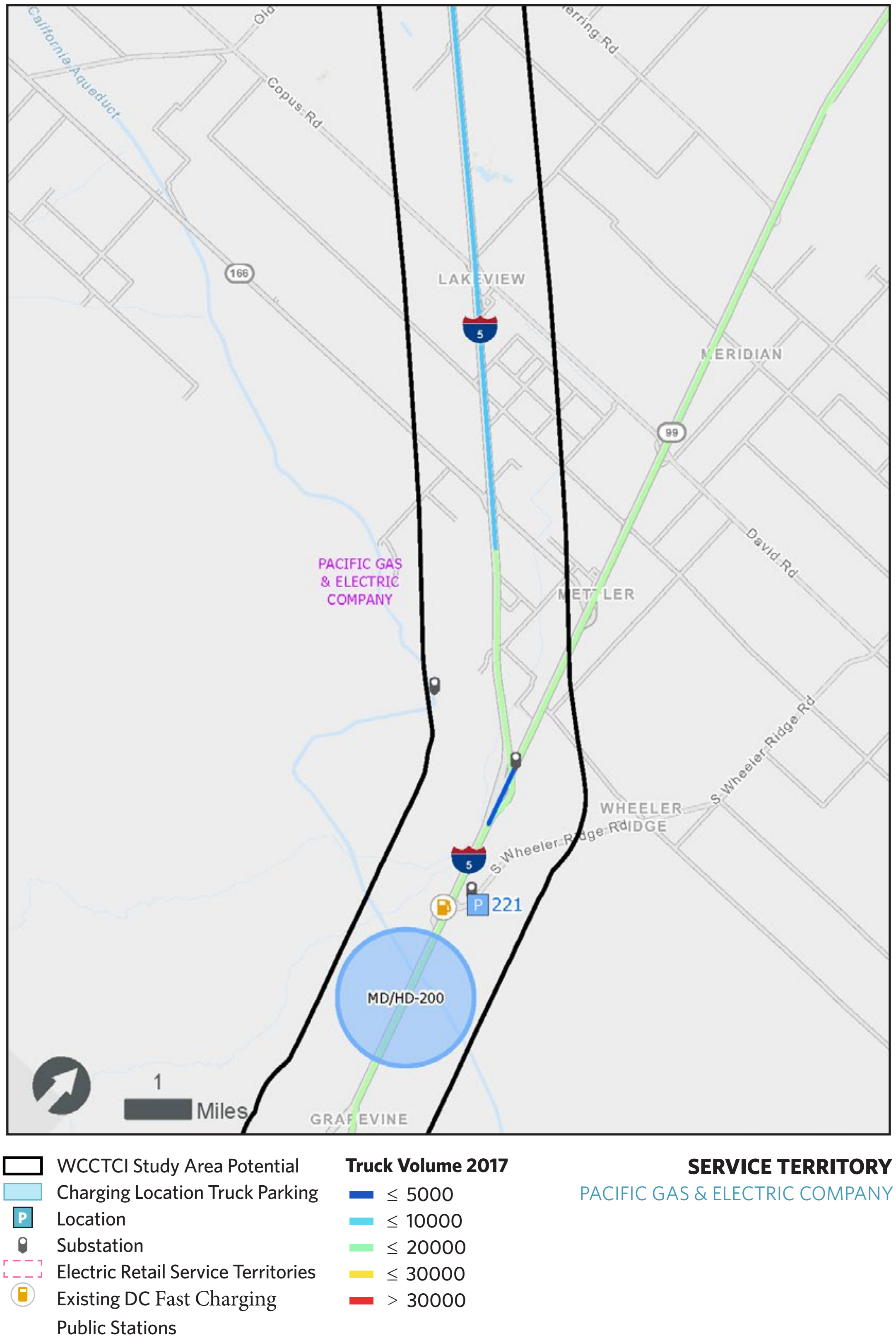
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, LOS ANGELES DEPARTMENT OF WATER & POWER, BURBANK WATER & POWER, CITY OF GLENDALE - (CA)

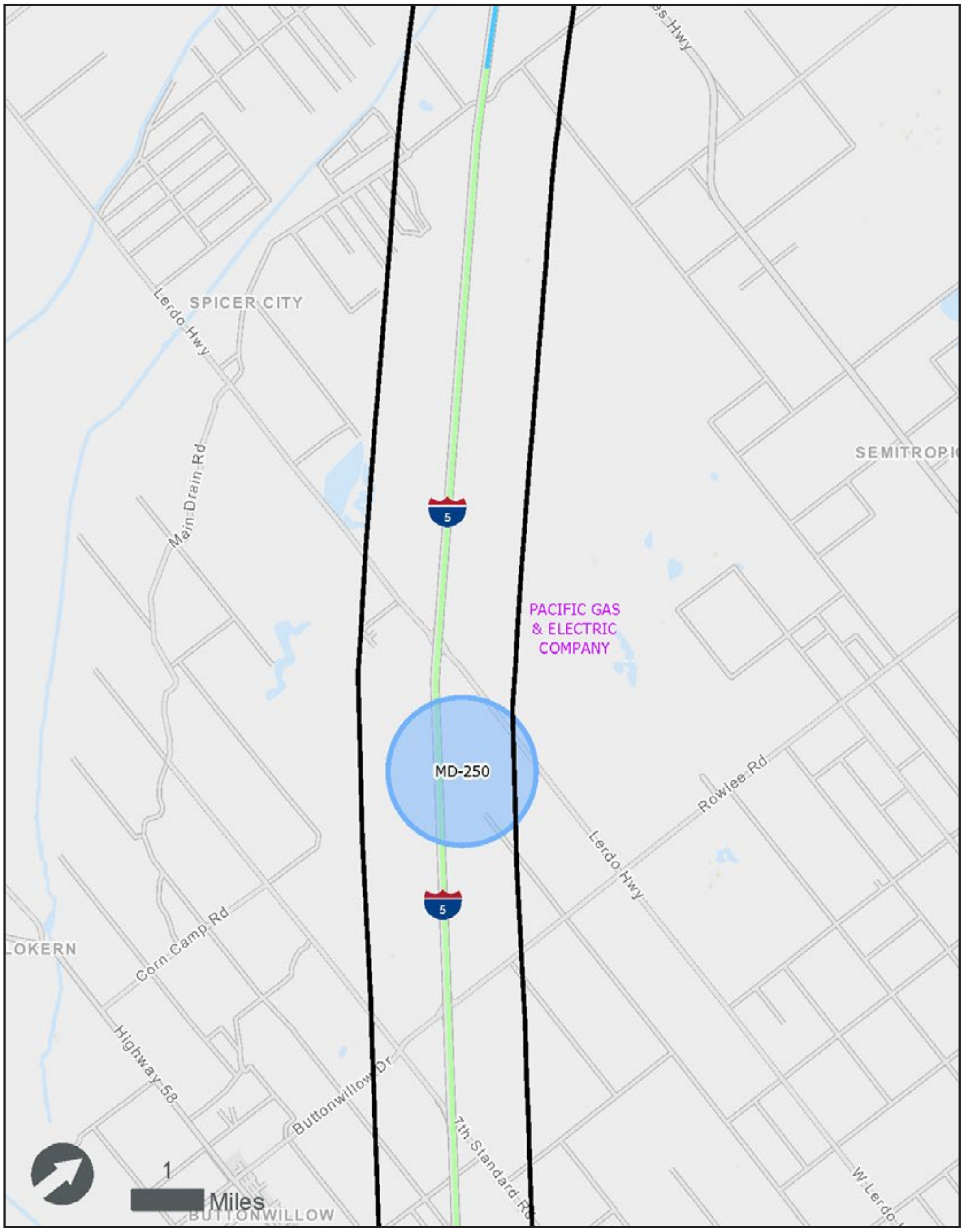
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-4: I-5 Proposed Charging Location MD-150



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

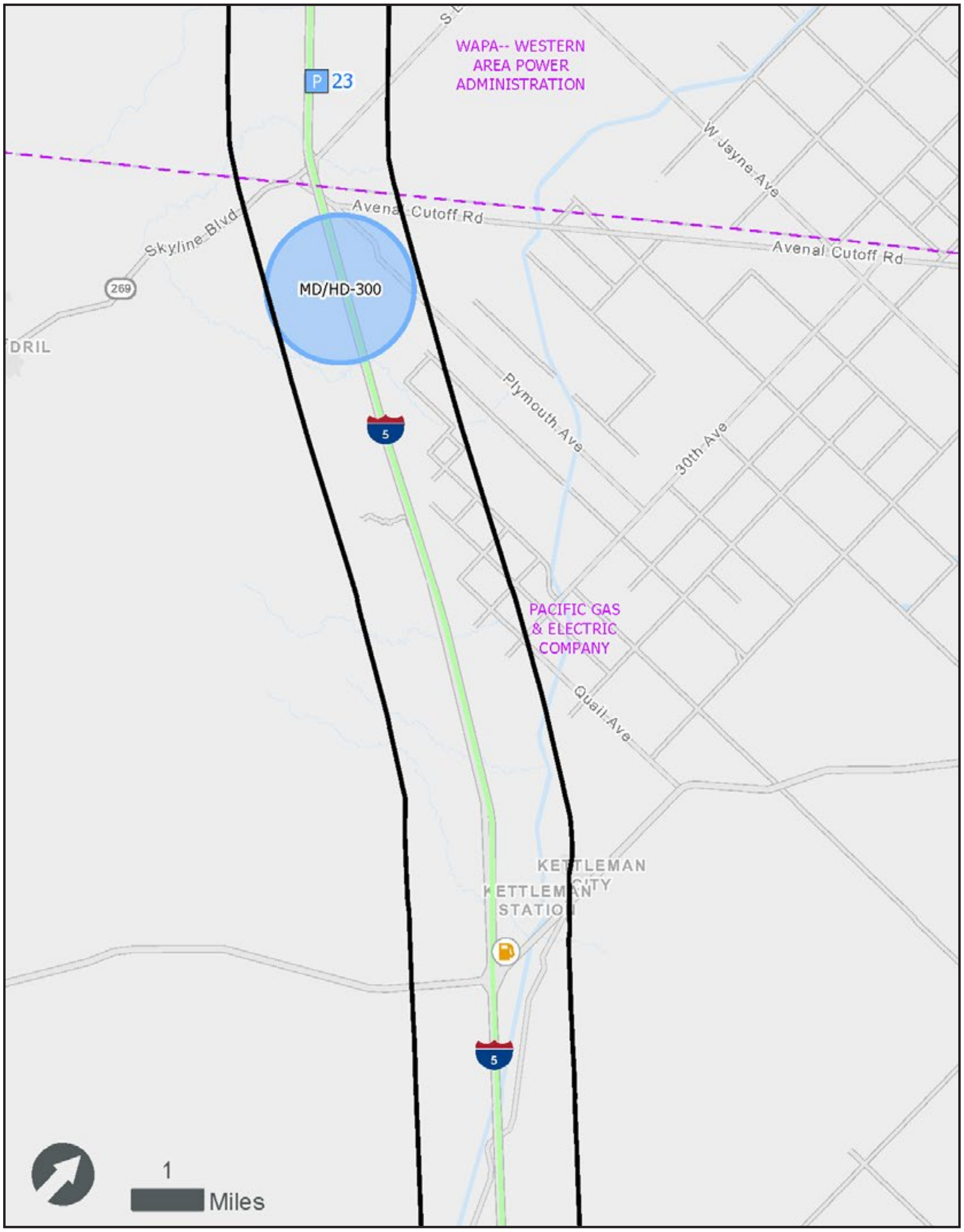
Figure B-5: I-5 Proposed Charging Location MD/HD-200



WCCTCI Study Area Potential	**Truck Volume 2017**		**SERVICE TERRITORY**
Charging Location Truck Parking		≤ 5000	PACIFIC GAS & ELECTRIC COMPANY
Location		≤ 10000	
Substation		≤ 20000	
Electric Retail Service Territories		≤ 30000	
Existing DC Fast Charging Public Stations		> 30000	

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-6: I-5 Proposed Charging Location MD-250



WCCTCI Study Area Potential
Charging Location Truck Parking
P Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

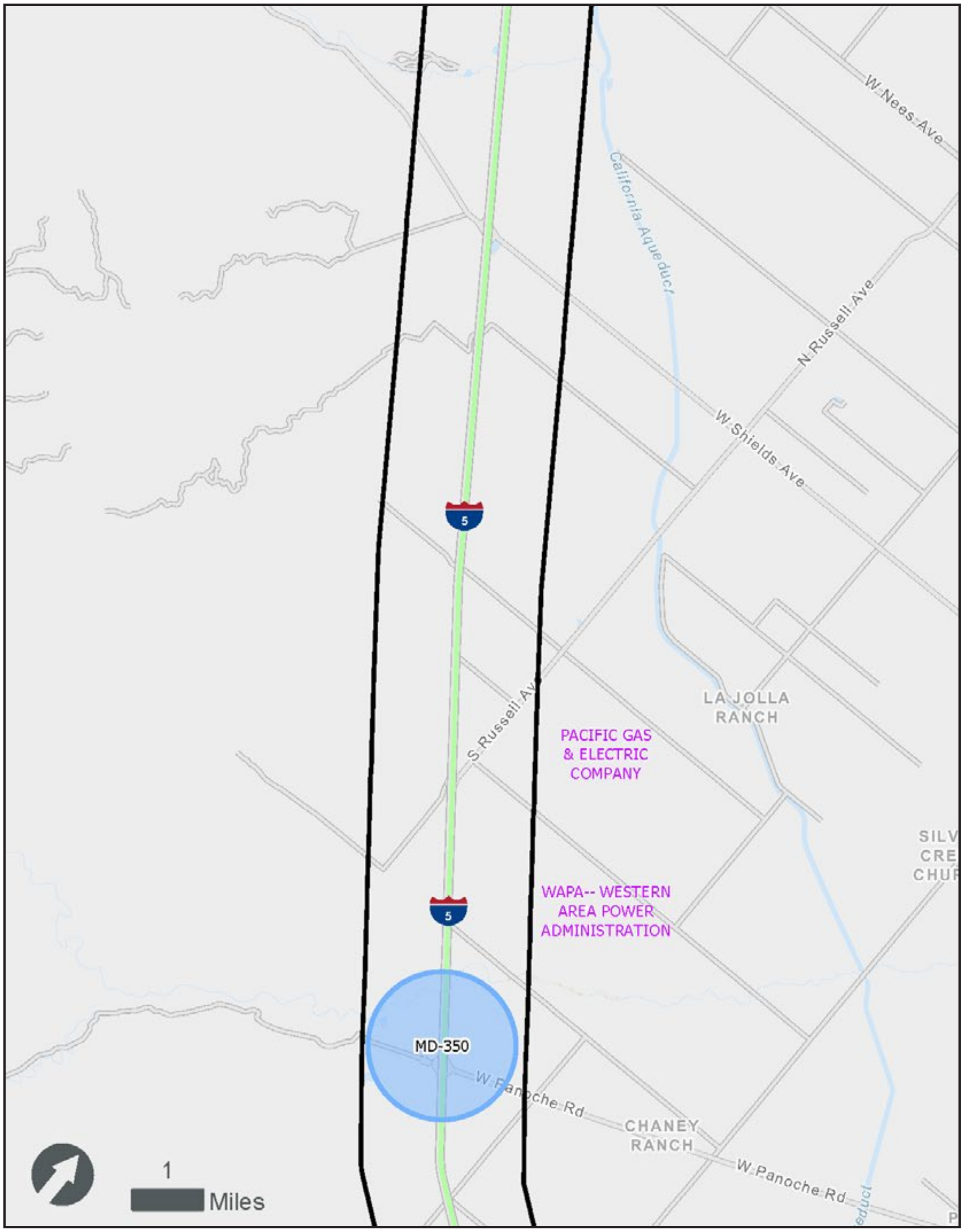
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-7: I-5 Proposed Charging Location MD/HD-300



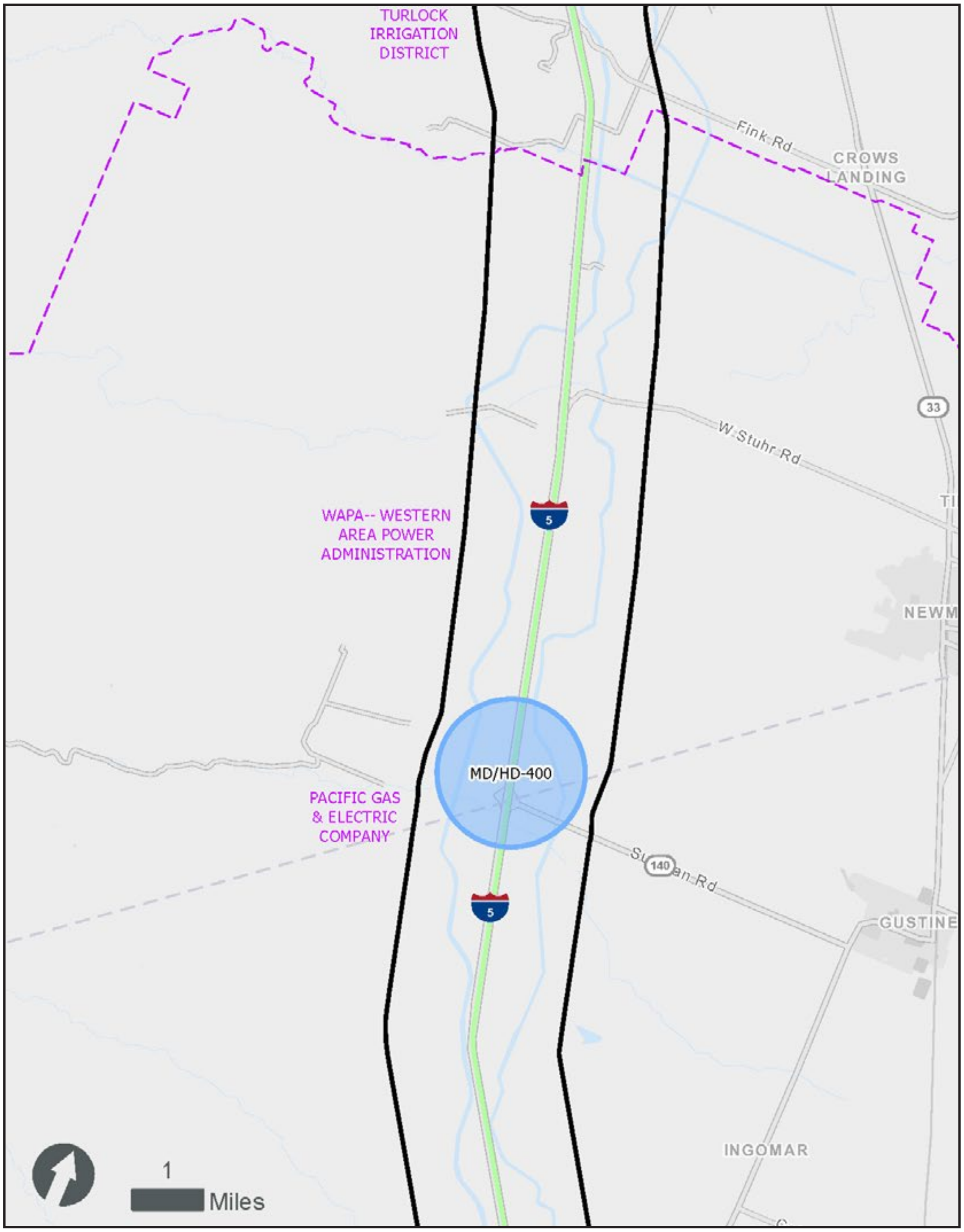
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
WAPA - WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-8: I-5 Proposed Charging Location MD-350



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

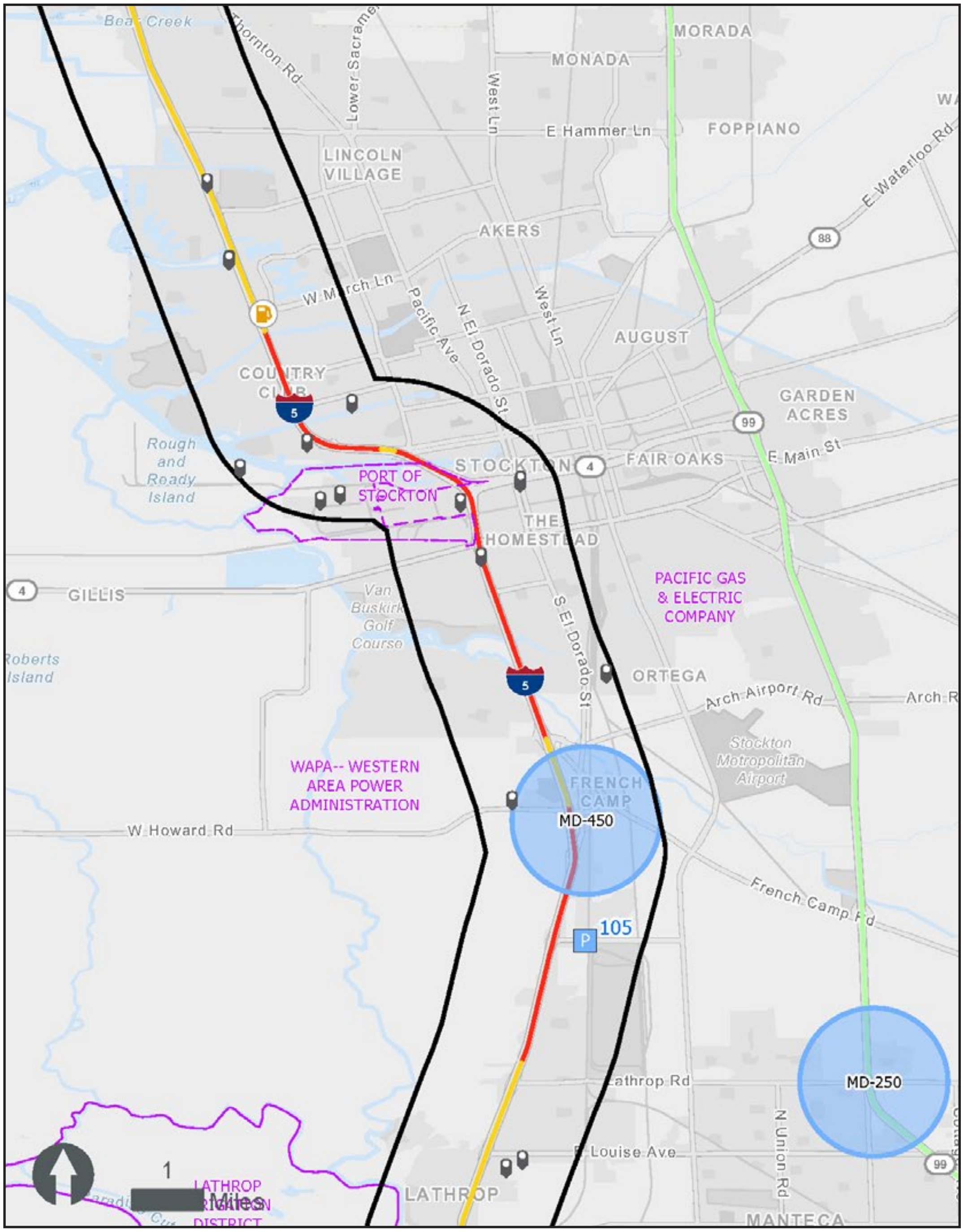
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

TURLOCK IRRIGATION DISTRICT, WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-9: I-5 Proposed Charging Location MD/HD-400



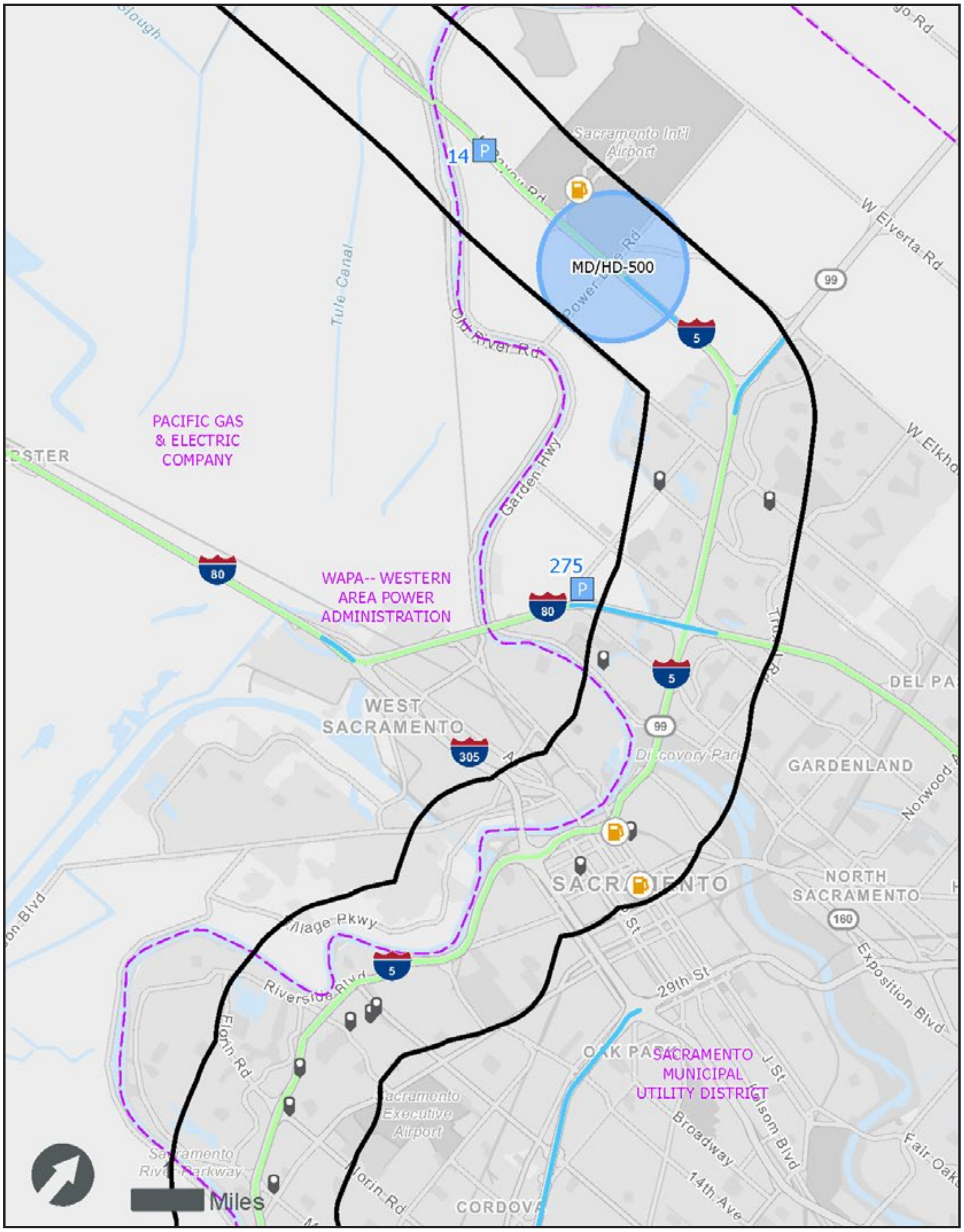
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
WAPA - WESTERN AREA POWER ADMINISTRATION,
LATHROP IRRIGATION DISTRICT,
PORT OF STOCKTON ,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

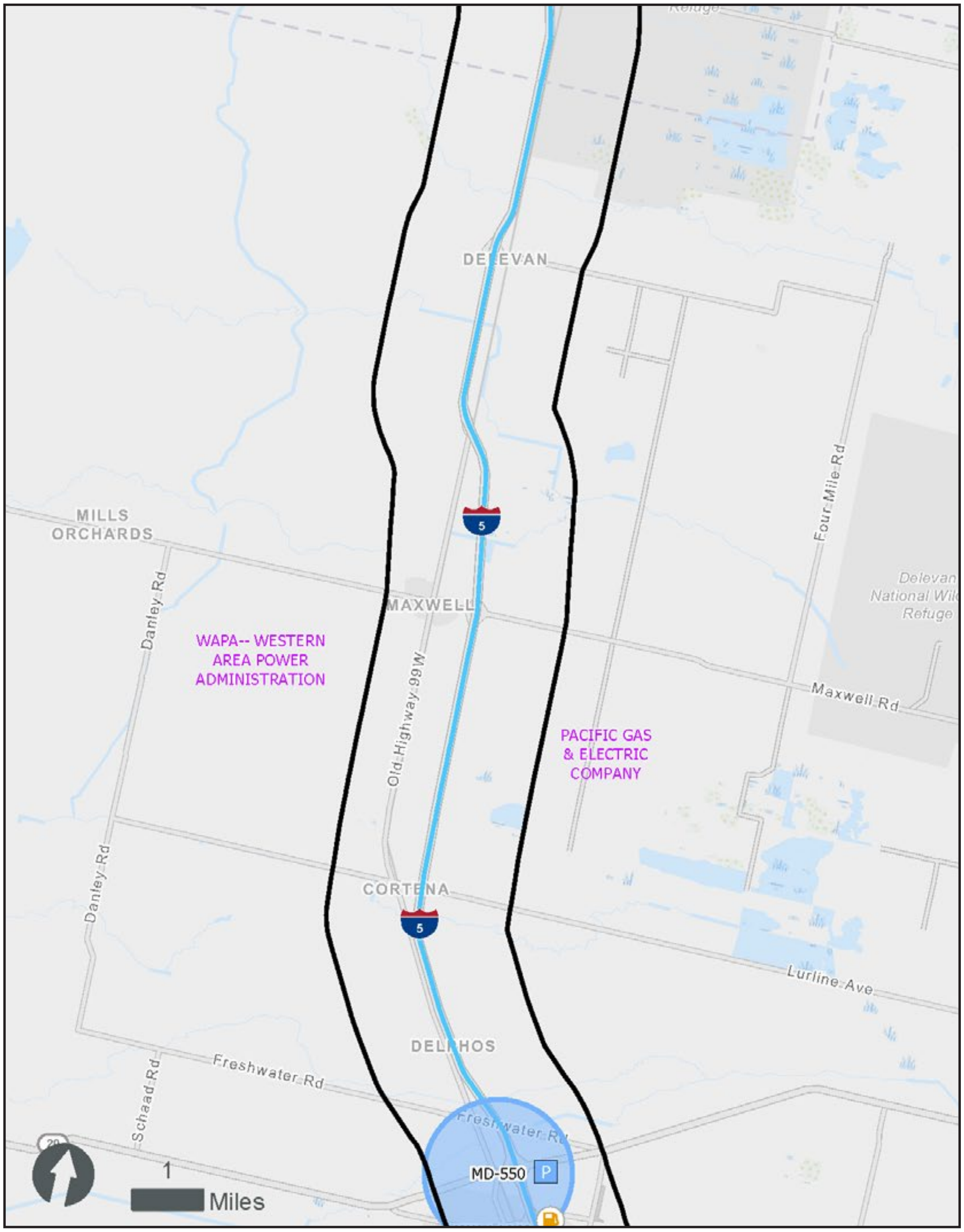
Figure B-10: I-5 Proposed Charging Location MD-450



WCCTCI Study Area Potential	**Truck Volume 2017**			**SERVICE TERRITORY**
Charging Location Truck Parking		≤ 5000		SACRAMENTO MUNICIPAL UTILITY DISTRICT,
Location		≤ 10000		WAPA - WESTERN AREA POWER ADMINISTRATION,
Substation		≤ 20000		PACIFIC GAS & ELECTRIC COMPANY
Electric Retail Service Territories		≤ 30000		
Existing DC Fast Charging Public Stations		> 30000		

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-11: I-5 Proposed Charging Location MD/HD-500



- WCCTCI Study Area Potential
- Charging Location Truck Parking
- Location
- Substation
- Electric Retail Service Territories
- Existing DC Fast Charging Public Stations

Truck Volume 2017

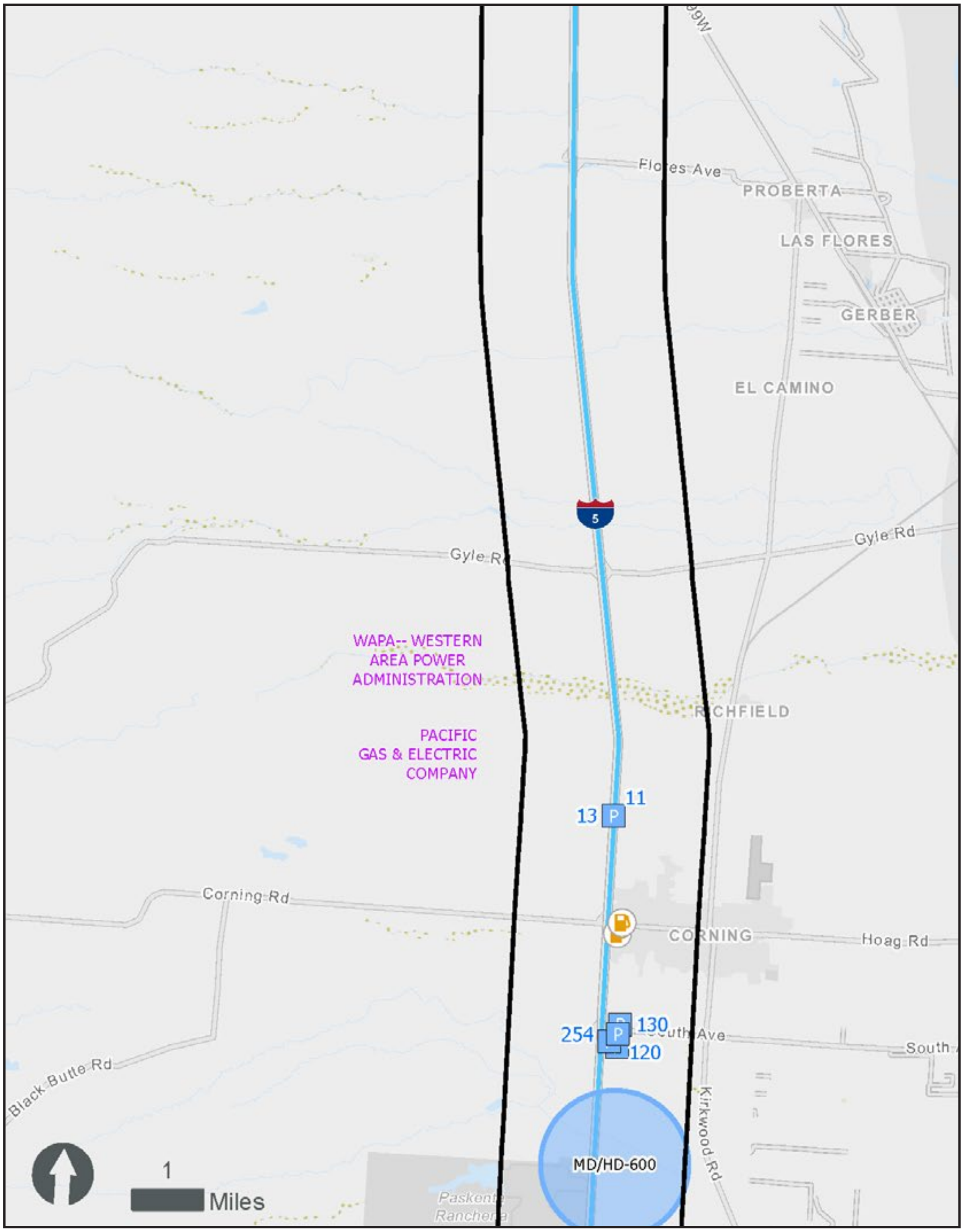
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA-- WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-12: I-5 Proposed Charging Location MD-550



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

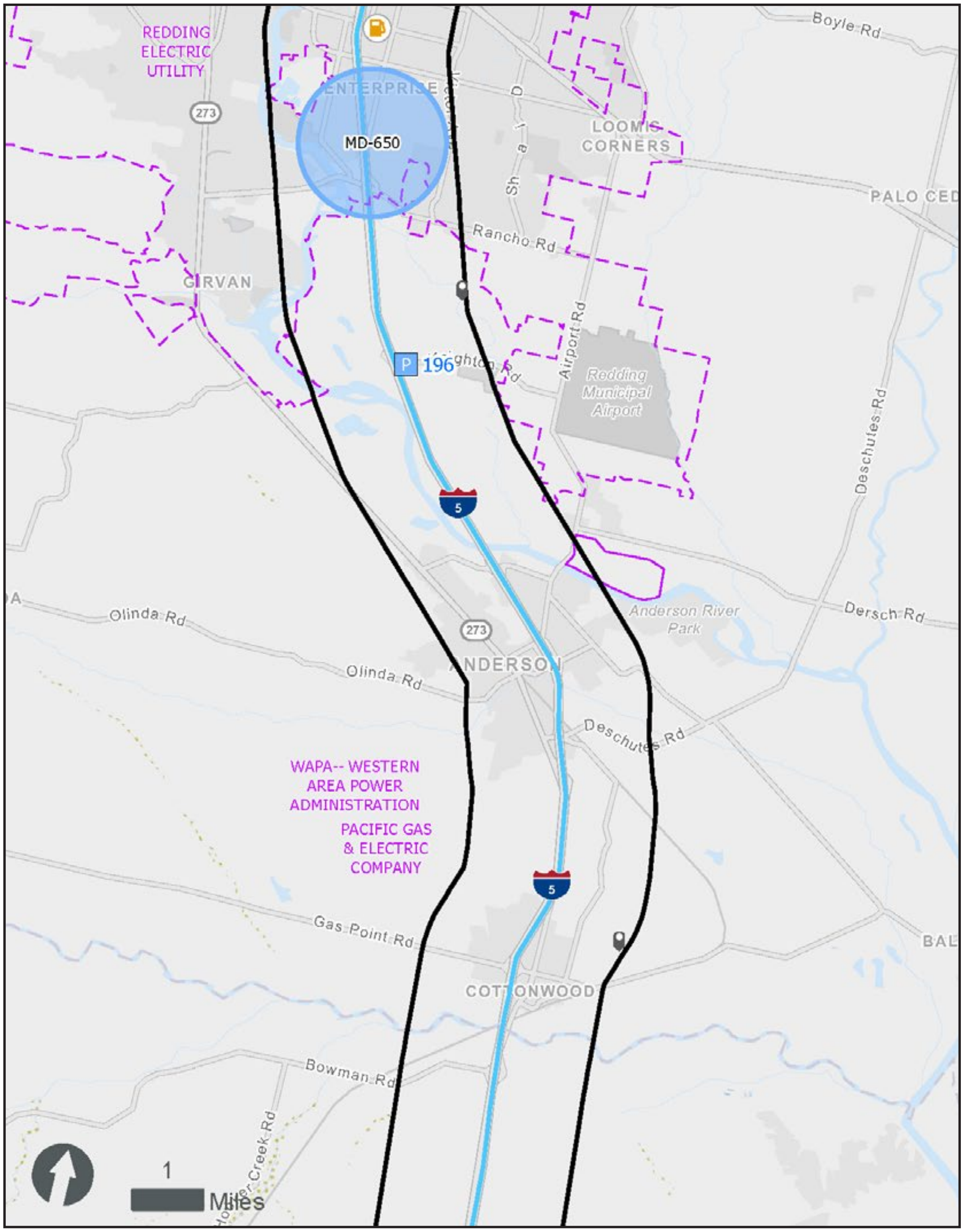
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA-- WESTERN AREA POWER ADMINISTRATION, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-13: I-5 Proposed Charging Location MD/HD-600



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

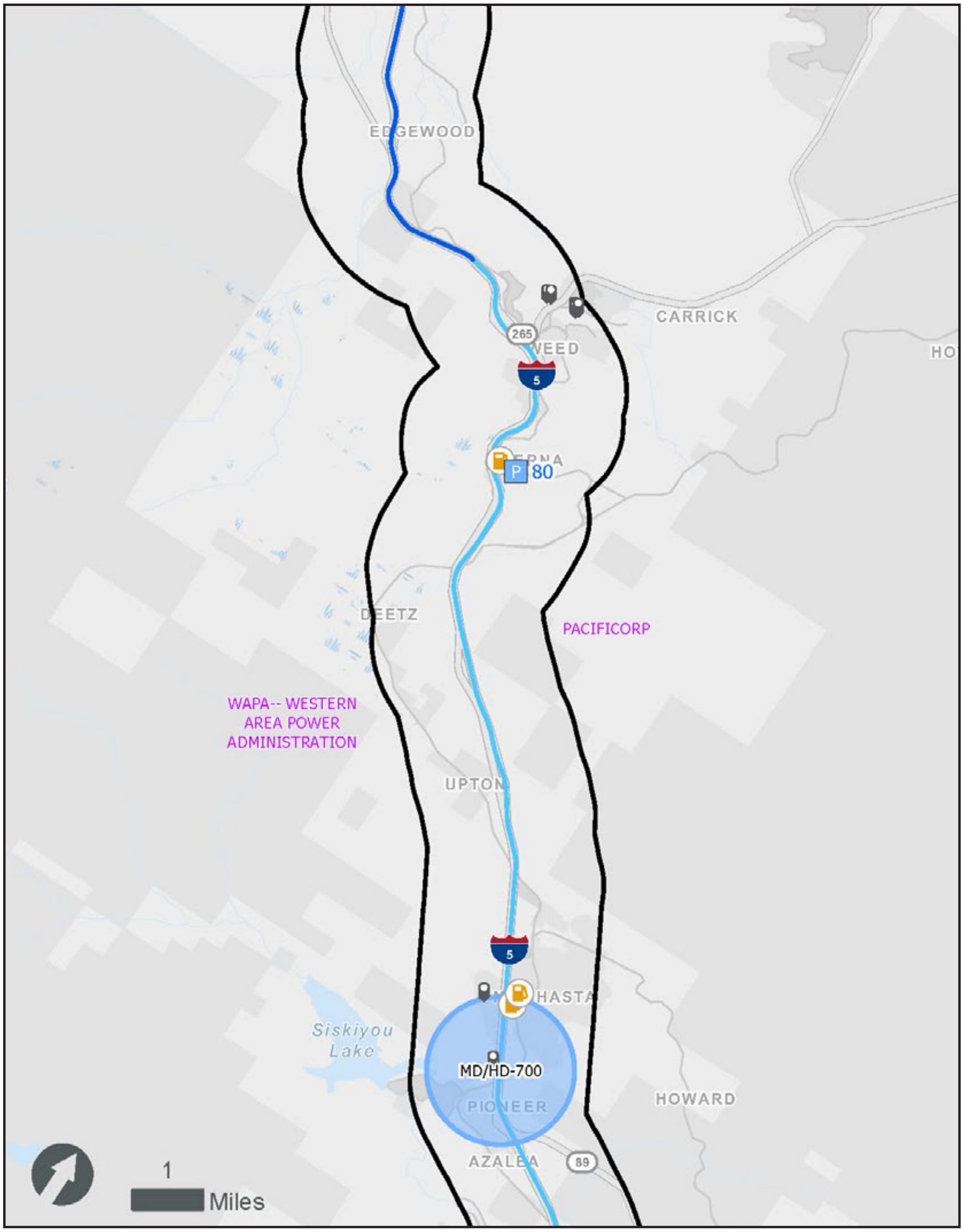
Truck Volume 2017

- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
REDDING ELECTRIC UTILITY, WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-14: I-5 Proposed Charging Location MD-650



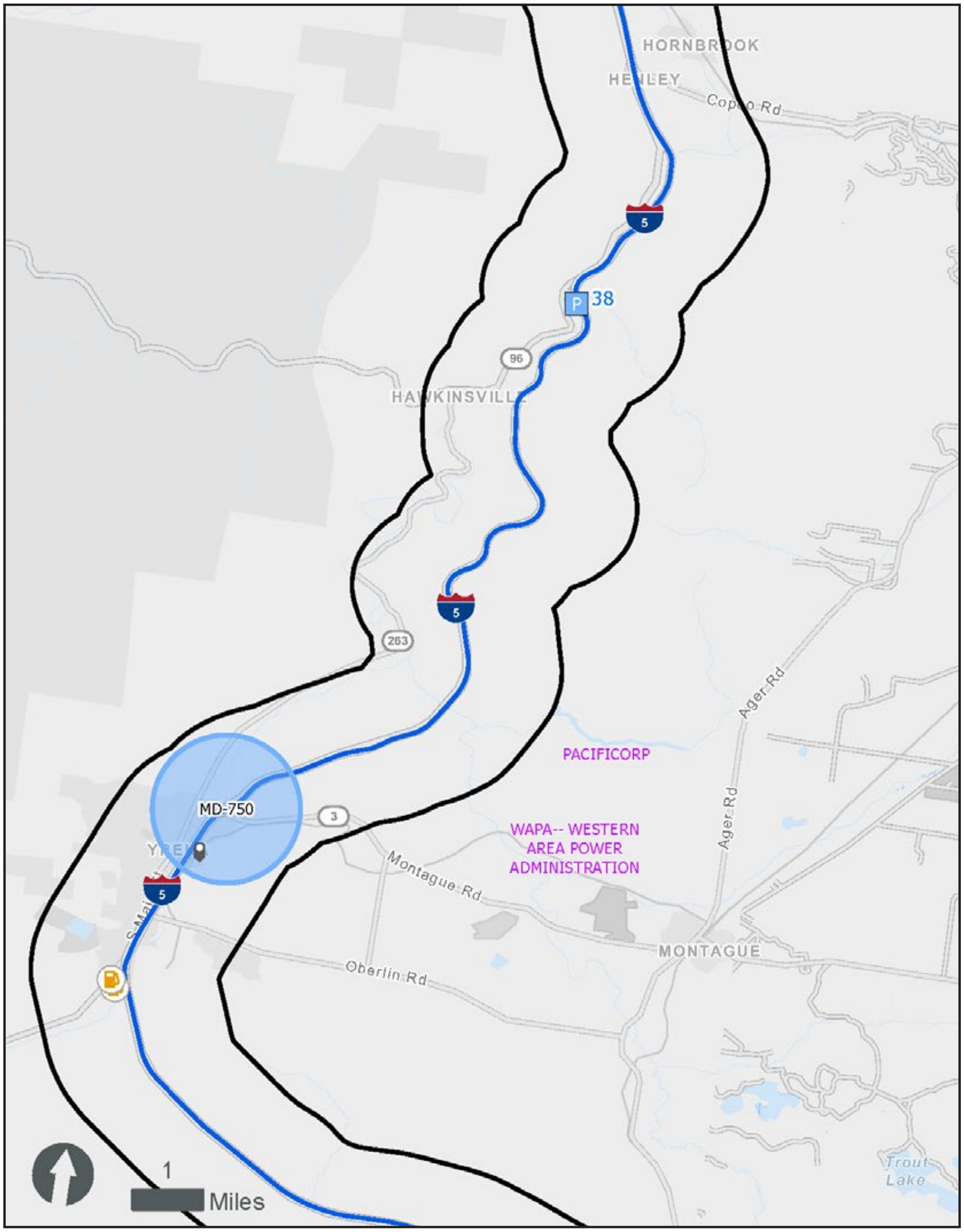
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-15: I-5 Proposed Charging Location MD/HD-700



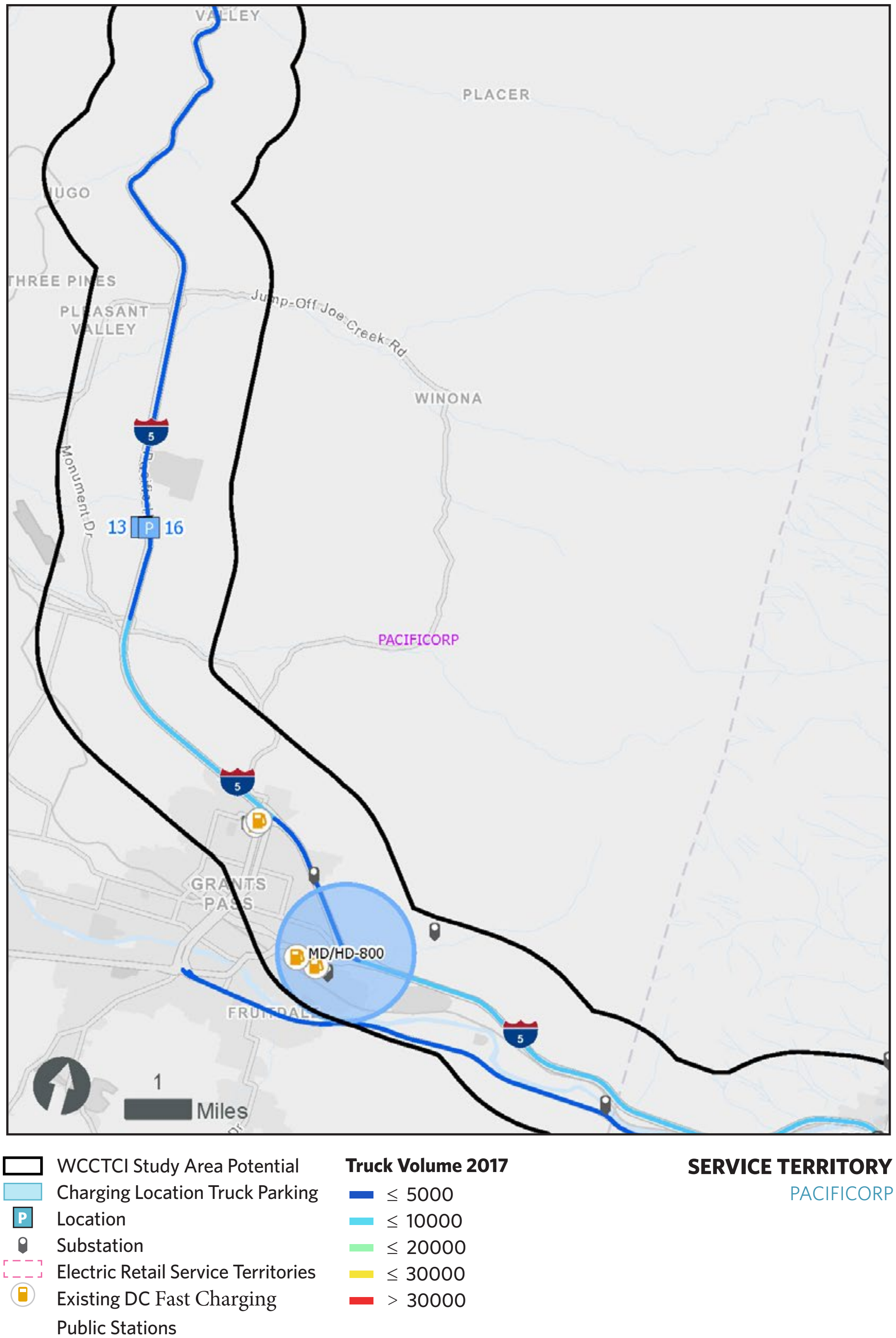
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFICORP

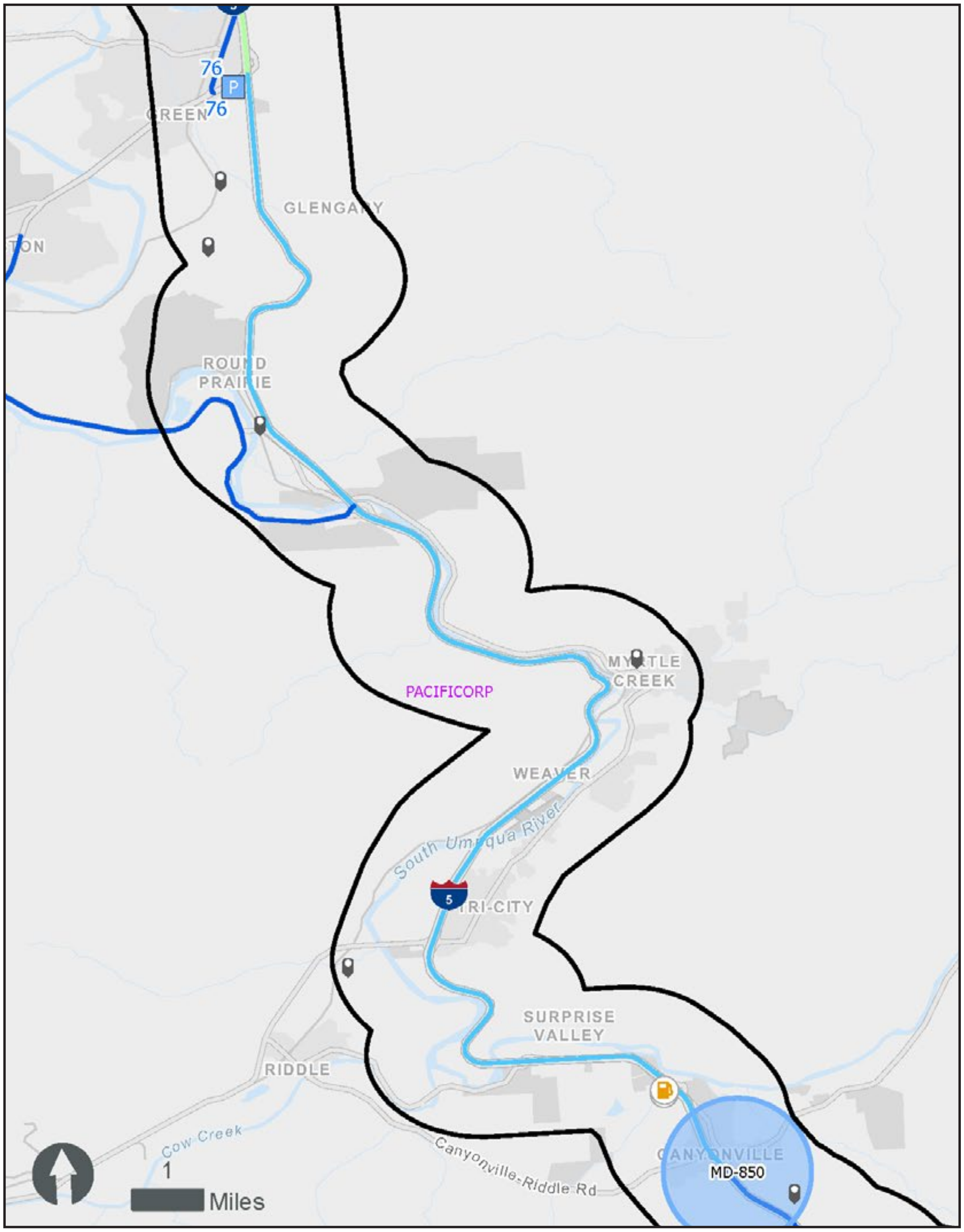
Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-16: I-5 Proposed Charging Location MD-750



Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-17: I-5 Proposed Charging Location MD/HD-800

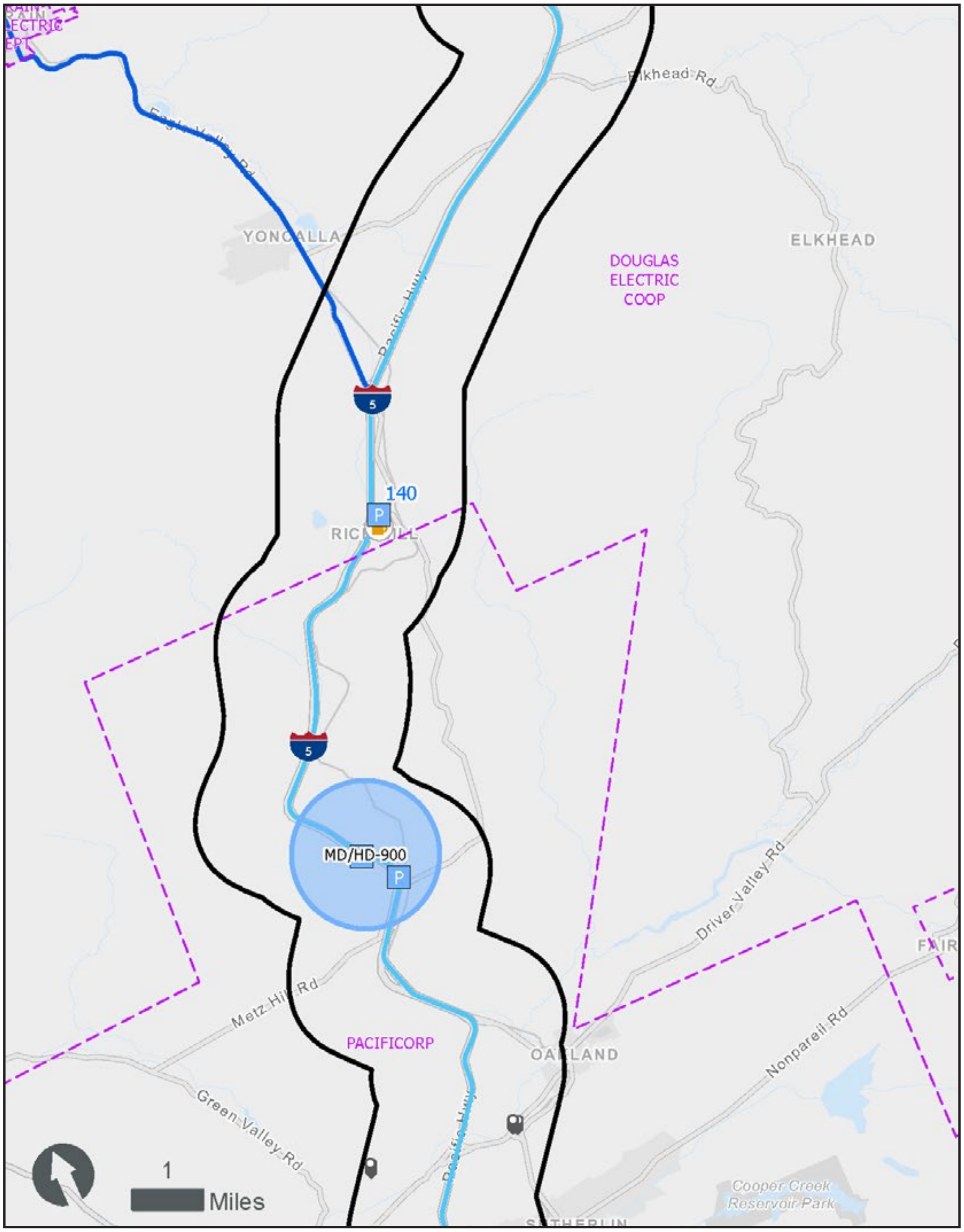


	WCCTCI Study Area Potential	**Truck Volume 2017**	
	Charging Location Truck Parking		≤ 5000
P	Location		≤ 10000
	Substation		≤ 20000
	Electric Retail Service Territories		≤ 30000
	Existing DC Fast Charging Public Stations		> 30000

SERVICE TERRITORY
PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-18: I-5 Proposed Charging Location MD-850



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

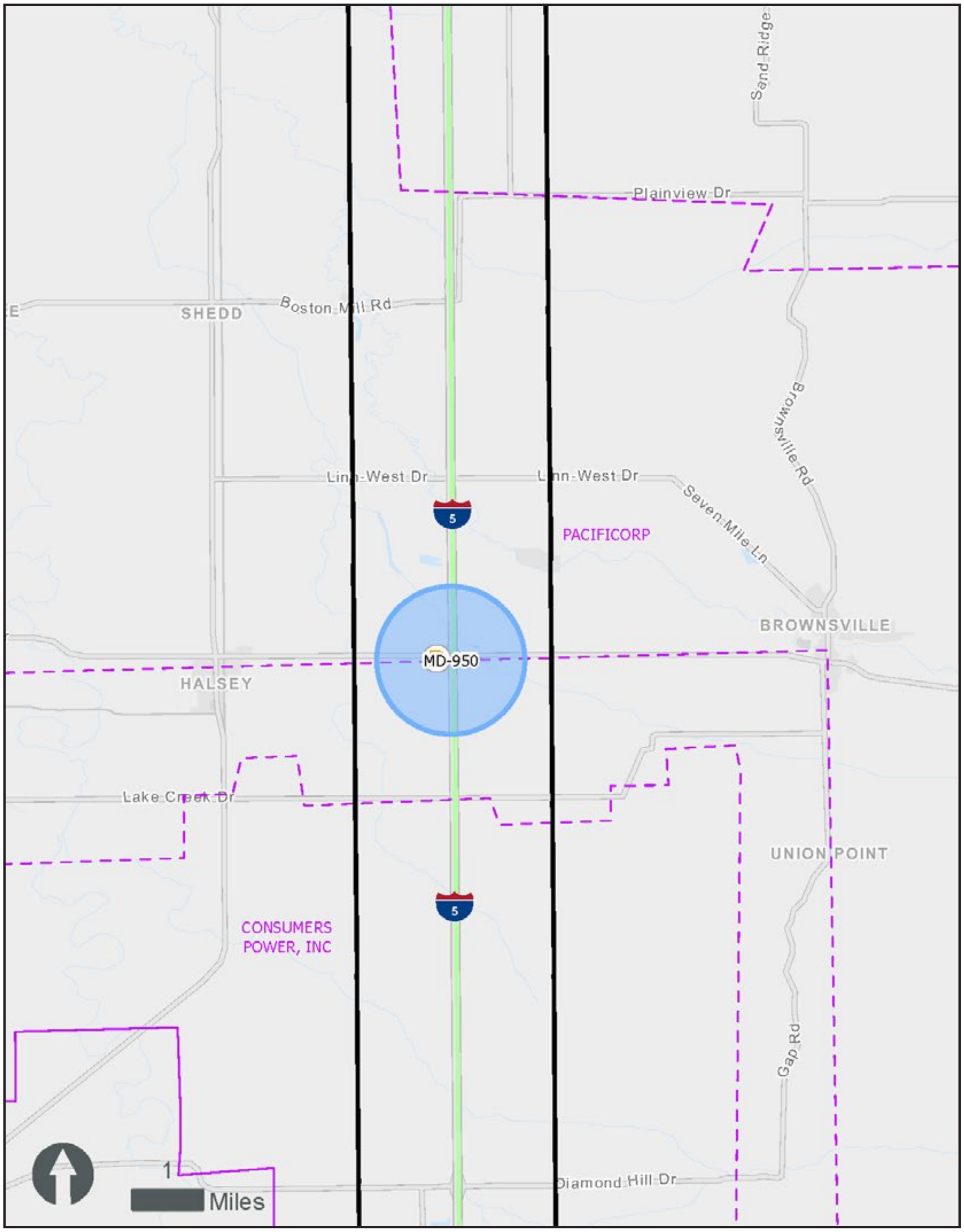
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PACIFICORP,
DOUGLAS ELECTRIC COOP,
DRAIN ELECTRIC DEPT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-19: I-5 Proposed Charging Location MD/HD-900



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

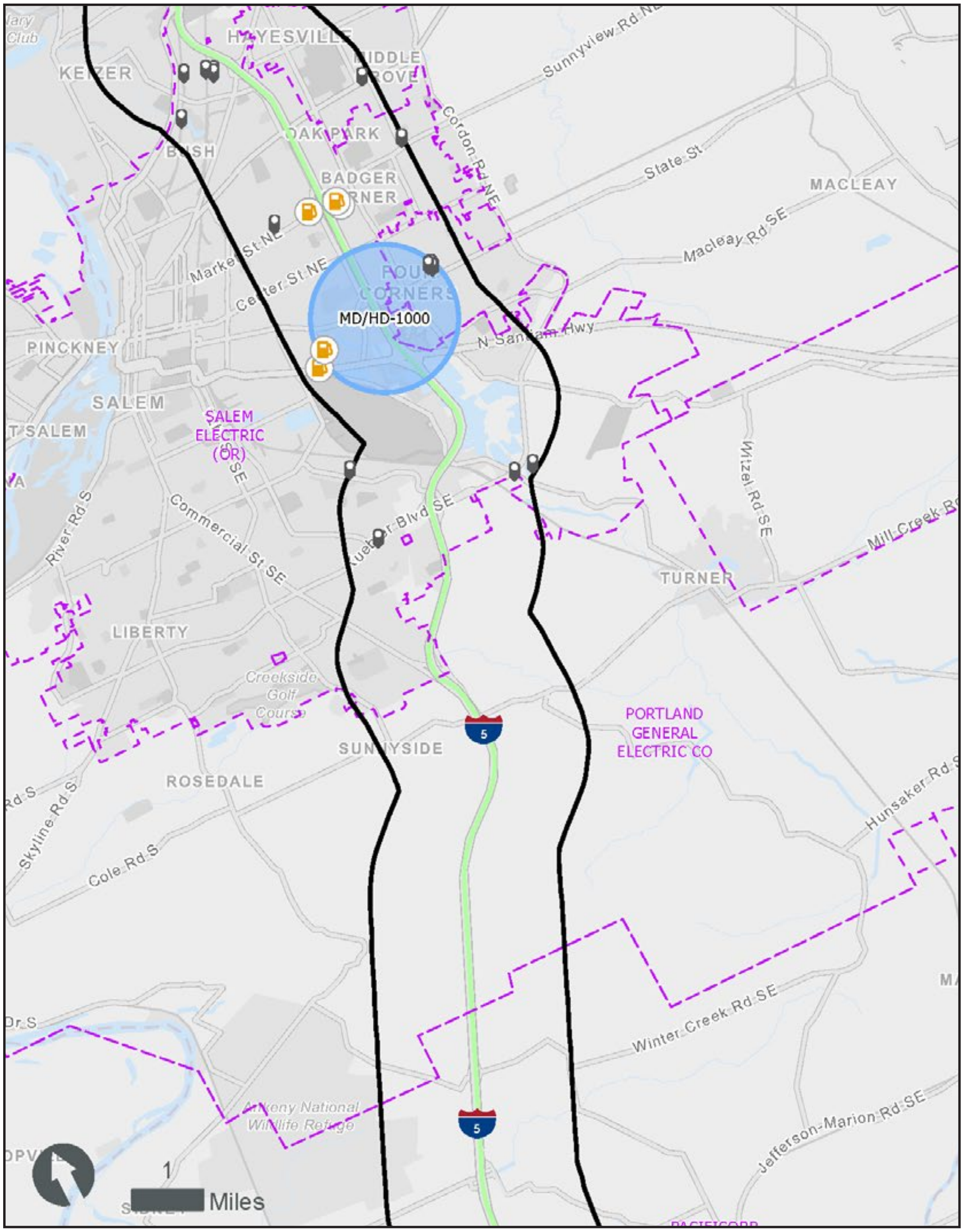
Truck Volume 2017

- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
PACIFICORP, CONSUMERS POWER, INC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-20: I-5 Proposed Charging Location MD-950



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

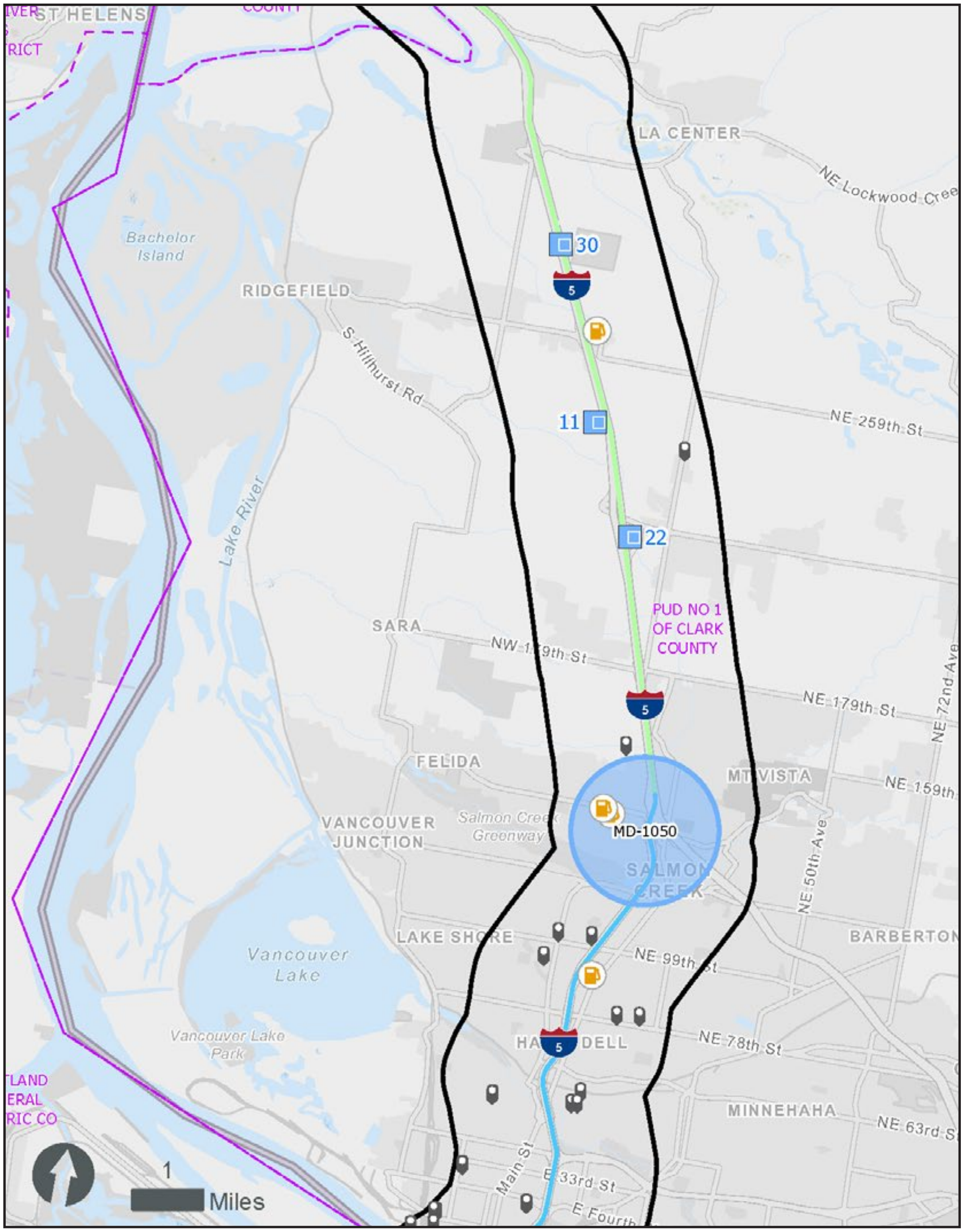
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PORTLAND GENERAL ELECTRIC CO, SALEM ELECTRIC (OR), PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-21: I-5 Proposed Charging Location MD/HD-1000



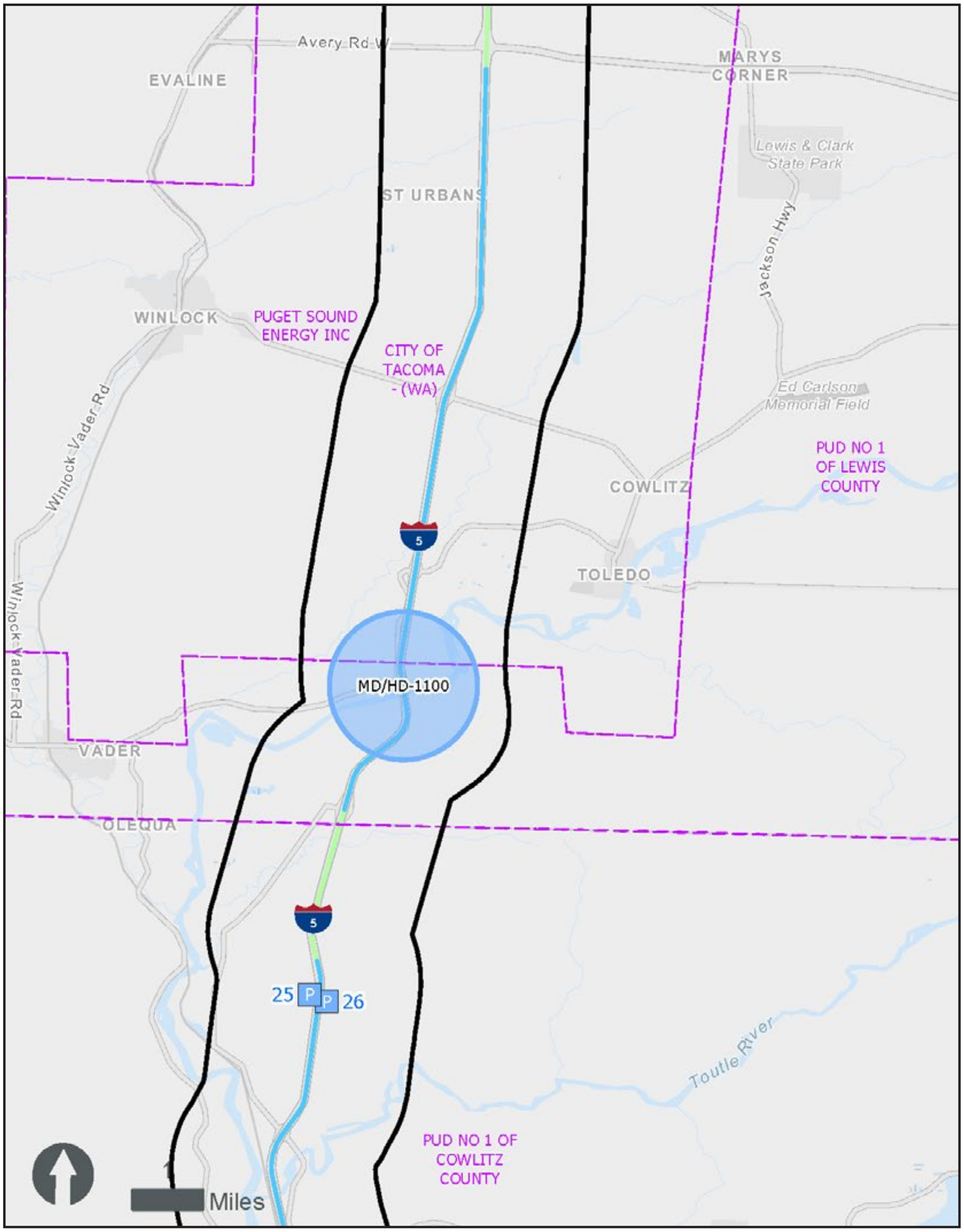
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
PORTLAND GENERAL ELECTRIC CO,
COLUMBIA RIVER PEOPLE'S UTILITY DISTRICT,
PUD NO 1 OF CLARK COUNTY ,
PUD NO 1 OF COWLITZ COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-22: I-5 Proposed Charging Location MD-1050



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

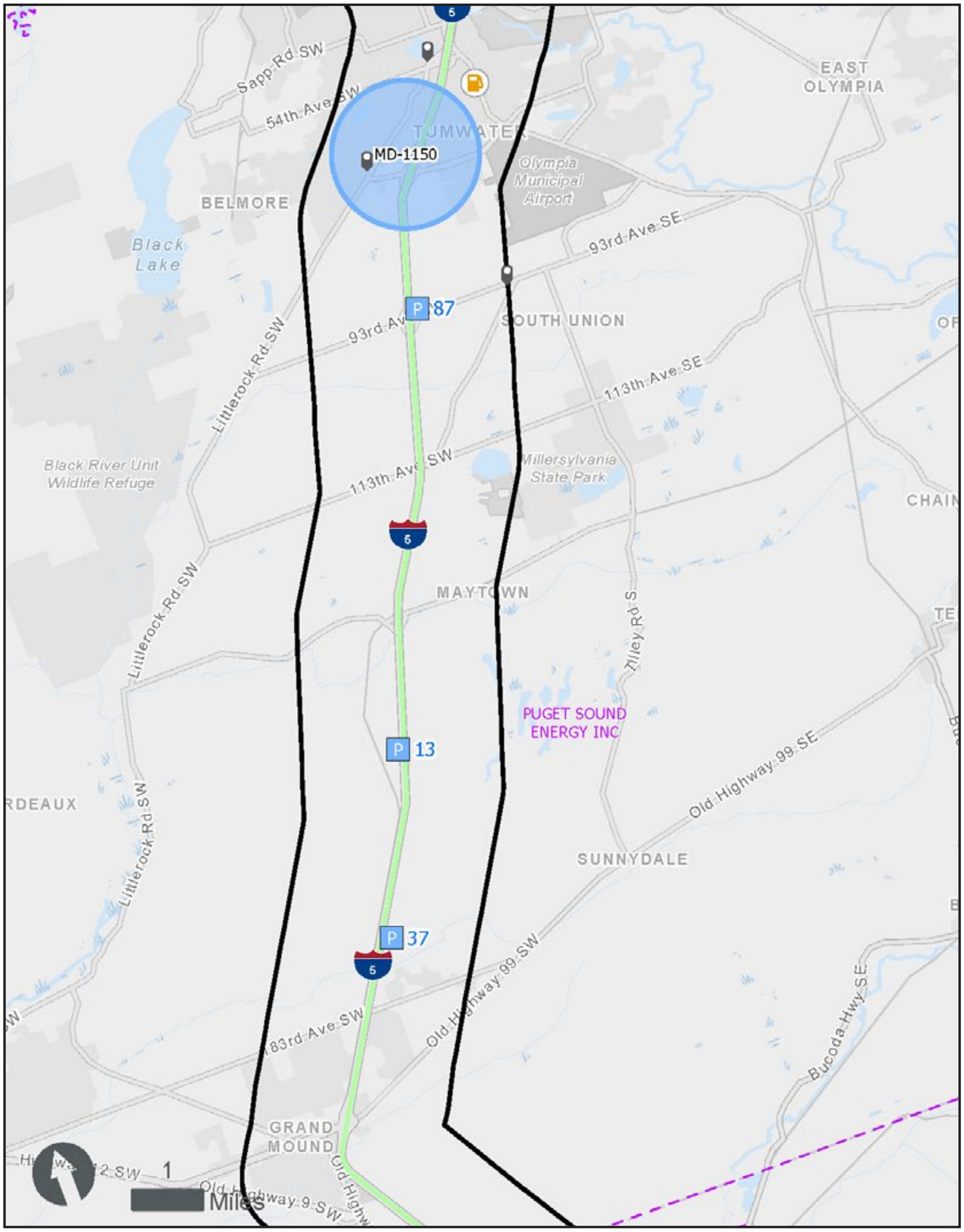
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUGET SOUND ENERGY INC,
CITY OF TACOMA - (WA),
PUD NO 1 OF LEWIS COUNTY,
PUD NO 1 OF COWLITZ COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-23: I-5 Proposed Charging Location MD/HD-1100



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

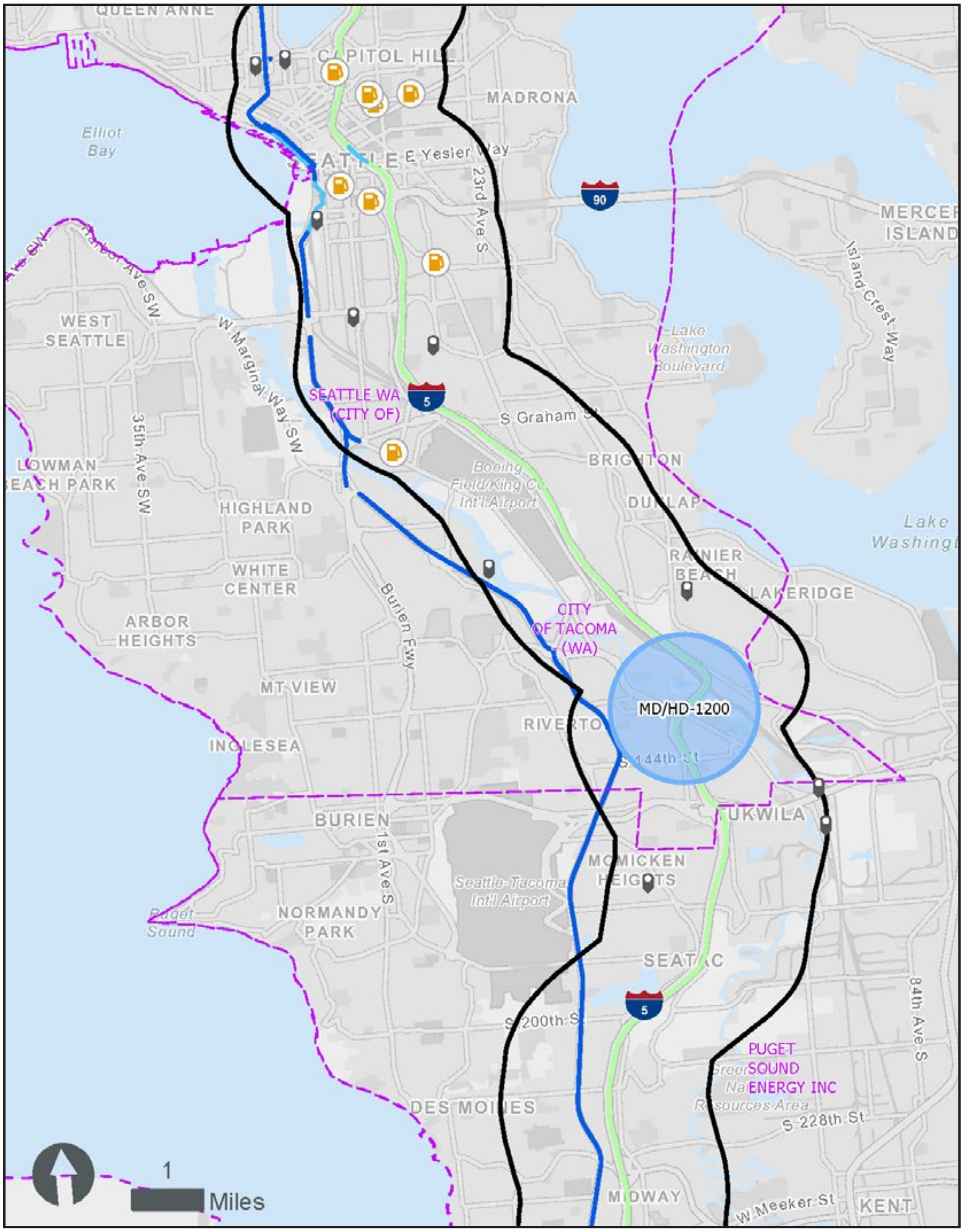
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUGET SOUND ENERGY INC,
CITY OF TACOMA - (WA),
PUD NO 1 OF LEWIS COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-24: I-5 Proposed Charging Location MD-1150



WCCTCI Study Area Potential Charging Location Truck Parking

Location

Substation

Electric Retail Service Territories

Existing DC Fast Charging Public Stations

Truck Volume 2017

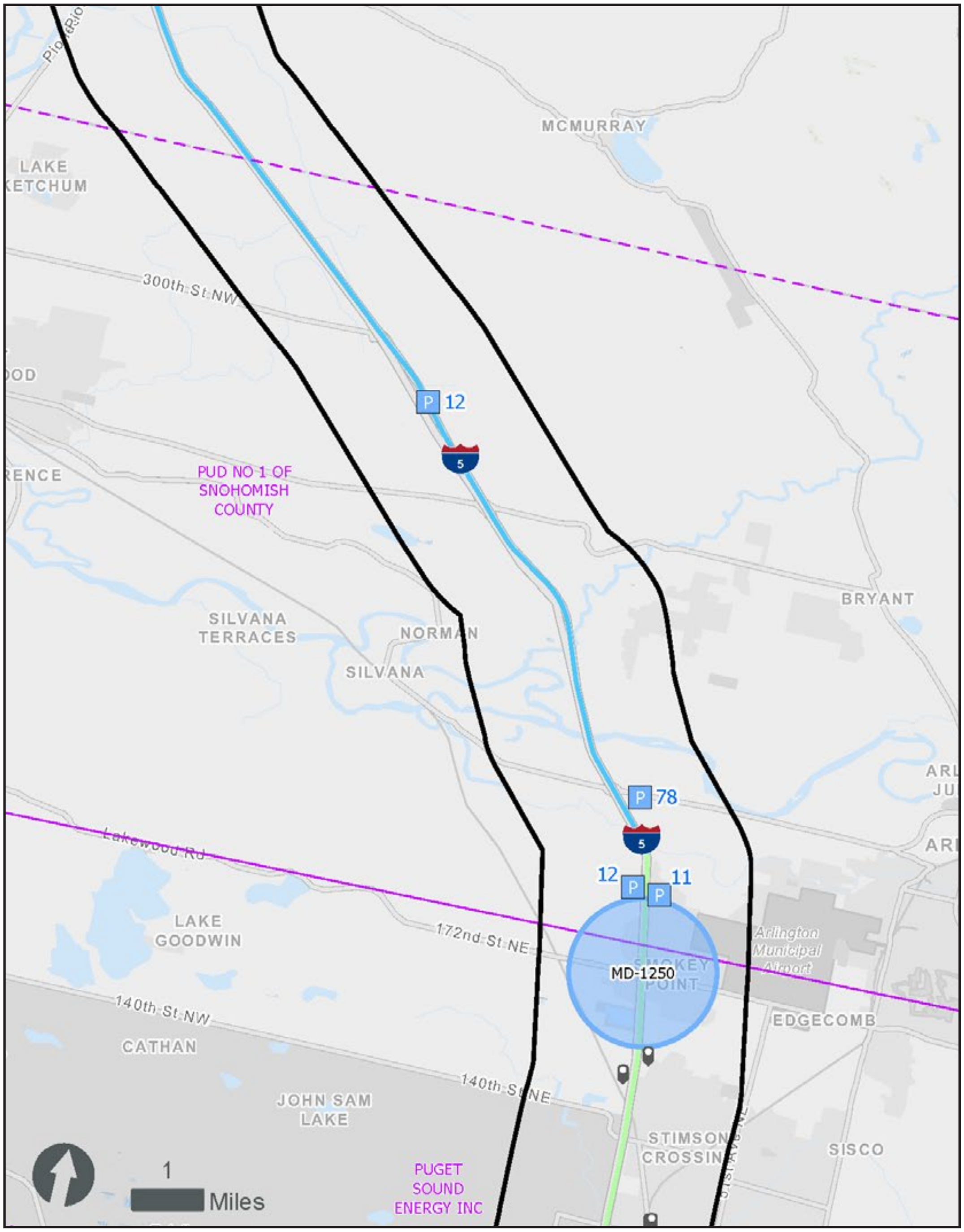
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUGET SOUND ENERGY INC, SEATTLE WA (CITY OF), CITY OF TACOMA - (WA)

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-25: I-5 Proposed Charging Location MD/HD-1200



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

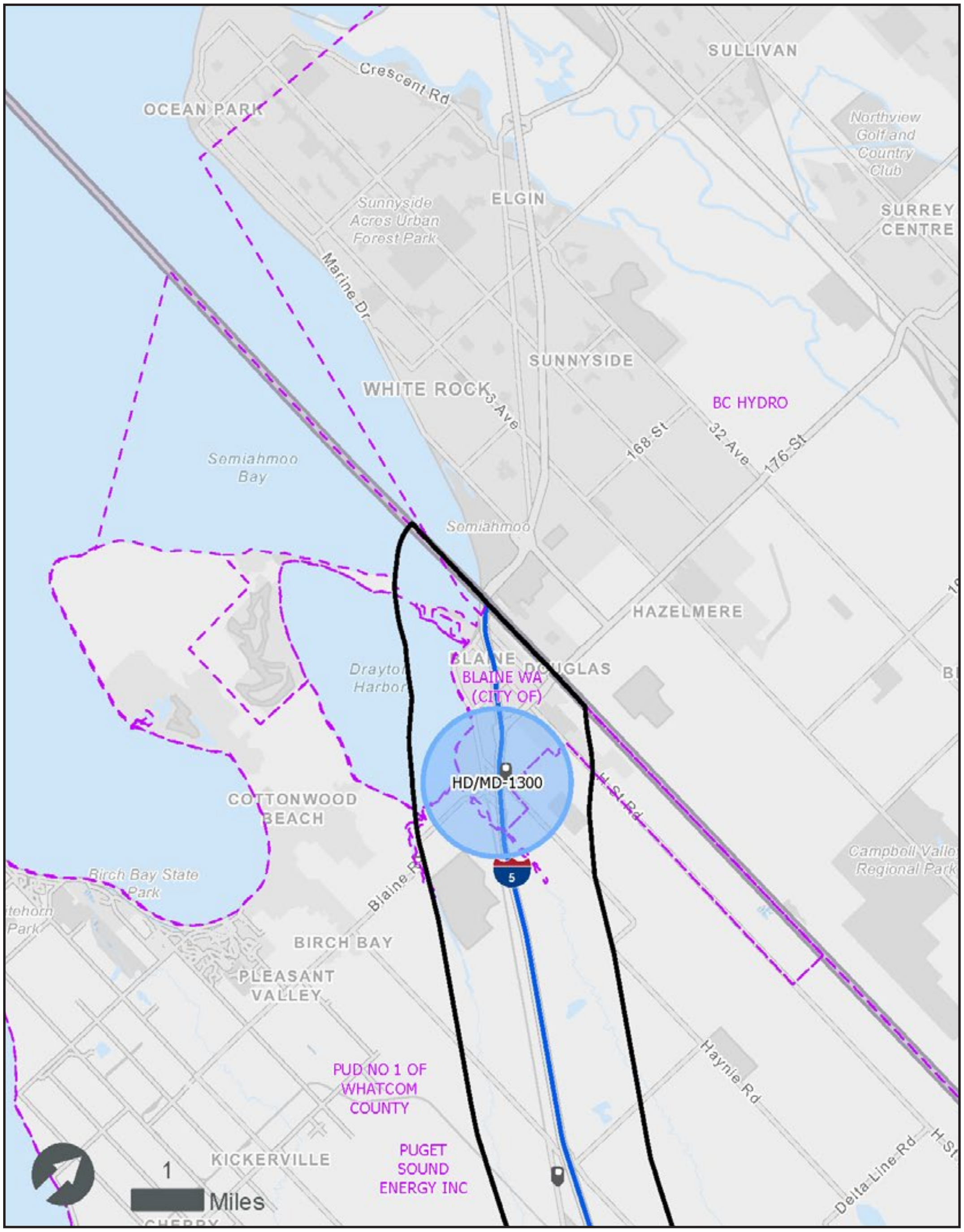
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUGET SOUND ENERGY INC,
PUD NO 1 OF SNOHOMISH COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-26: I-5 Proposed Charging Location MD-1250



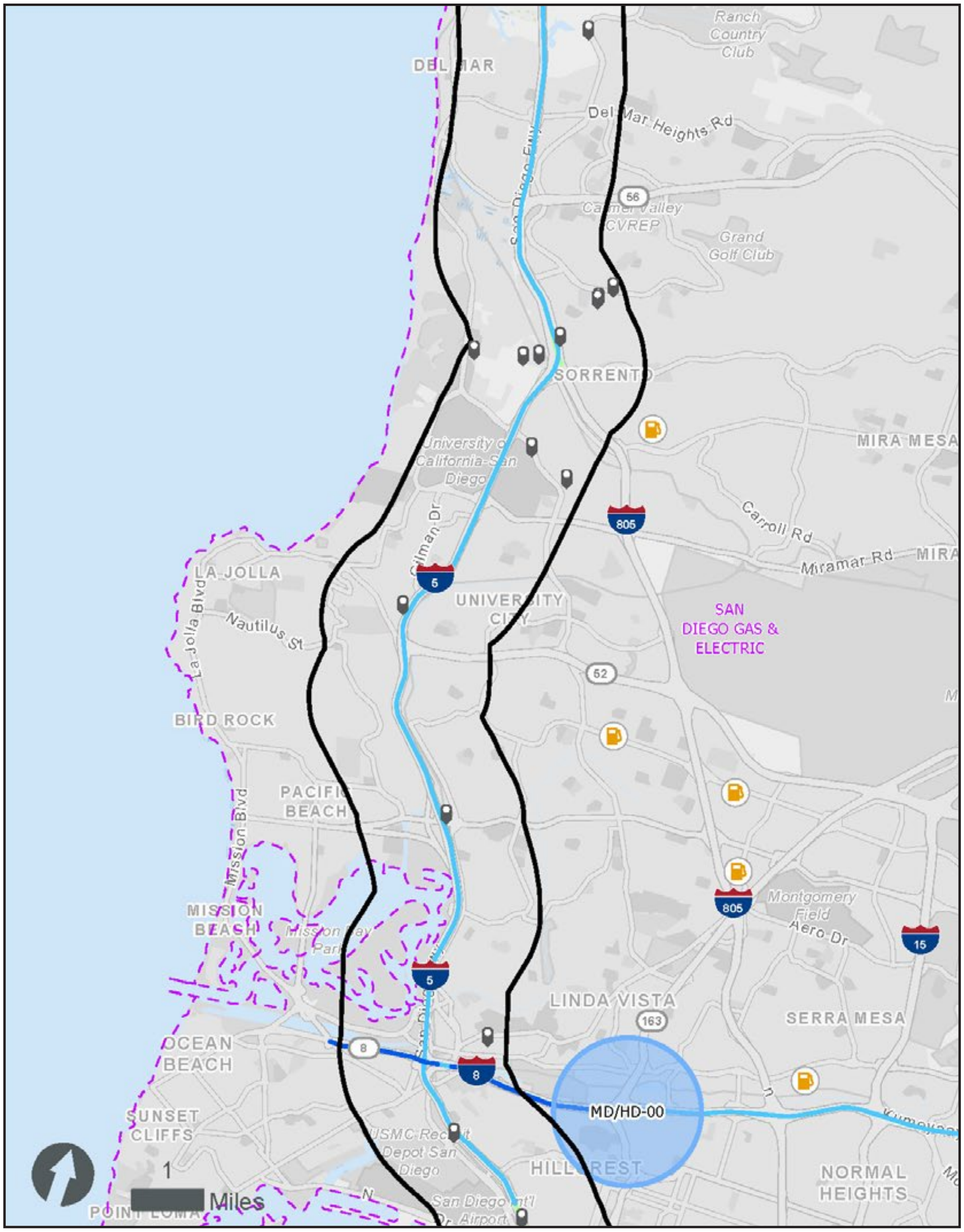
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
PUGET SOUND ENERGY INC,
PUD NO 1 OF WHATCOM COUNTY,
BC HYDRO, BLAINE WA (CITY OF)

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-27: I-5 Proposed Charging Location MD/HD-1300



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

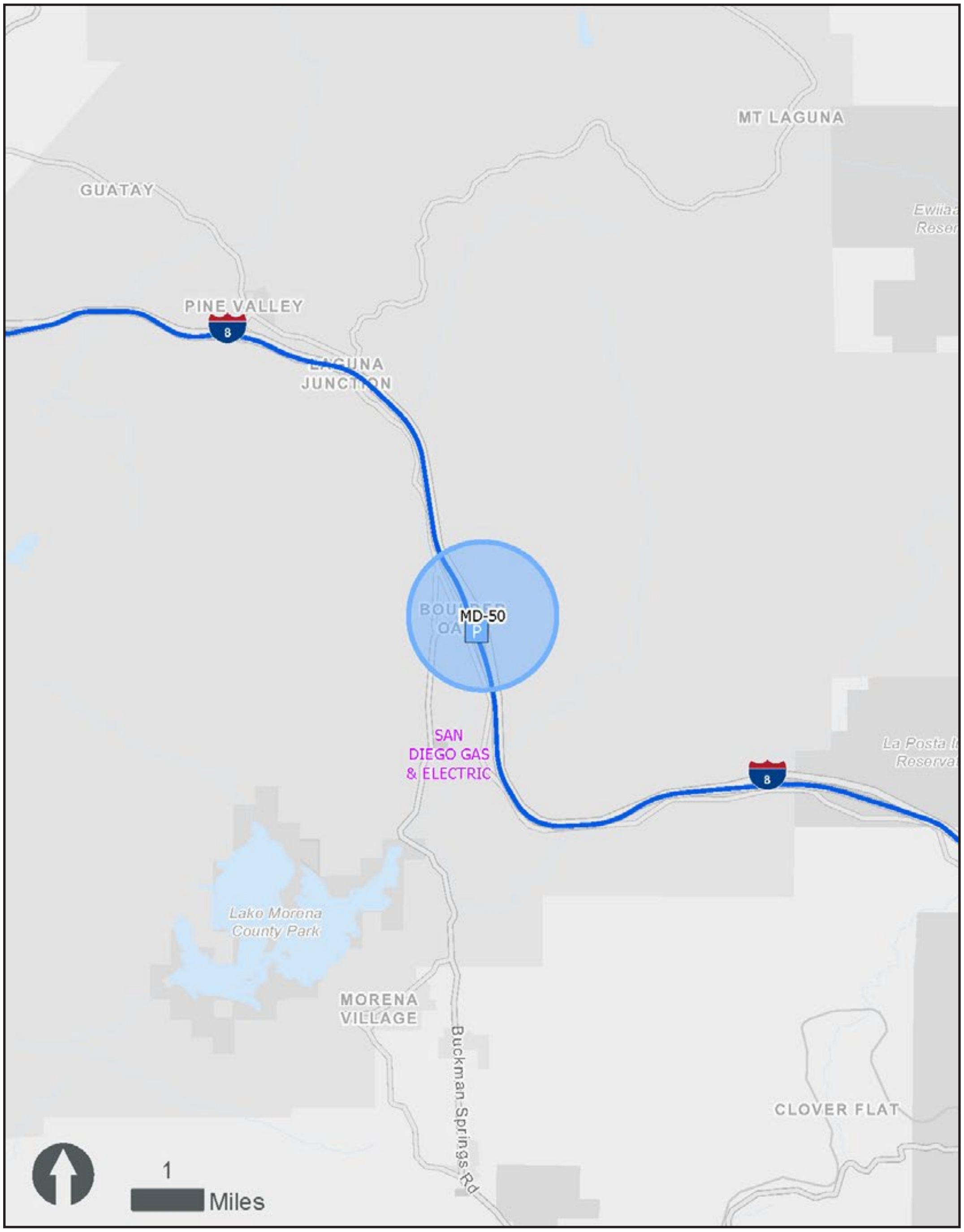
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SAN DIEGO GAS & ELECTRIC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

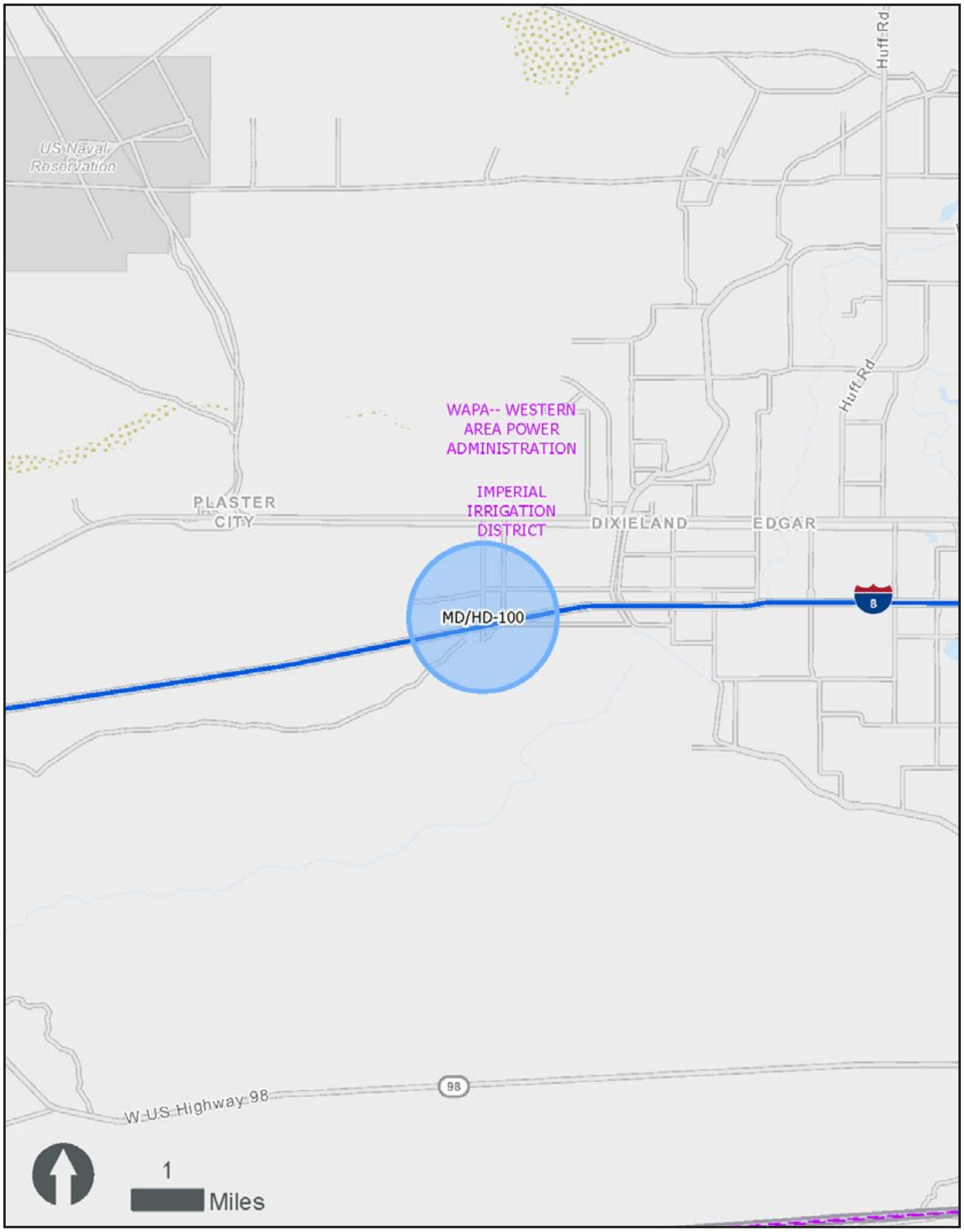
Figure B-28: I-8 Proposed Charging Location MD/HD-0



WCCTCI Study Area Potential Charging Location Truck Parking	**Truck Volume 2017**		**SERVICE TERRITORY**
Location	≤ 5000		SAN DIEGO GAS & ELECTRIC
Substation	≤ 10000		
Electric Retail Service Territories	≤ 20000		
Existing DC Fast Charging Public Stations	≤ 30000		
	> 30000		

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-29: I-8 Proposed Charging Location MD-50



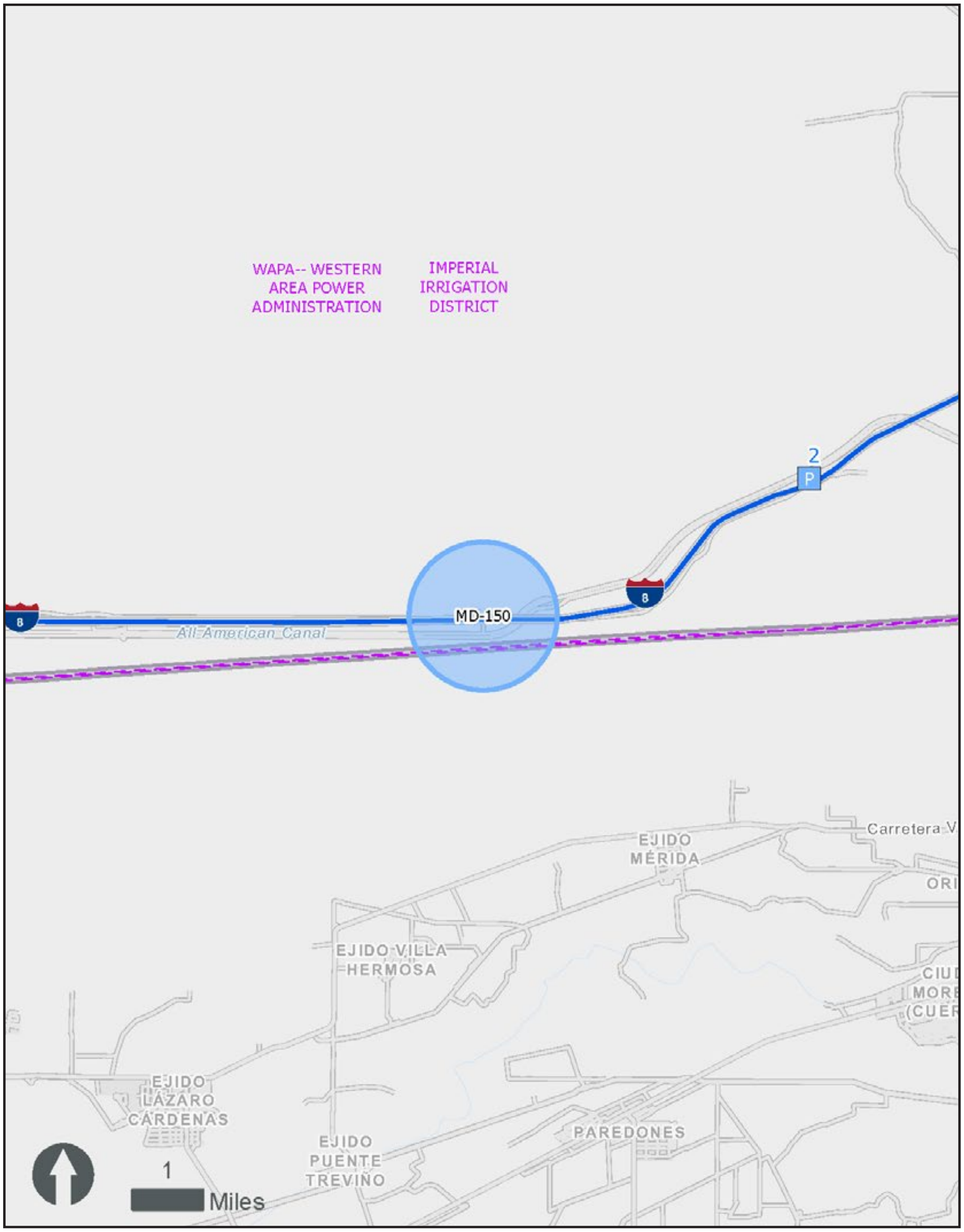
WCCTCI Study Area Potential Charging Location Truck Parking Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
WAPA-- WESTERN AREA POWER ADMINISTRATION, IMPERIAL IRRIGATION DISTRICT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-30: I-8 Proposed Charging Location MD/HD-100



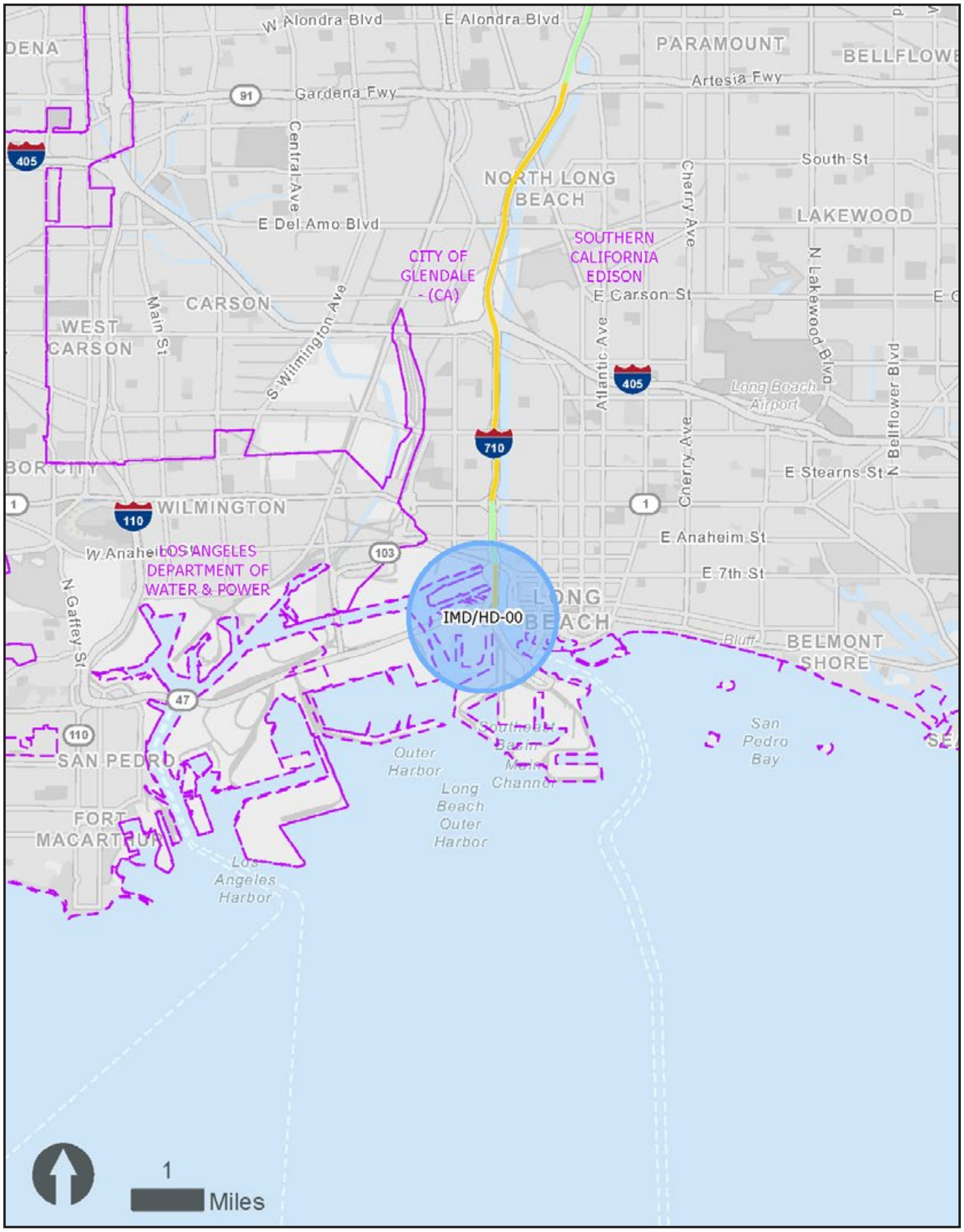
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
WAPA-- WESTERN AREA POWER ADMINISTRATION, IMPERIAL IRRIGATION DISTRICT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-31: I-8 Proposed Charging Location MD-150



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

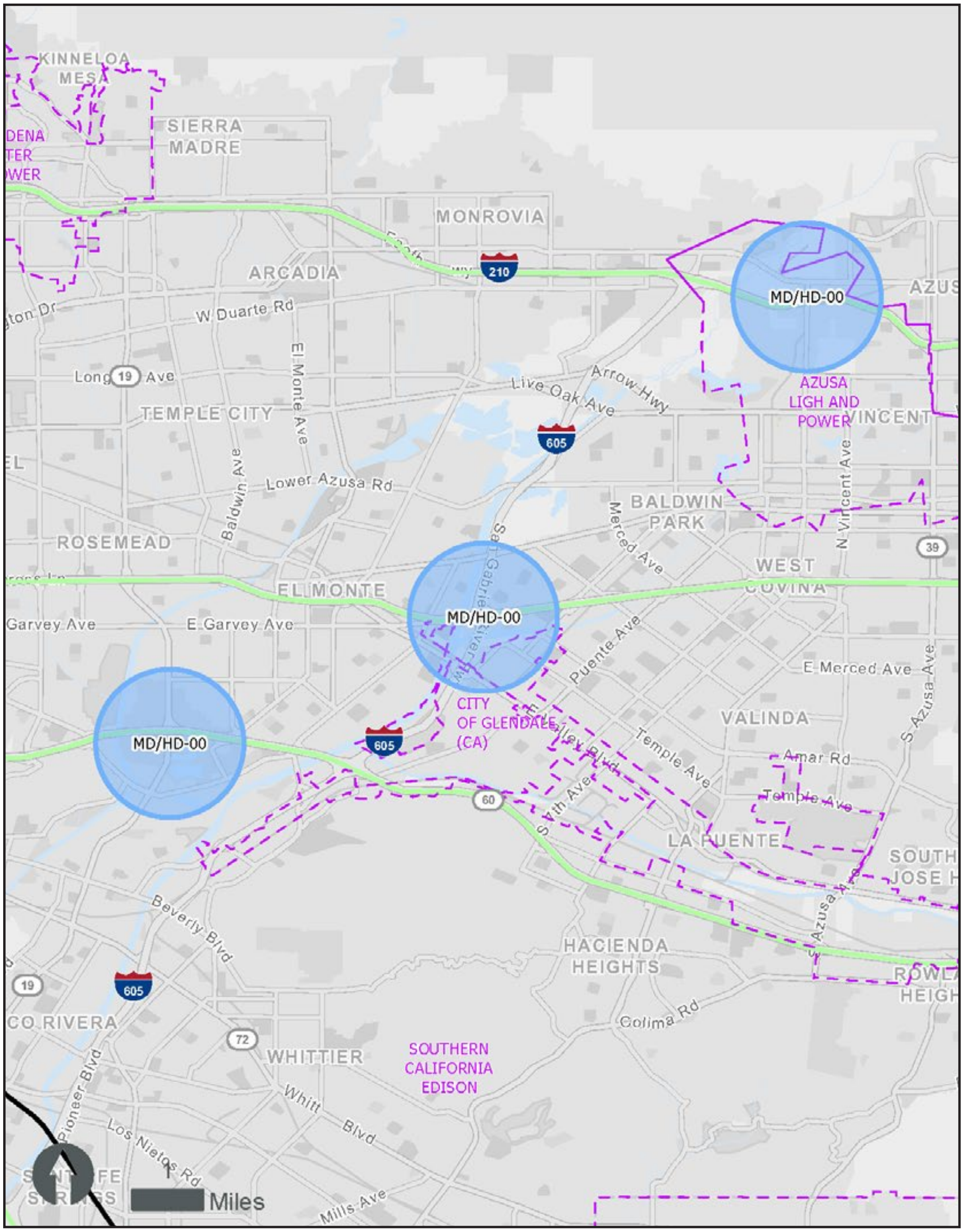
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, LOS ANGELES DEPARTMENT OF WATER & POWER, CITY OF GLENDALE - (CA)

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-32: I-710 Proposed Charging Location MD/HD-0



☐	WCCTCI Study Area Potential
	Charging Location Truck Parking
P	Location
	Substation
	Electric Retail Service Territories
	Existing DC Fast Charging Public Stations

Truck Volume 2017

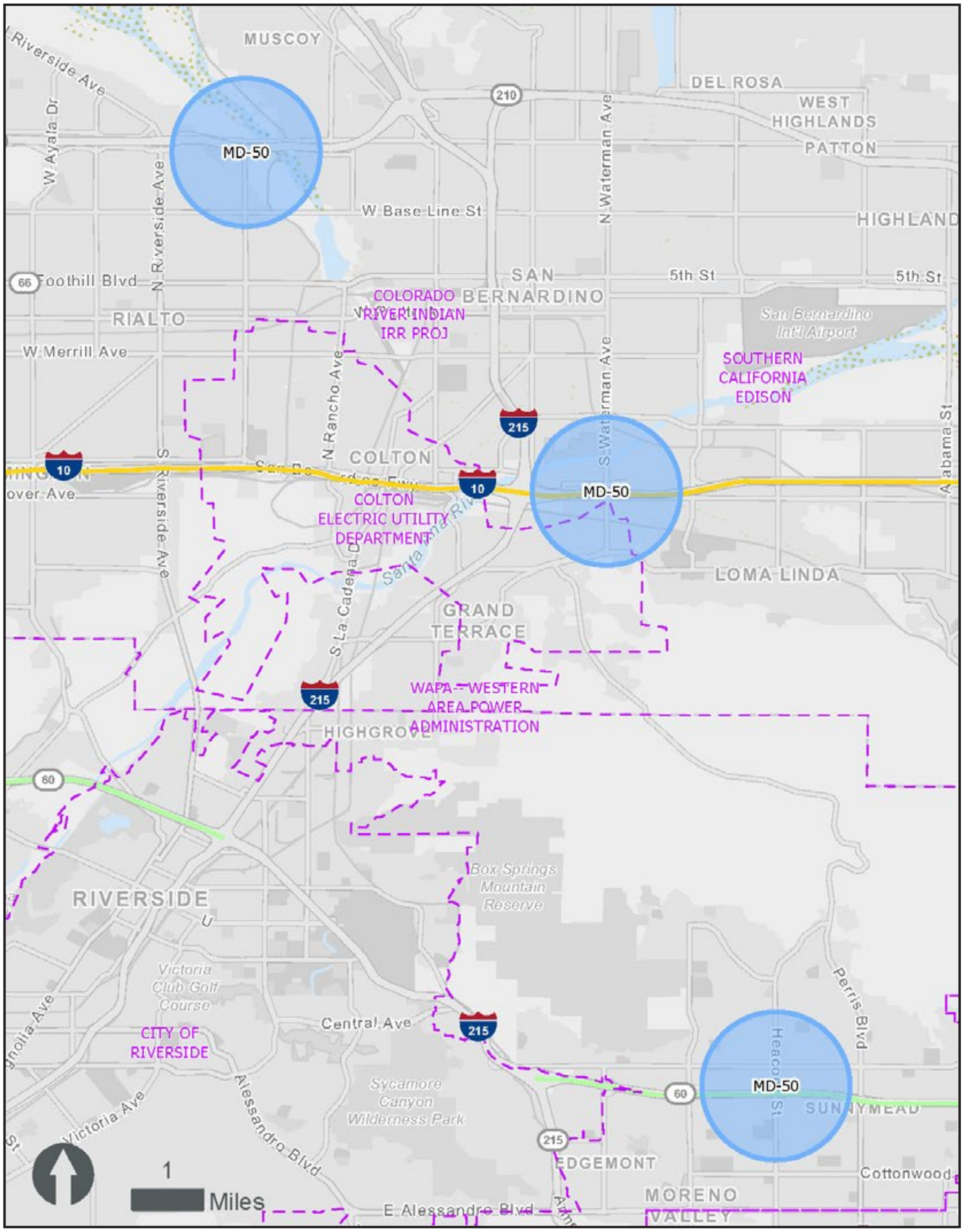
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, PASADENA WATER & POWER, AZUSA LIGH AND POWER, CITY OF GLENDALE - (CA)

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-33: I-10, I-210, CA-60 Proposed Charging Locations MD/HD-0



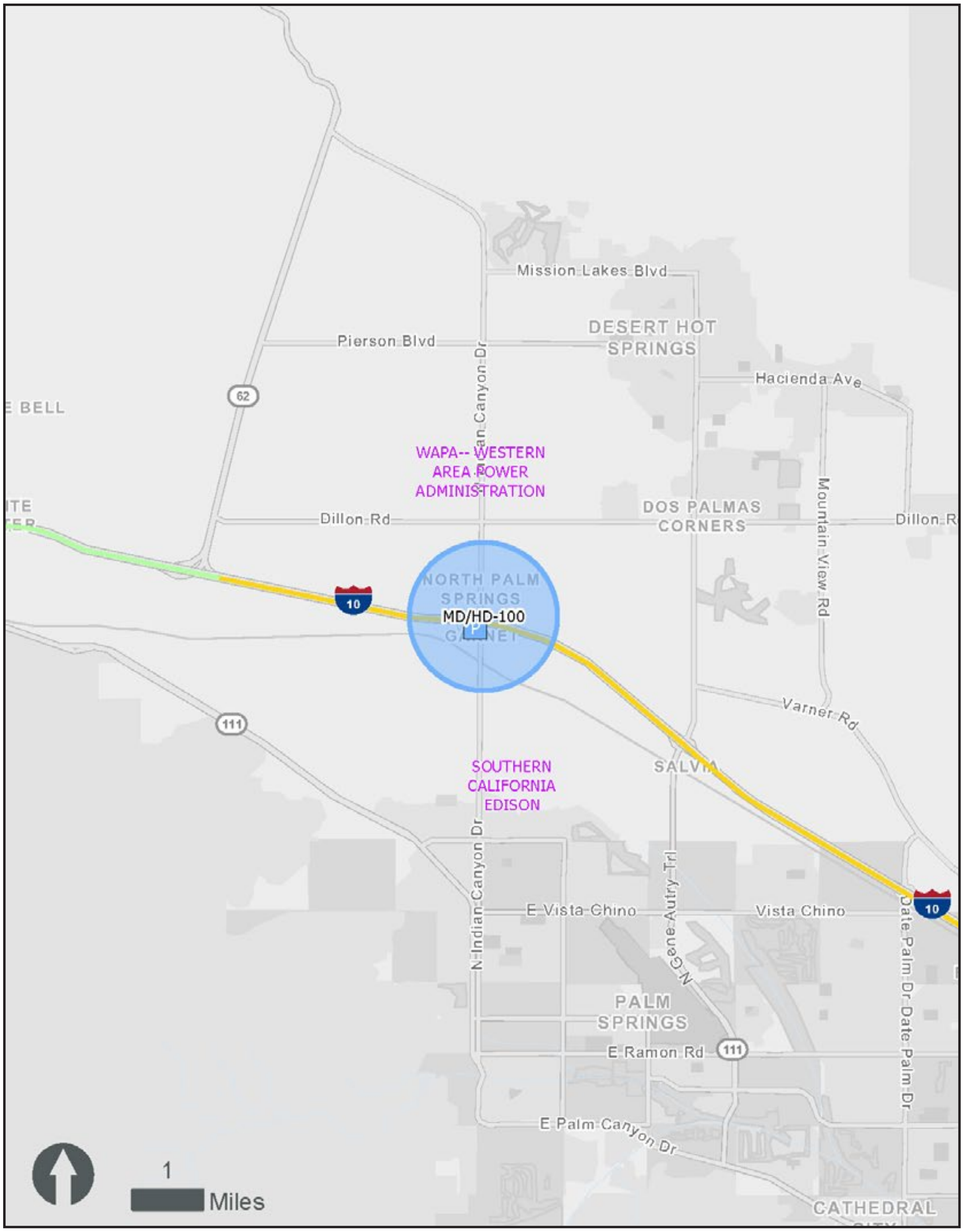
WCCTCI Study Area Potential Charging Location	Truck Parking Location
Substation	Electric Retail Service Territories
Existing DC Fast Charging Public Stations	

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
CITY OF RIVERSIDE,
SOUTHERN CALIFORNIA EDISON,
WAPA - WESTERN AREA POWER ADMINISTRATION,
MORENO VALLEY UTILITY,
COLORADO RIVER INDIAN IRR PROJ,
COLTON ELECTRIC UTILITY DEPARTMENT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-34: I-10, I-210, CA-60 Proposed Charging Locations MD-50



WCCTCI Study Area Potential Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

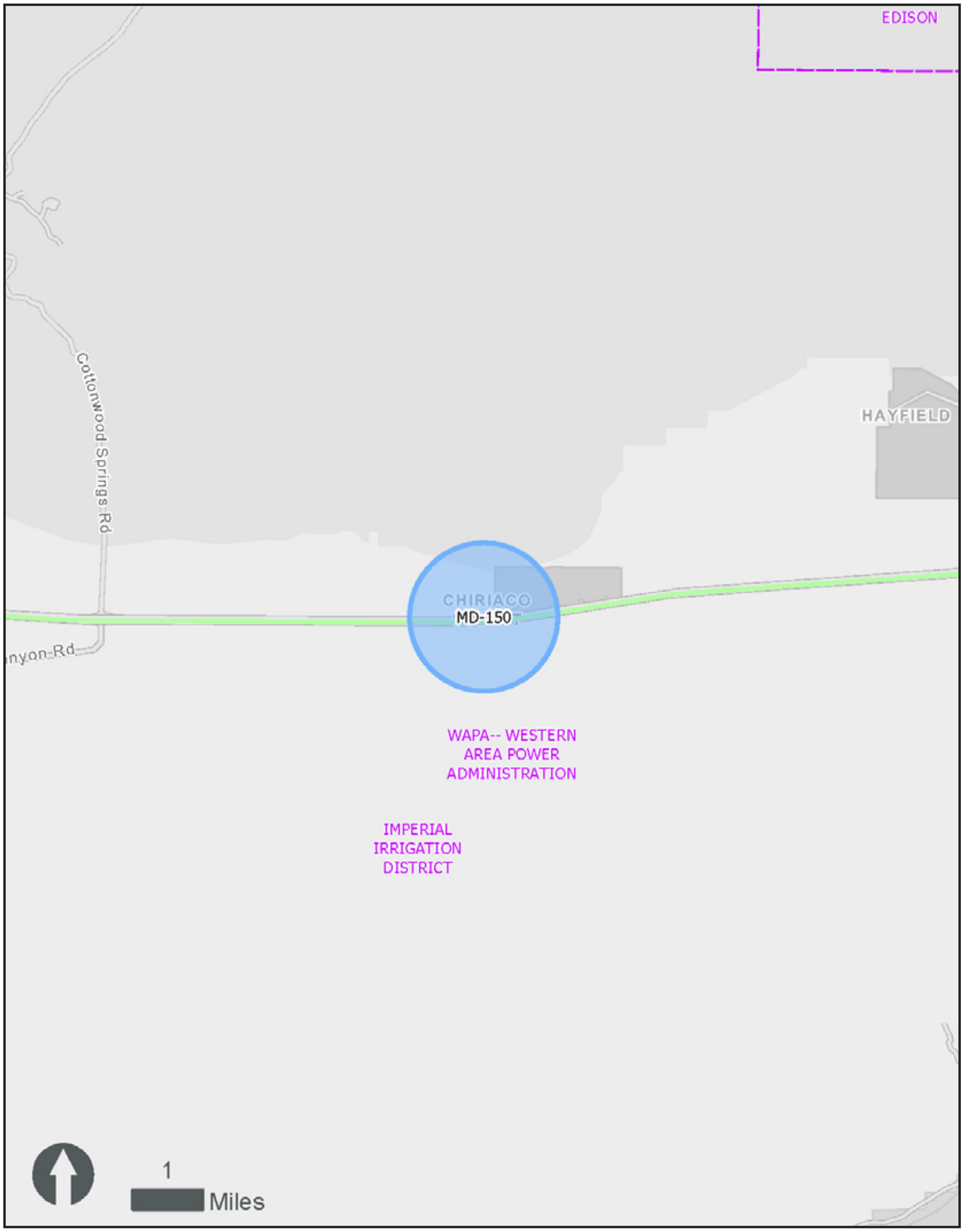
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, WAPA - WESTERN AREA POWER ADMINISTRATION

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-35: I-10 Proposed Charging Locations MD/HD-100



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017

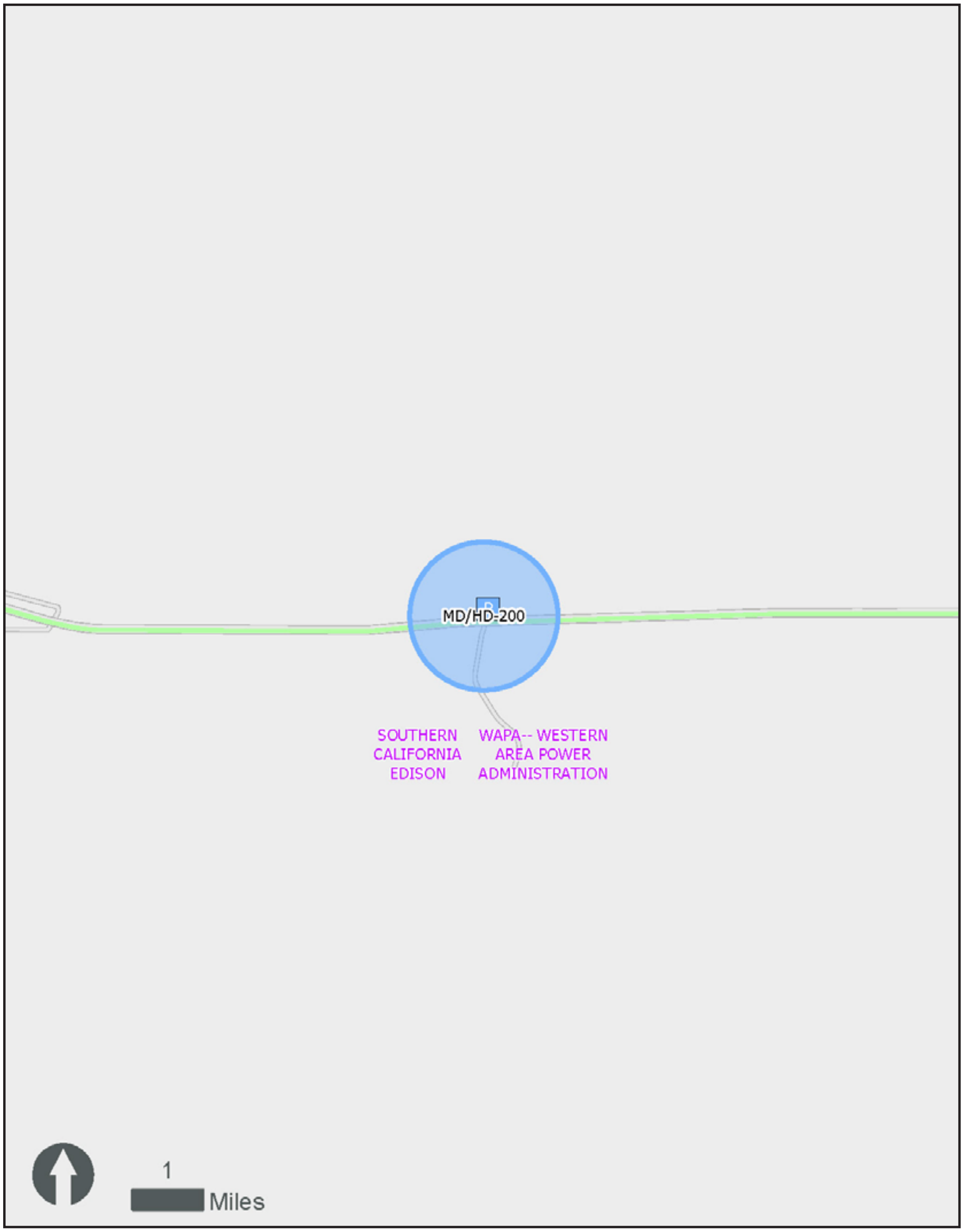
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON,
WAPA - WESTERN AREA POWER
ADMINISTRATION,
IMPERIAL IRRIGATION DISTRICT

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-36: I-10 Proposed Charging Locations MD-150



WCCTCI Study Area Potential

Charging Location Truck Parking

Location

Substation

Electric Retail Service Territories

Existing DC Fast Charging Public Stations

Truck Volume 2017

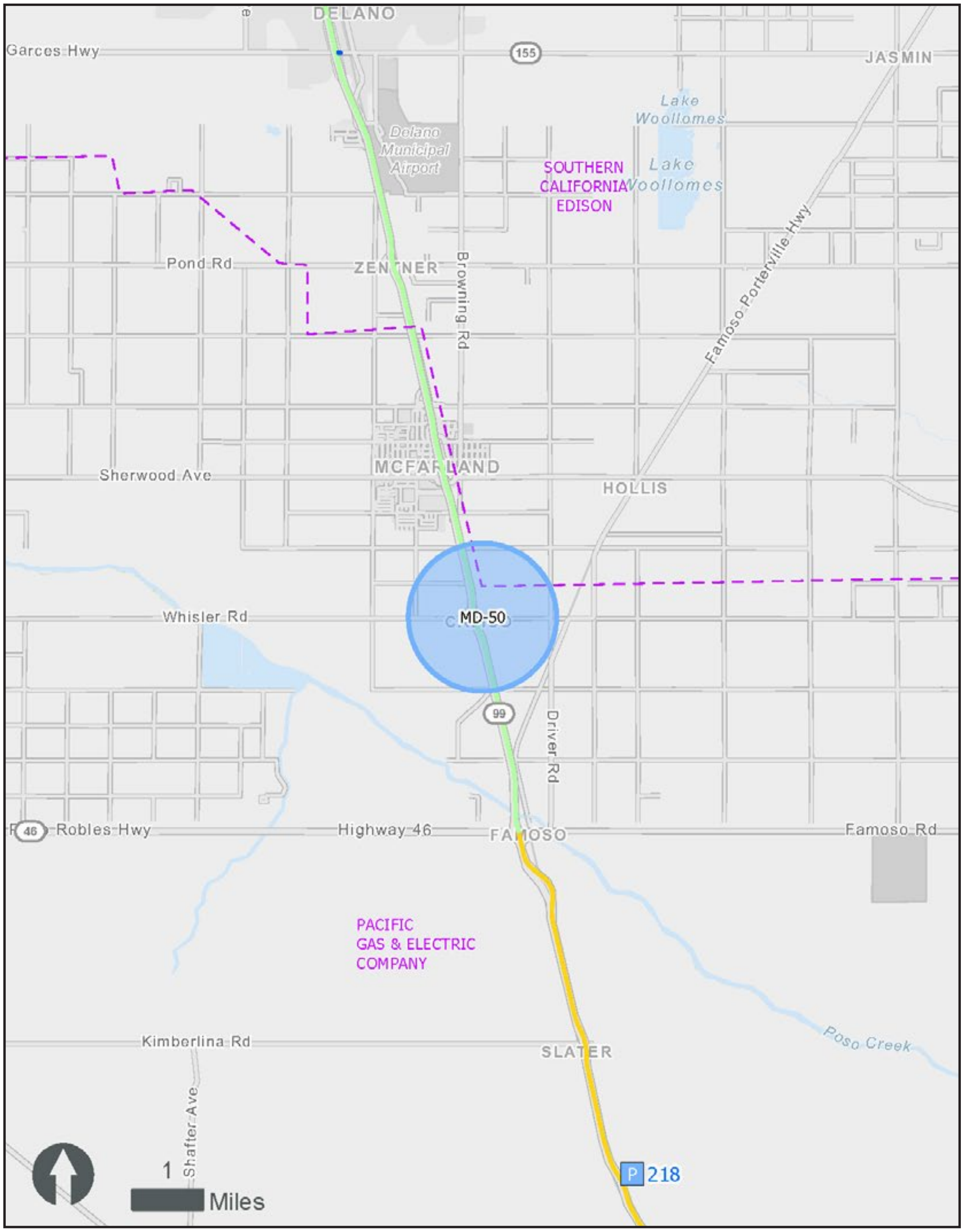
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, WAPA - WESTERN AREA POWER ADMINISTRATION

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-37: I-10 Proposed Charging Locations MD/HD-200



WCCTCI Study Area Potential Charging Location
Truck Parking Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

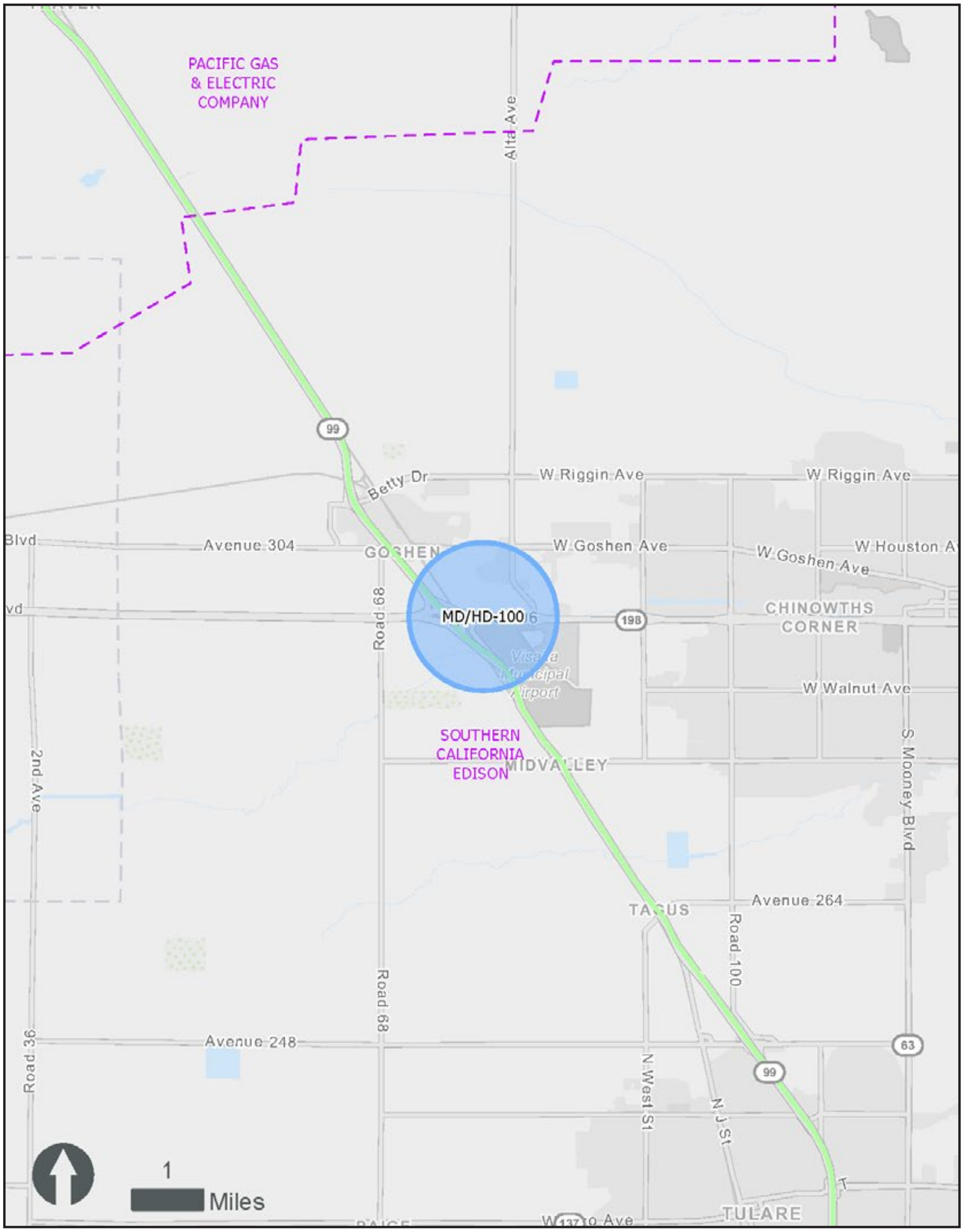
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-38: SR-99 Proposed Charging Locations MD-50



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017

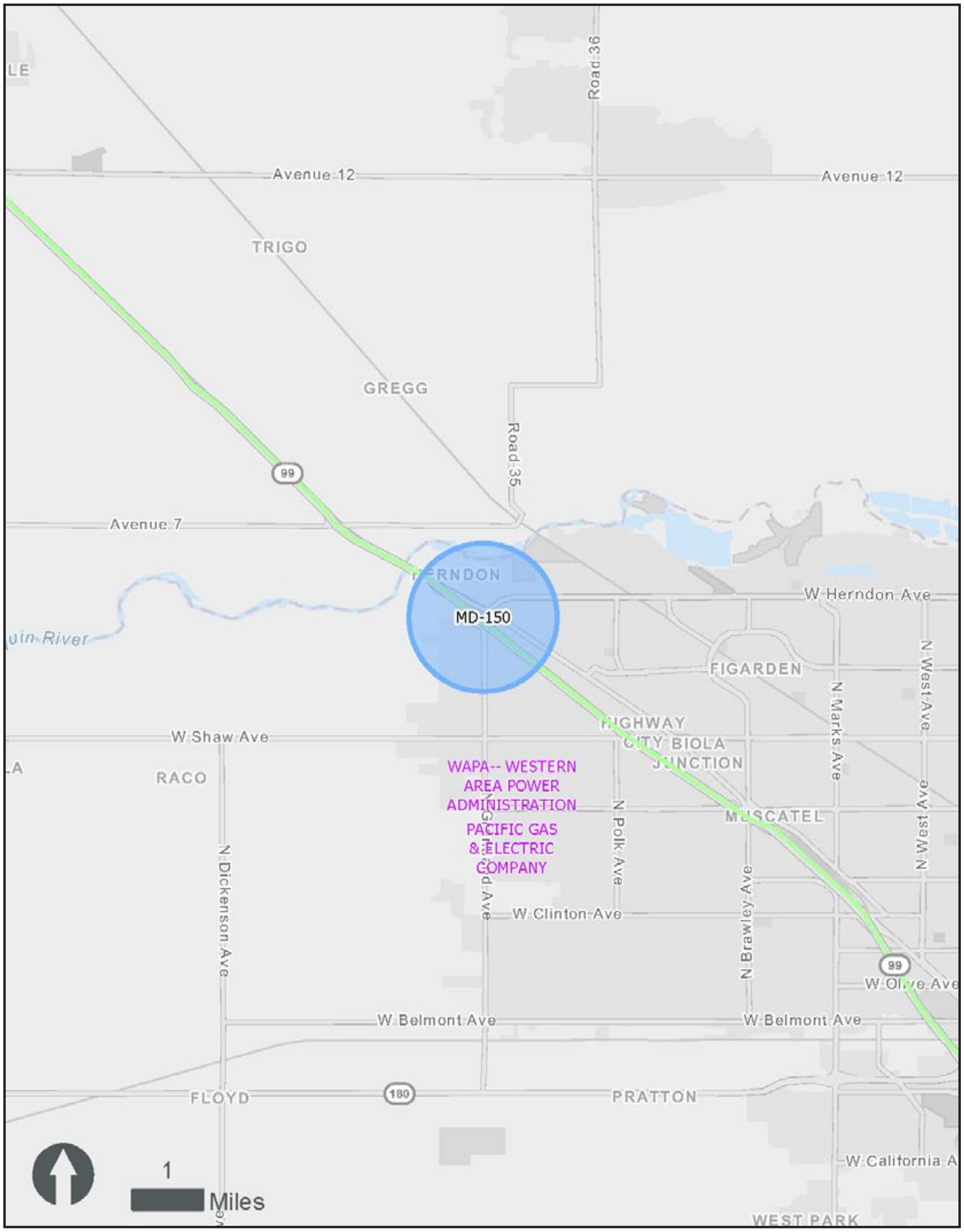
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SOUTHERN CALIFORNIA EDISON,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-39: SR-99 Proposed Charging Locations MD/HD-100



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

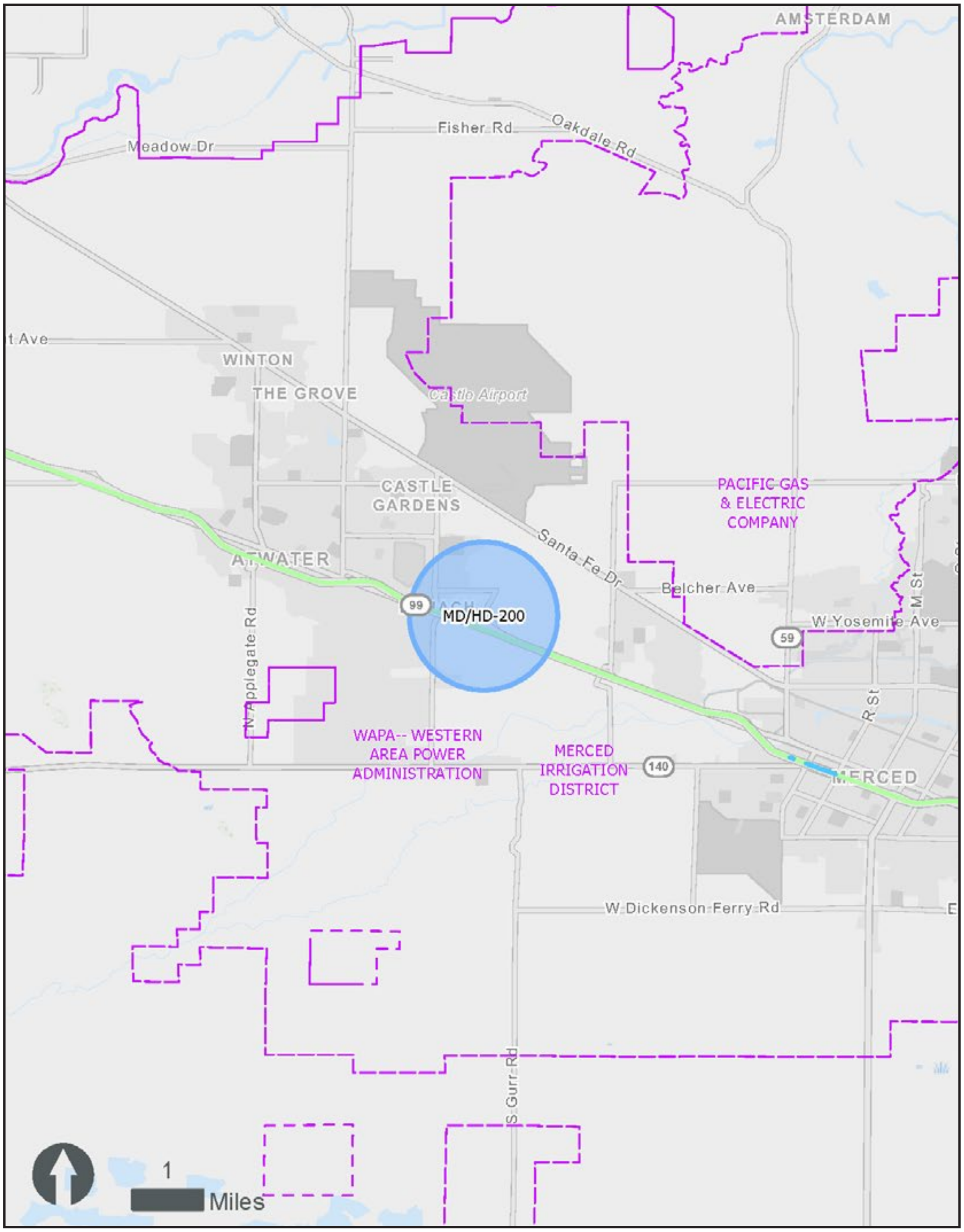
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-40: SR-99 Proposed Charging Locations MD-150



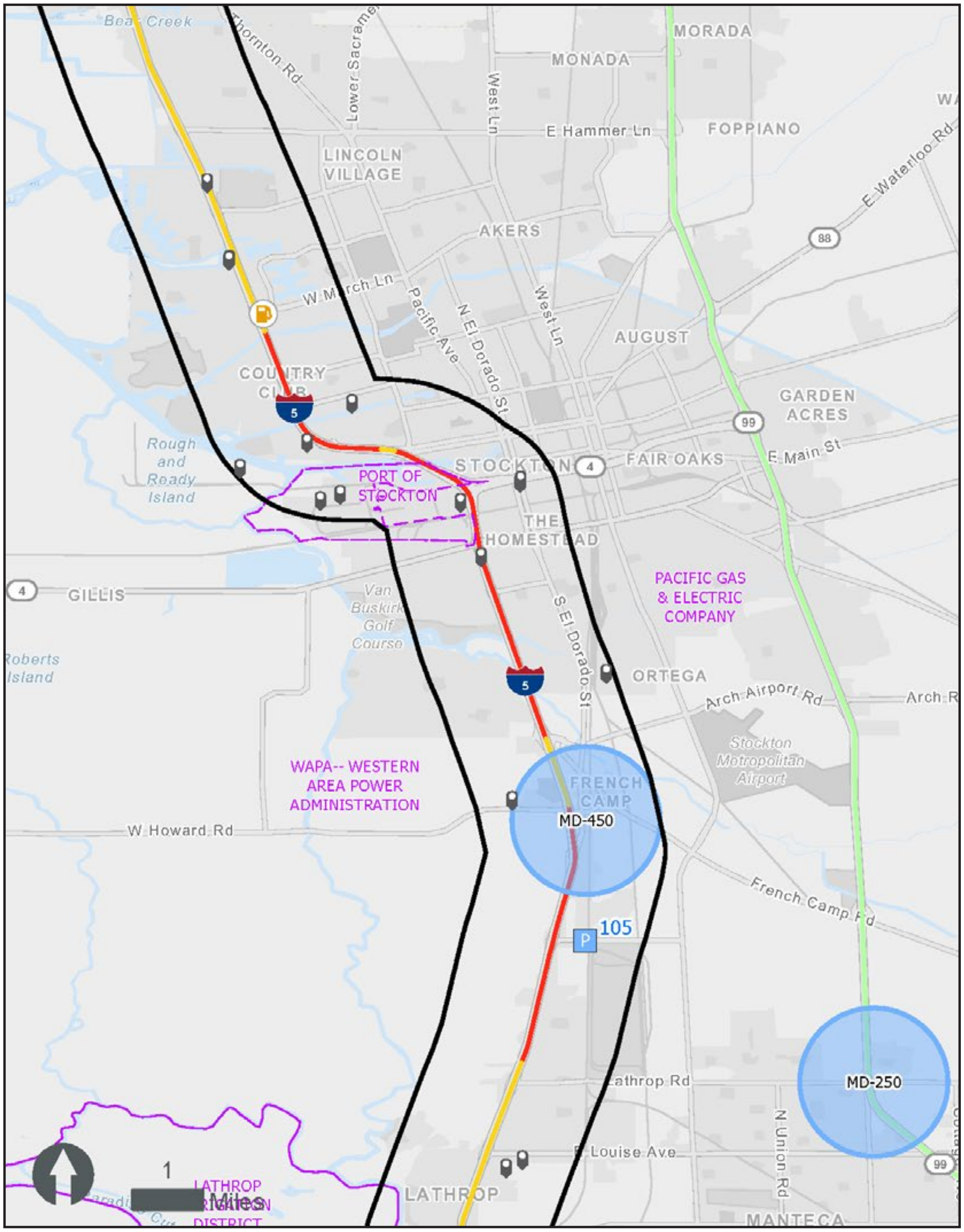
WCCTCI Study Area Potential Charging Location Truck Parking
P Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY
WAPA - WESTERN AREA POWER ADMINISTRATION, MERCED IRRIGATION DISTRICT, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-41: SR-99 Proposed Charging Locations MD/HD-200



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

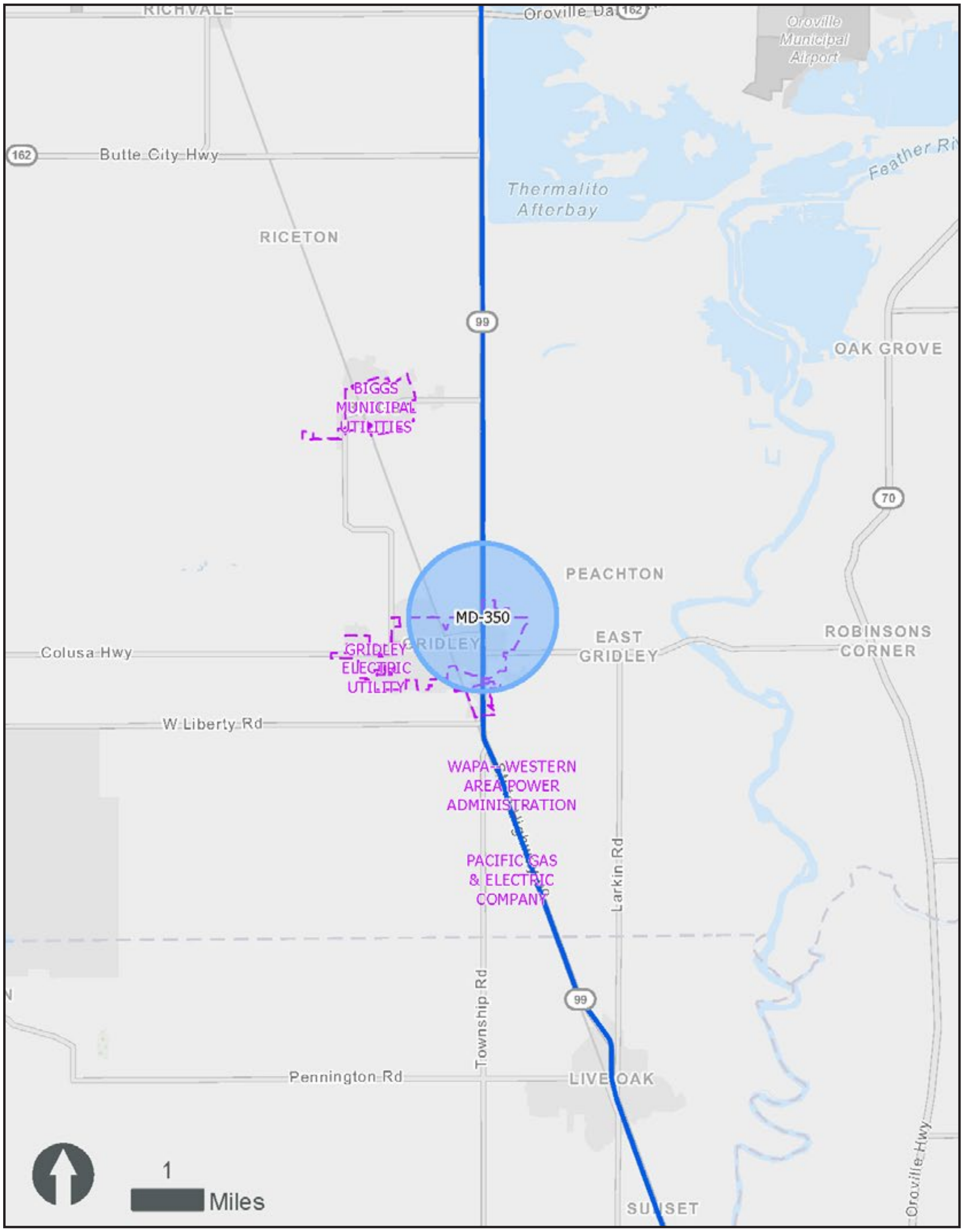
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION,
LATHROP IRRIGATION DISTRICT,
PORT OF STOCKTON,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-42: SR-99 Proposed Charging Locations MD-250



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

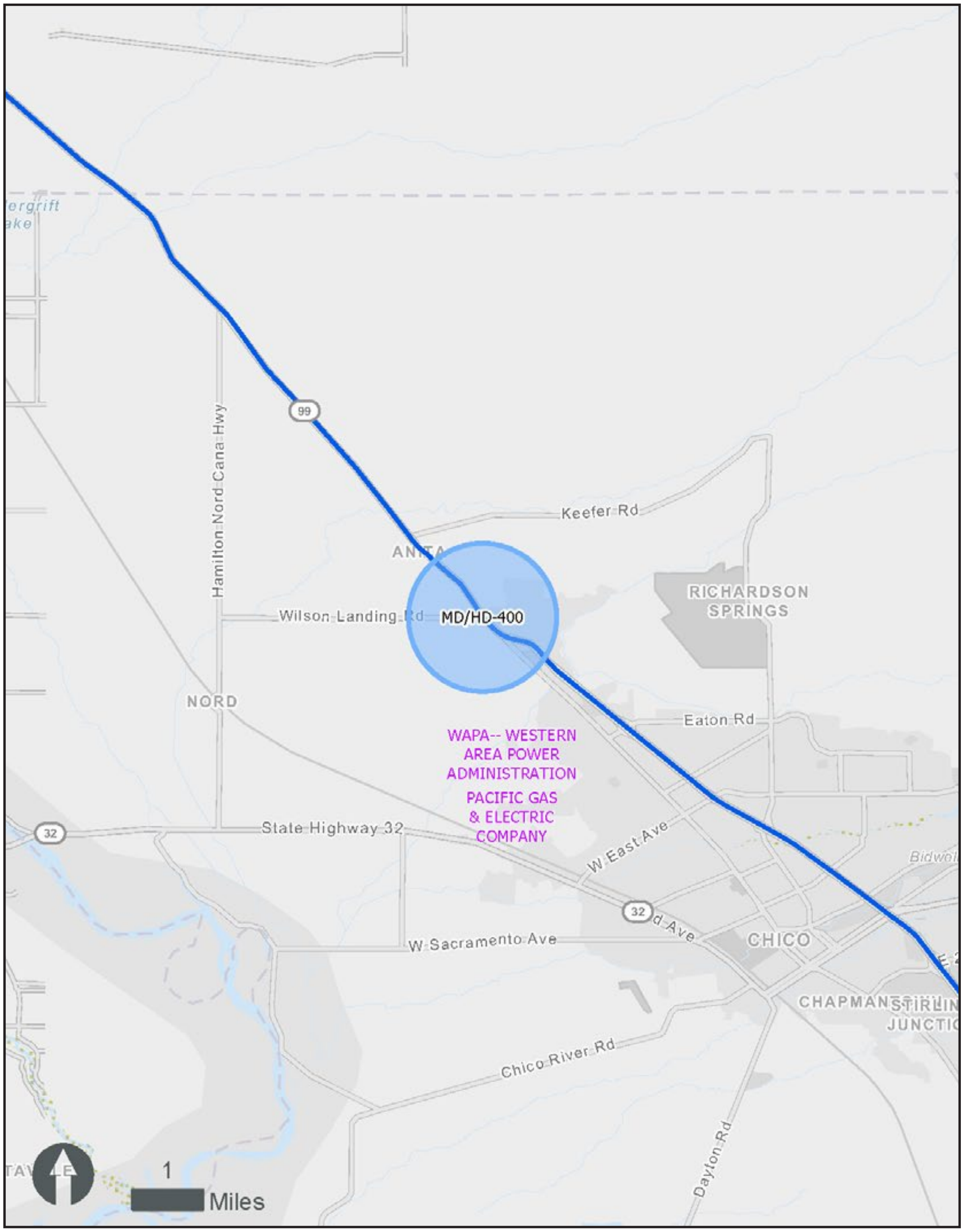
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFIC GAS & ELECTRIC COMPANY, BIGGS MUNICIPAL UTILITIES, GRIDLEY ELECTRIC UTILITY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-43: SR-99 Proposed Charging Locations MD-350



WCCTCI Study Area Potential Charging Location Truck Parking

Location

Substation

Electric Retail Service Territories

Existing DC Fast Charging Public Stations

Truck Volume 2017

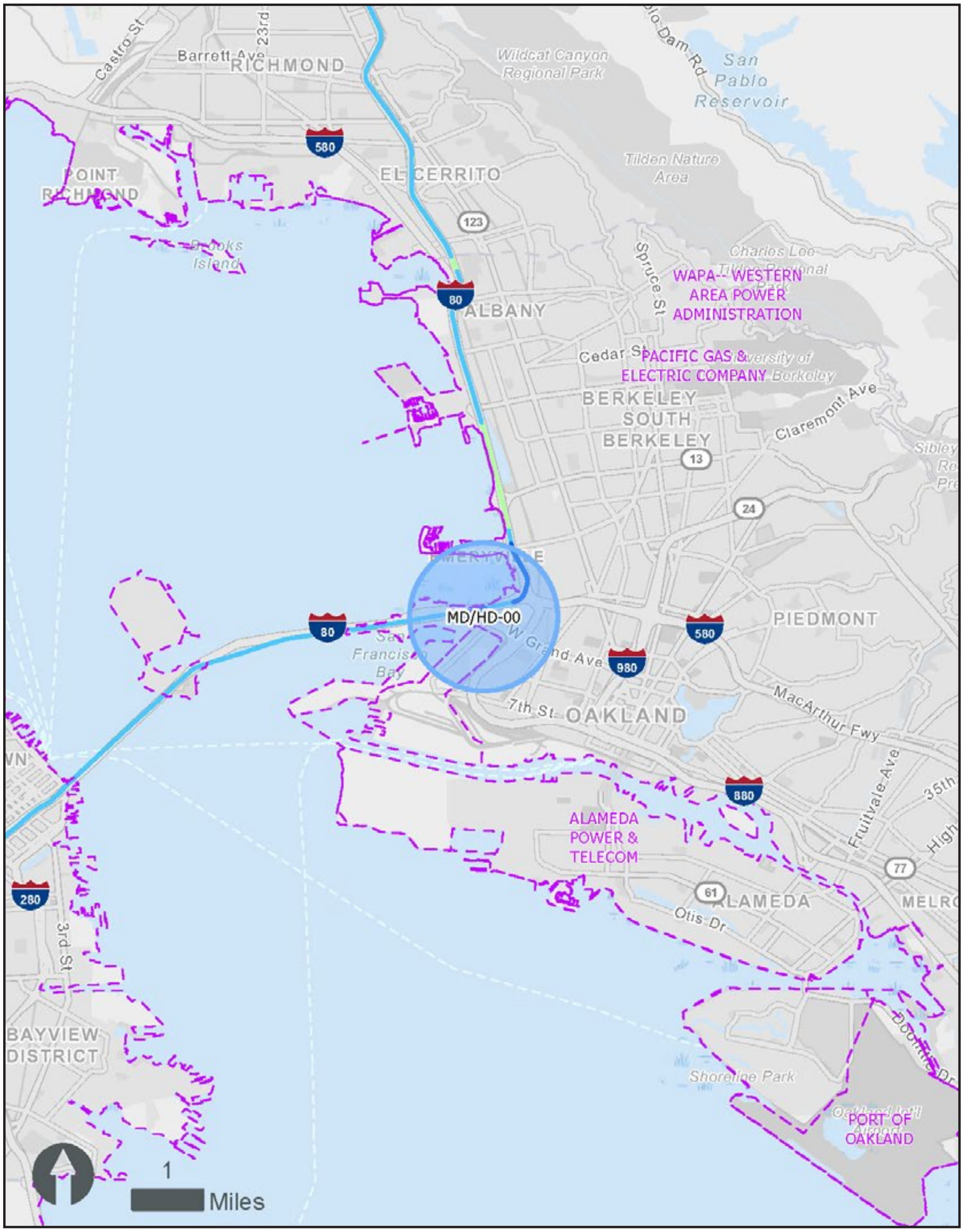
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION, PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-44: SR-99 Proposed Charging Locations MD/HD-400



WCCTCI Study Area Potential Charging Location Truck Parking Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

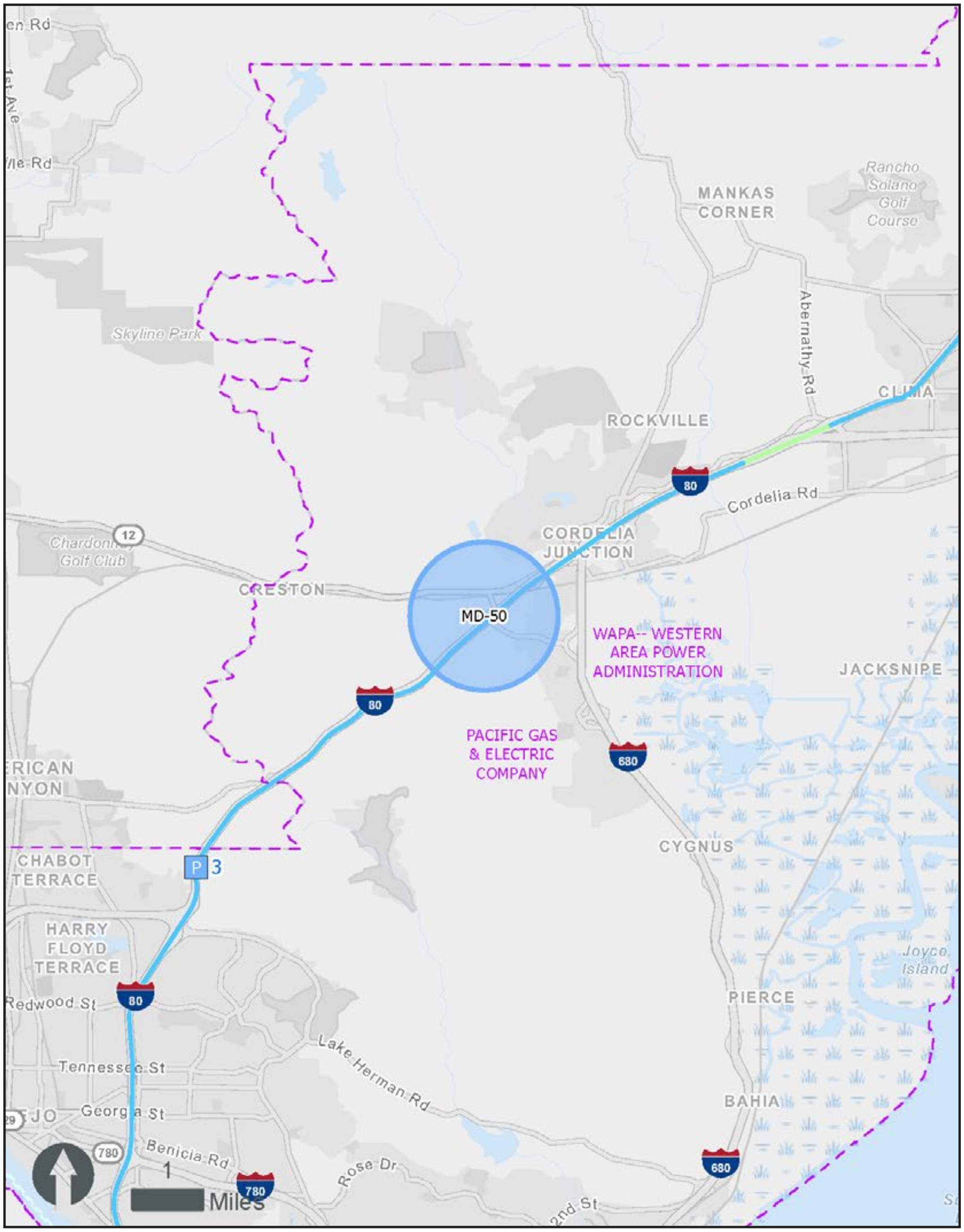
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION, PORT OF OAKLAND, PACIFIC GAS & ELECTRIC COMPANY ,ALAMEDA POWER & TELECOM

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

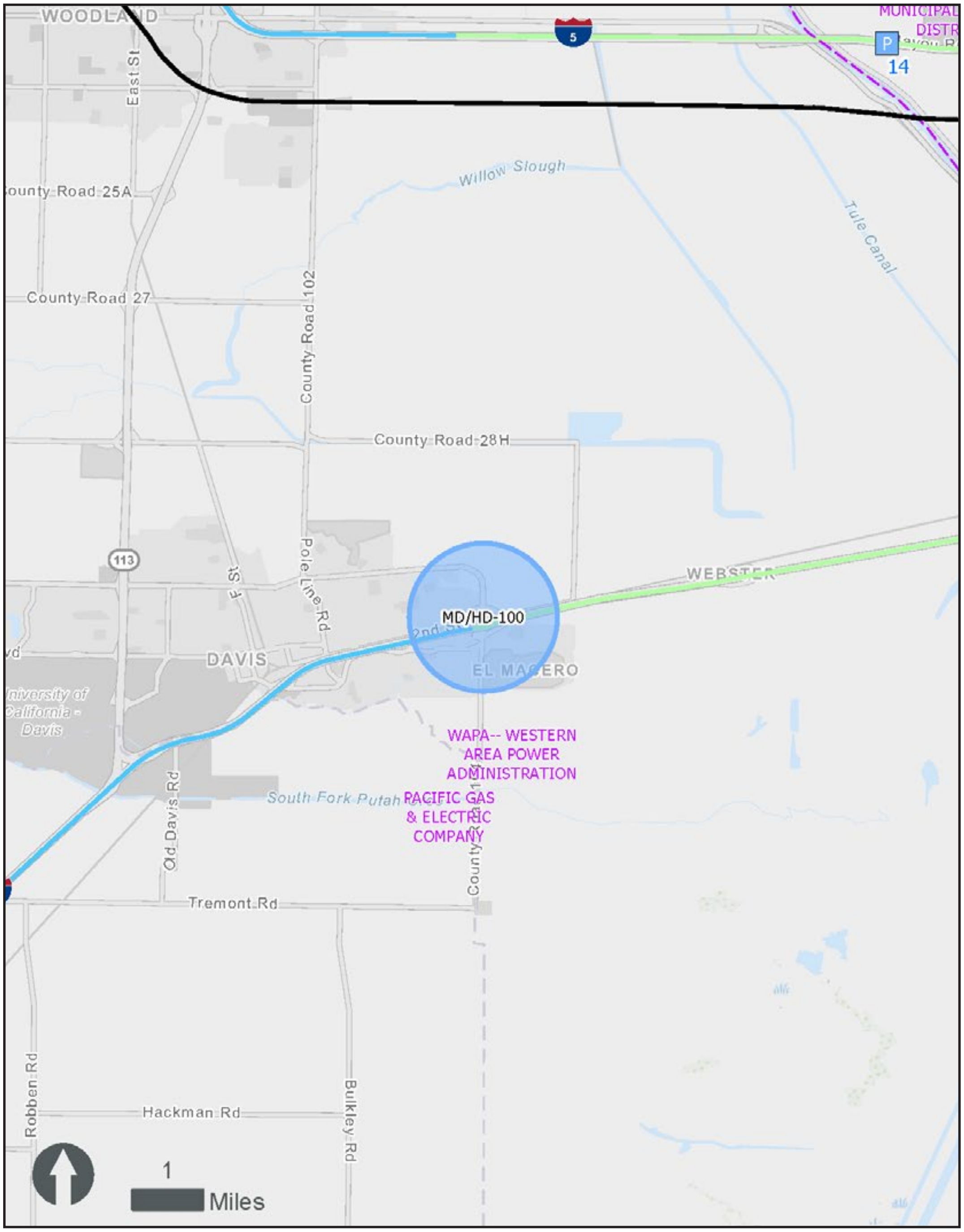
Figure B-45: I-80 Proposed Charging Locations MD/HD-0



WCCTCI Study Area Potential	**Truck Volume 2017**			**SERVICE TERRITORY**
Charging Location Truck Parking	≤ 5000			WAPA - WESTERN AREA POWER ADMINISTRATION, CITY OF PITTSBURG, PACIFIC GAS & ELECTRIC COMPANY
Location	≤ 10000			
Substation	≤ 20000			
Electric Retail Service Territories	≤ 30000			
Existing DC Fast Charging Public Stations	> 30000			

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-46: I-80 Proposed Charging Locations MD-50



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

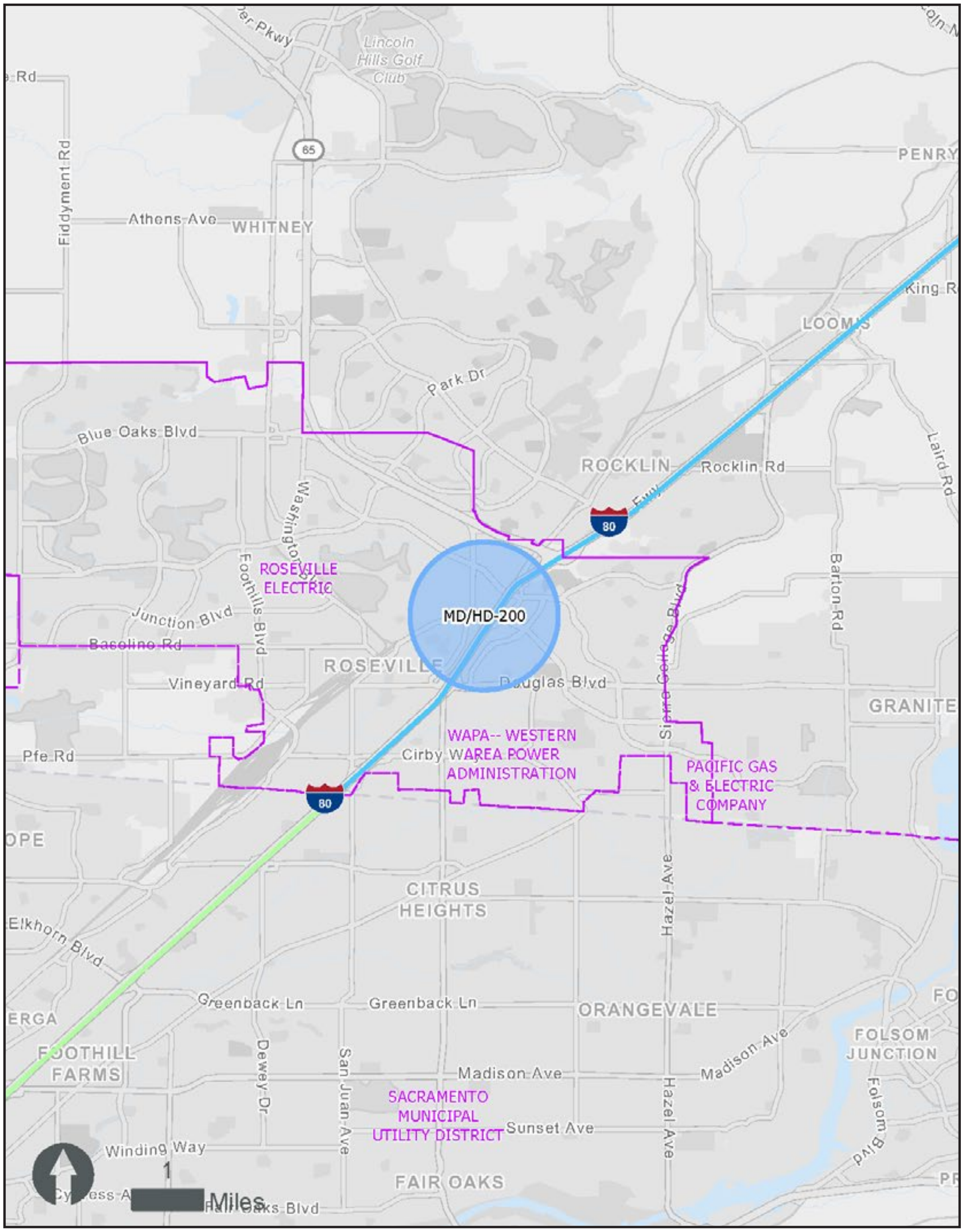
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY

SACRAMENTO MUNICIPAL UTILITY DISTRICT,
WAPA - WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-47: I-80 Proposed Charging Locations MD/HD-100



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

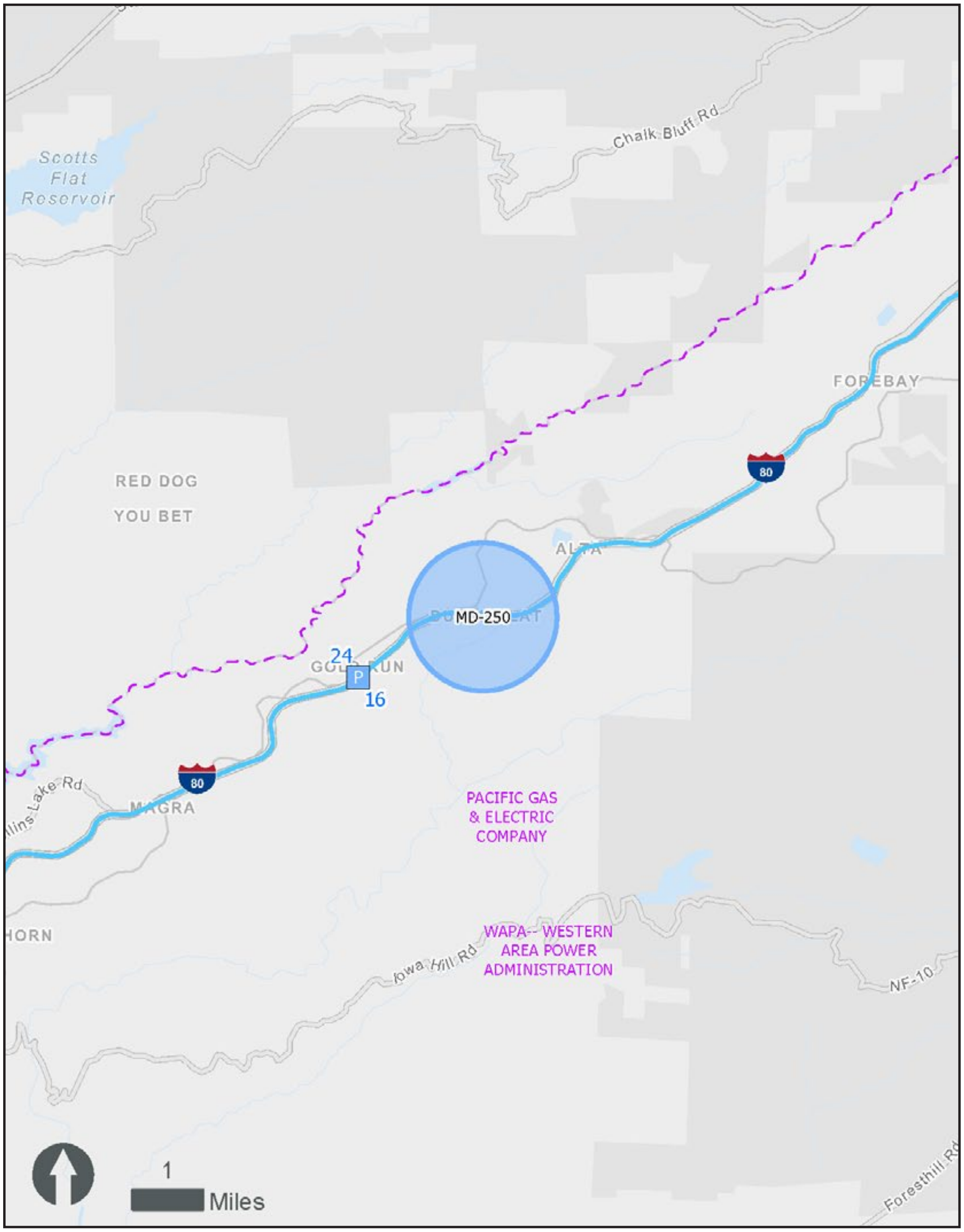
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY

ROSEVILLE ELECTRIC,
SACRAMENTO MUNICIPAL UTILITY DISTRICT,
WAPA - WESTERN AREA POWER ADMINISTRATION,
PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-48: I-80 Proposed Charging Locations MD/HD-200



WCCTCI Study Area Potential Charging Location Truck Parking

Location

Substation

Electric Retail Service Territories

Existing DC Fast Charging Public Stations

Truck Volume 2017

≤ 5000

≤ 10000

≤ 20000

≤ 30000

> 30000

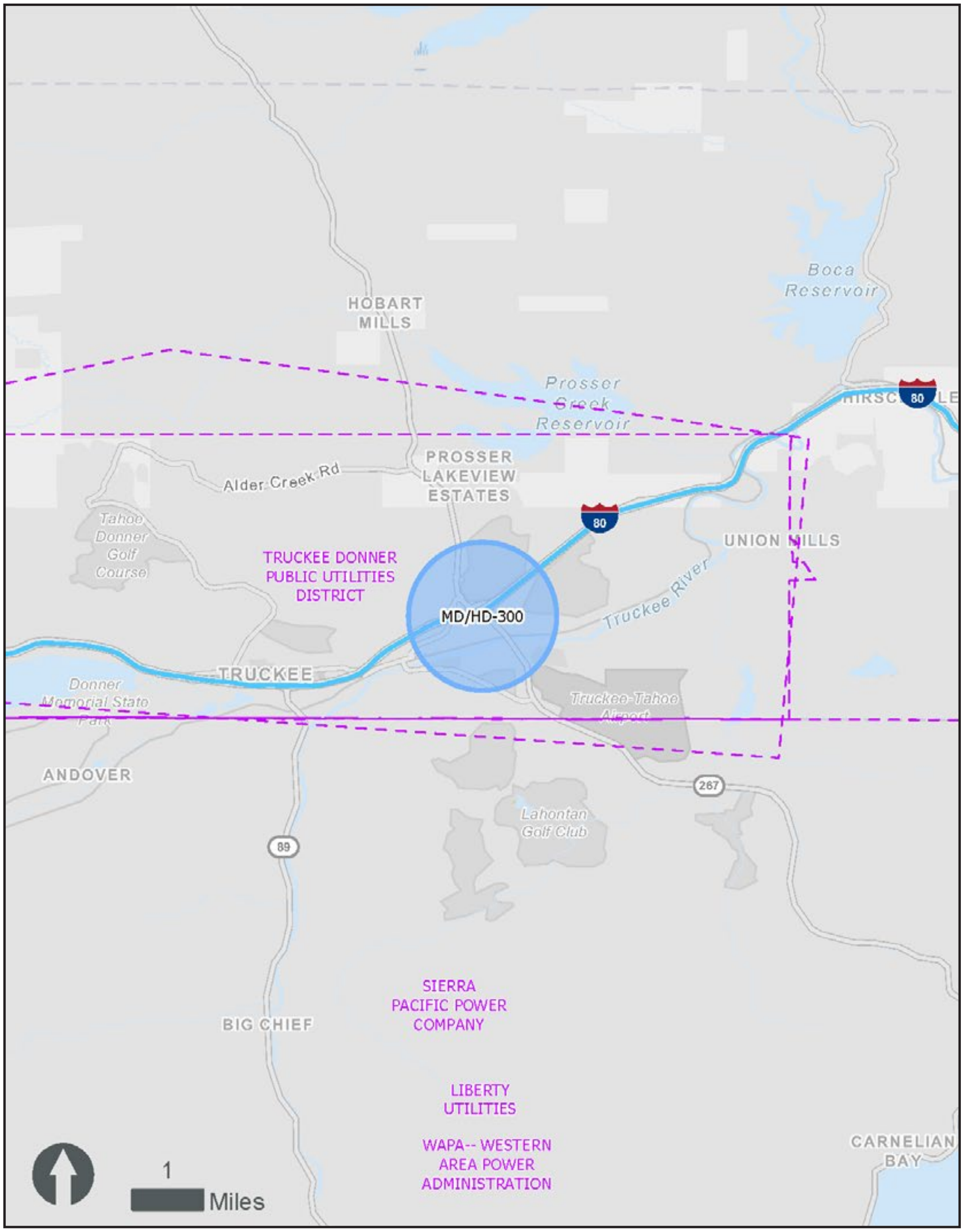
SERVICE TERRITORY

WAPA - WESTERN AREA POWER ADMINISTRATION,

PACIFIC GAS & ELECTRIC COMPANY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-49: I-80 Proposed Charging Locations MD-250



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

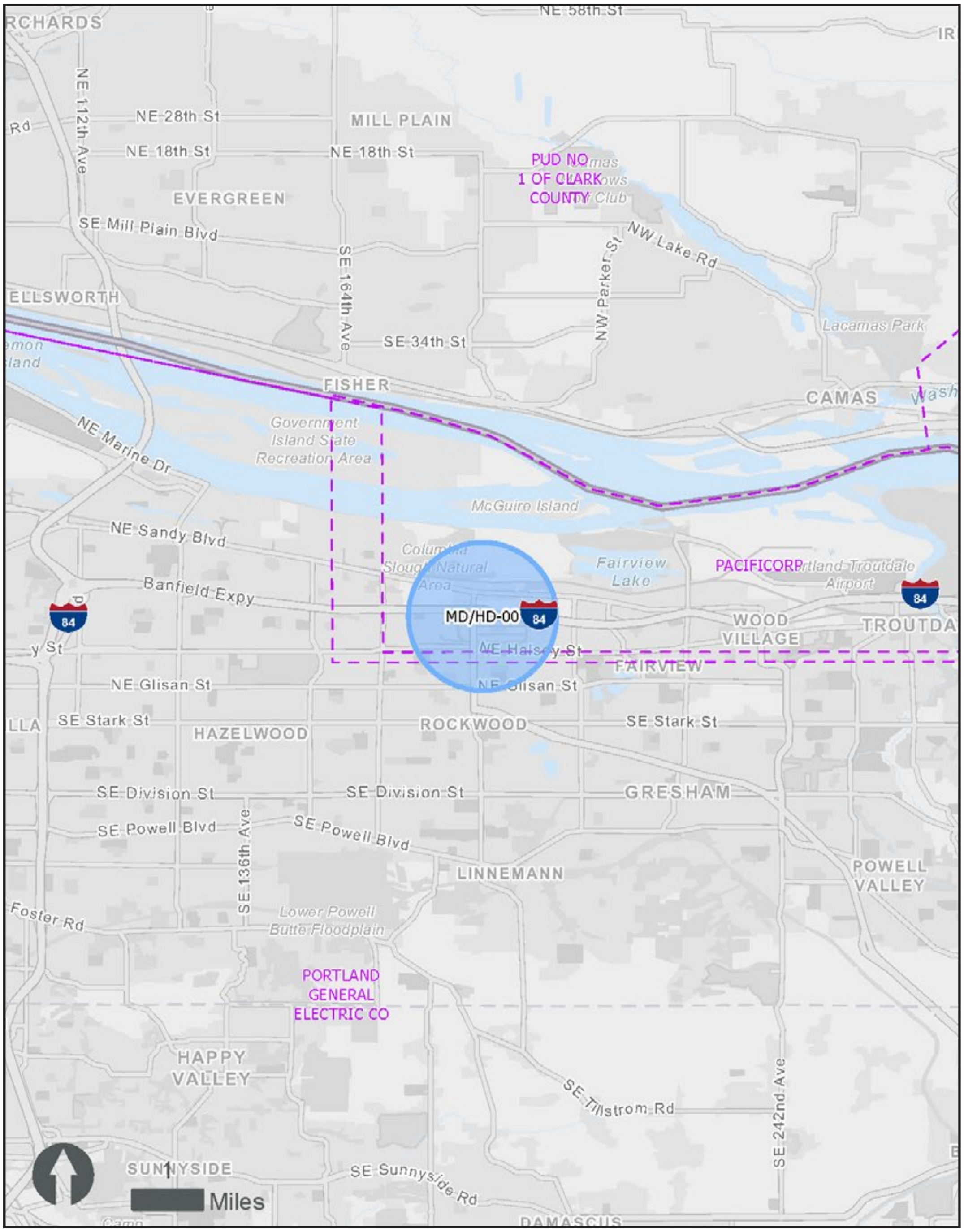
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

SIERRA PACIFIC POWER COMPANY, TRUCKEE DONNER PUBLIC UTILITIES DISTRICT, WAPA - WESTERN AREA POWER ADMINISTRATION, LIBERTY UTILITIES

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-50: I-80 Proposed Charging Locations MD/HD-300



WCCTCI Study Area Potential

Charging Location Truck Parking

Location

Substation

Electric Retail Service Territories

Existing DC Fast Charging Public Stations

Truck Volume 2017

≤ 5000

≤ 10000

≤ 20000

≤ 30000

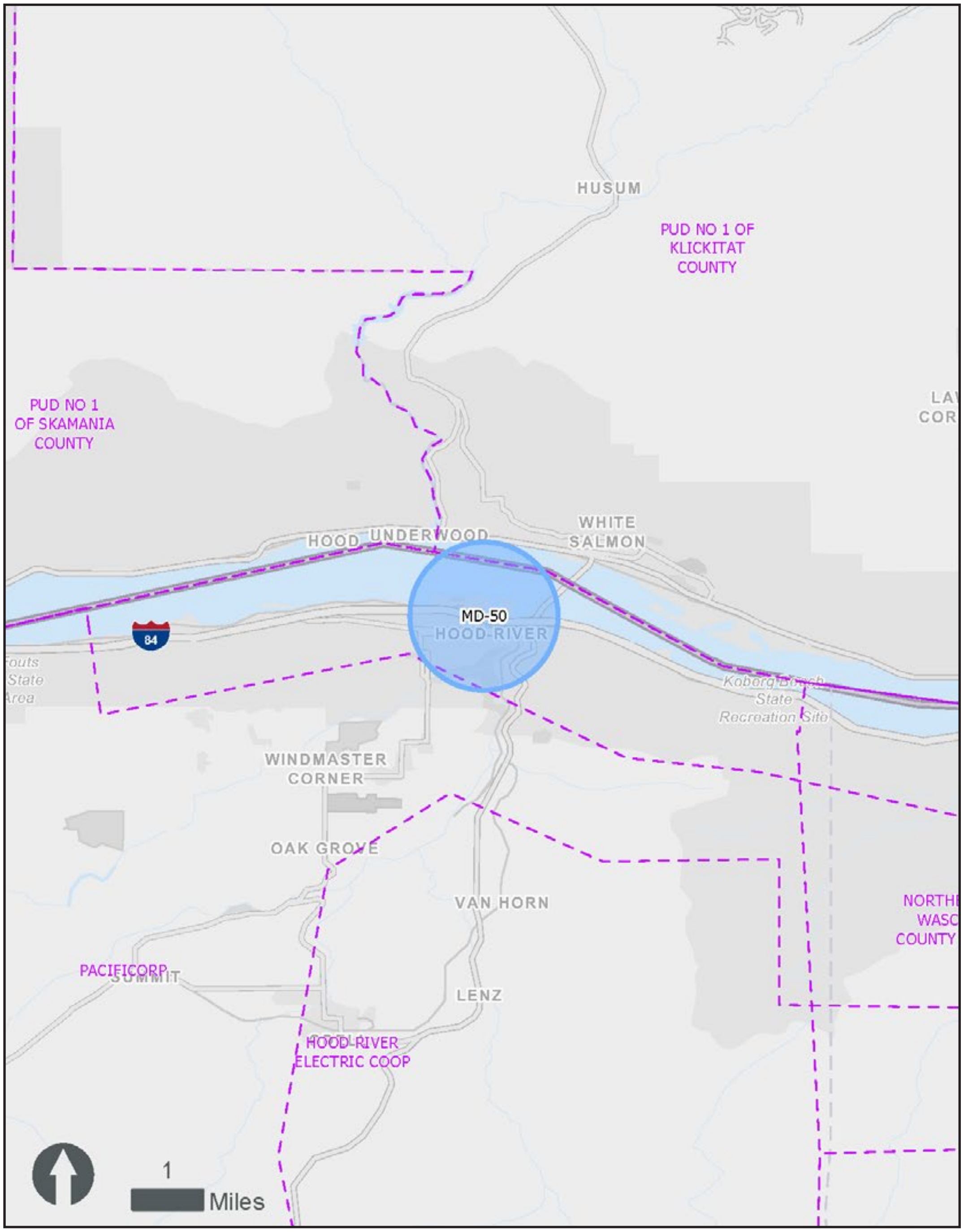
> 30000

SERVICE TERRITORY

PORTLAND GENERAL ELECTRIC CO,
PACIFICORP,
PUD NO 1 OF CLARK COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-51: I-80 Proposed Charging Locations MD/HD-0



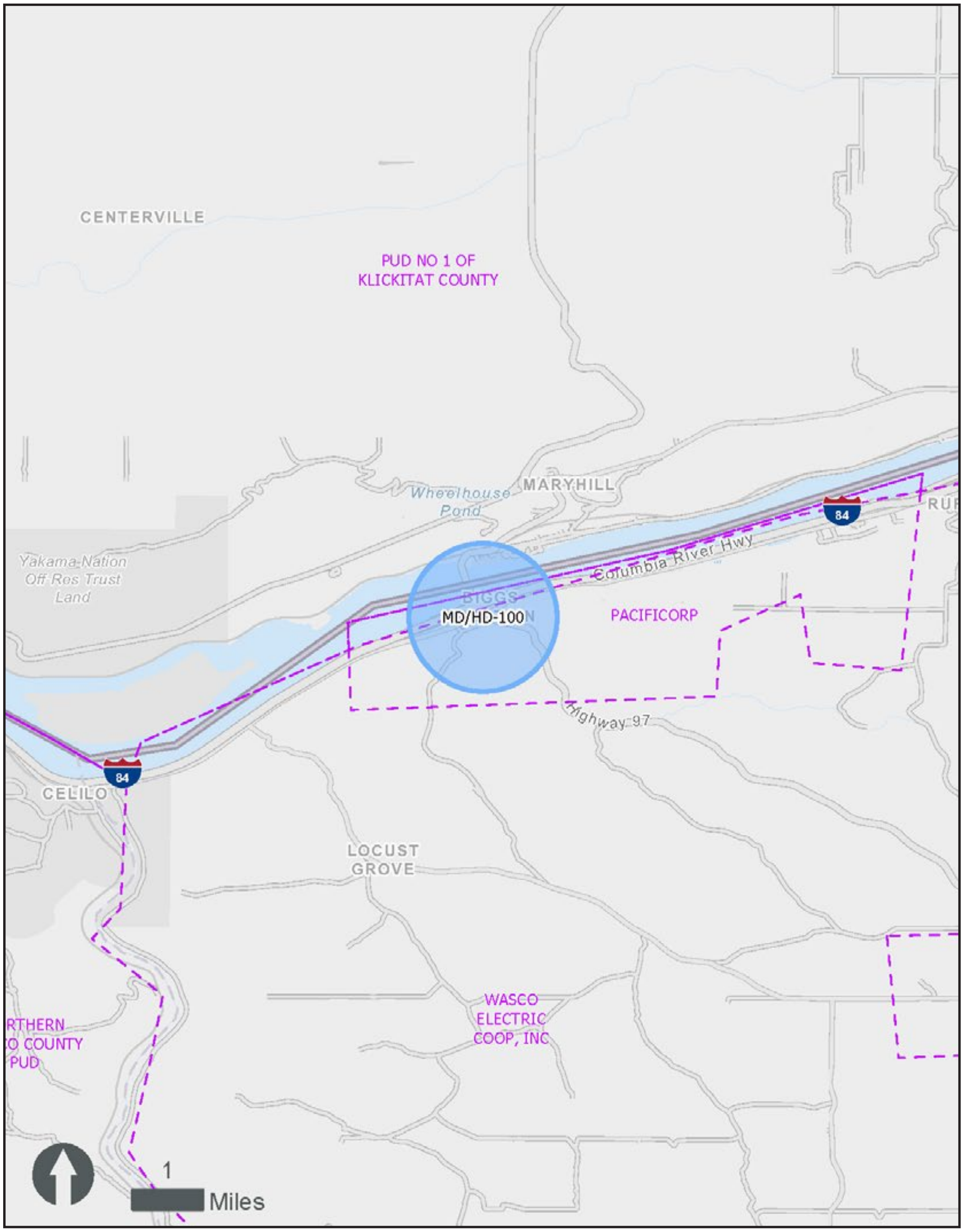
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
PUD NO 1 OF SKAMANIA COUNTY,
WASCO ELECTRIC COOP, INC,
HOOD RIVER ELECTRIC COOP,
PUD NO 1 OF KLICKITAT COUNTY,
NORTHERN WASCO COUNTY PUD,
PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-52: I-80 Proposed Charging Locations MD-50



WCCTCI Study Area Potential	
Charging Location Truck Parking	
Location	
Substation	
Electric Retail Service Territories	
Existing DC Fast Charging Public Stations	

Truck Volume 2017

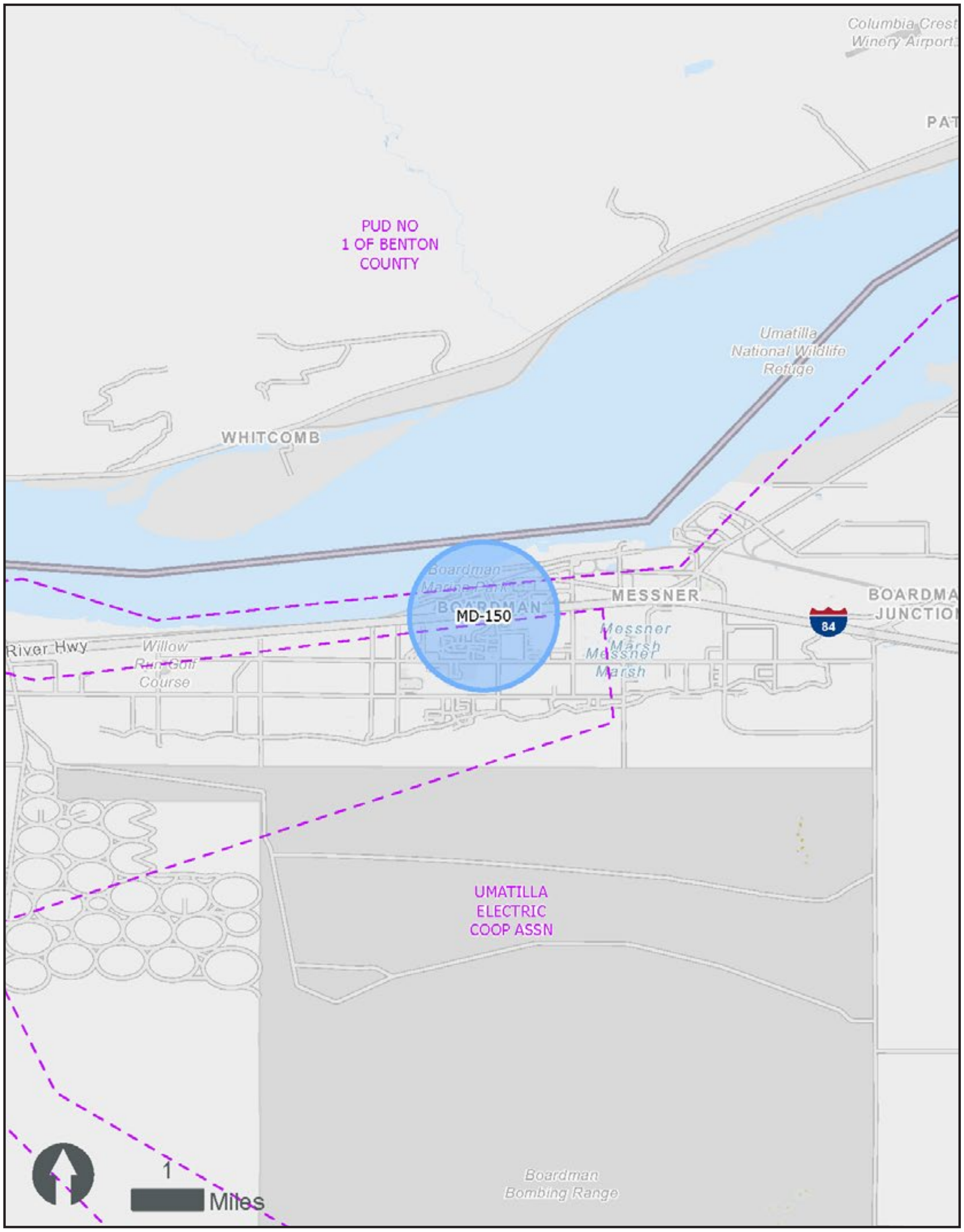
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

WASCO ELECTRIC COOP, INC, PUD NO 1 OF KLICKITAT COUNTY, NORTHERN WASCO COUNTY PUD, PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

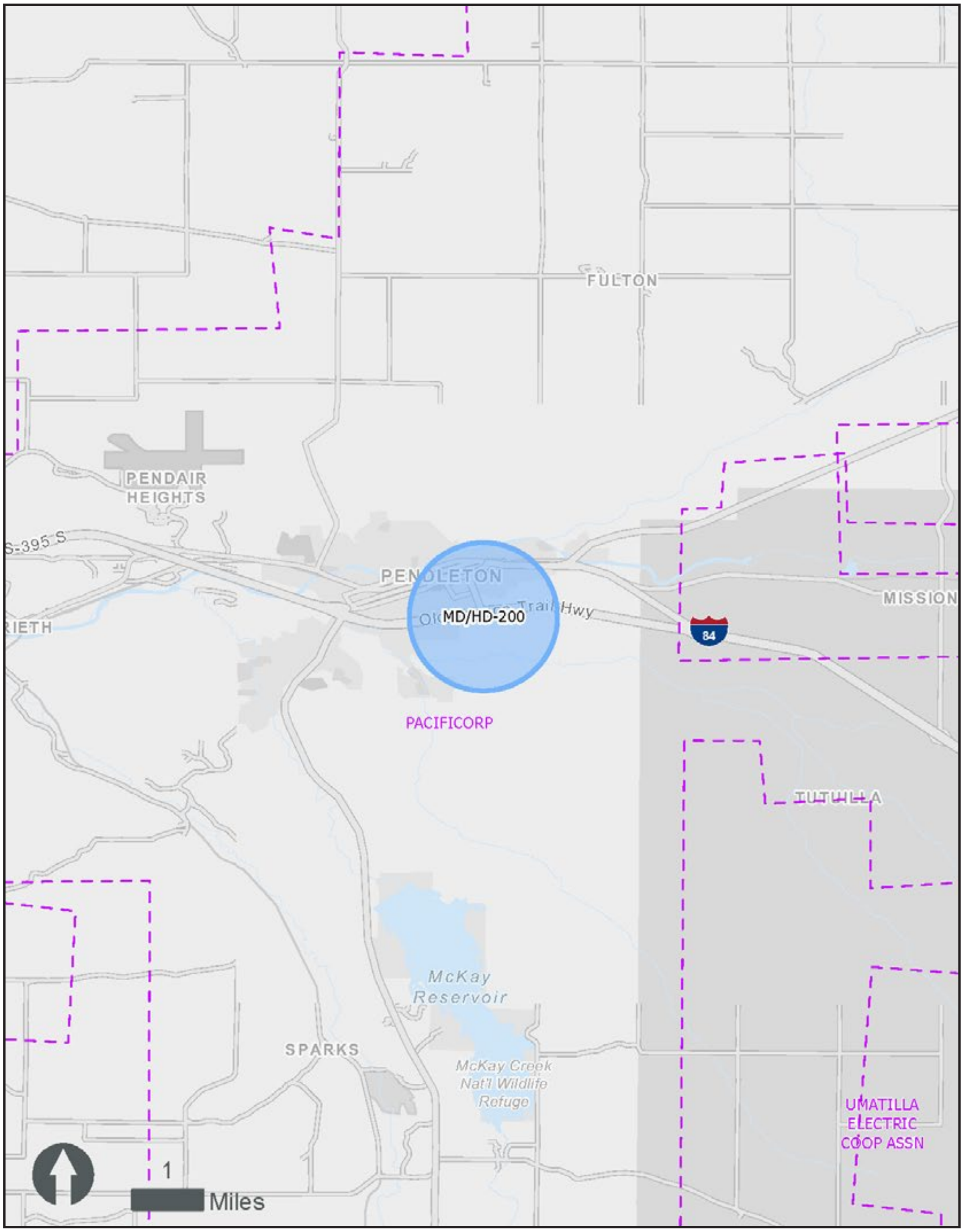
Figure B-53: I-80 Proposed Charging Locations MD/HD-100



WCCTCI Study Area Potential	**Truck Volume 2017**	**SERVICE TERRITORY**
Charging Location Truck Parking	≤ 5000	UMATILLA ELECTRIC COOP ASSN,
Location	≤ 10000	PACIFICORP,
Substation	≤ 20000	PUD NO 1 OF BENTON COUNTY
Electric Retail Service Territories	≤ 30000	
Existing DC Fast Charging Public Stations	> 30000	

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-54: I-80 Proposed Charging Locations MD-150



WCCTCI Study Area Potential Charging Location Truck Parking Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

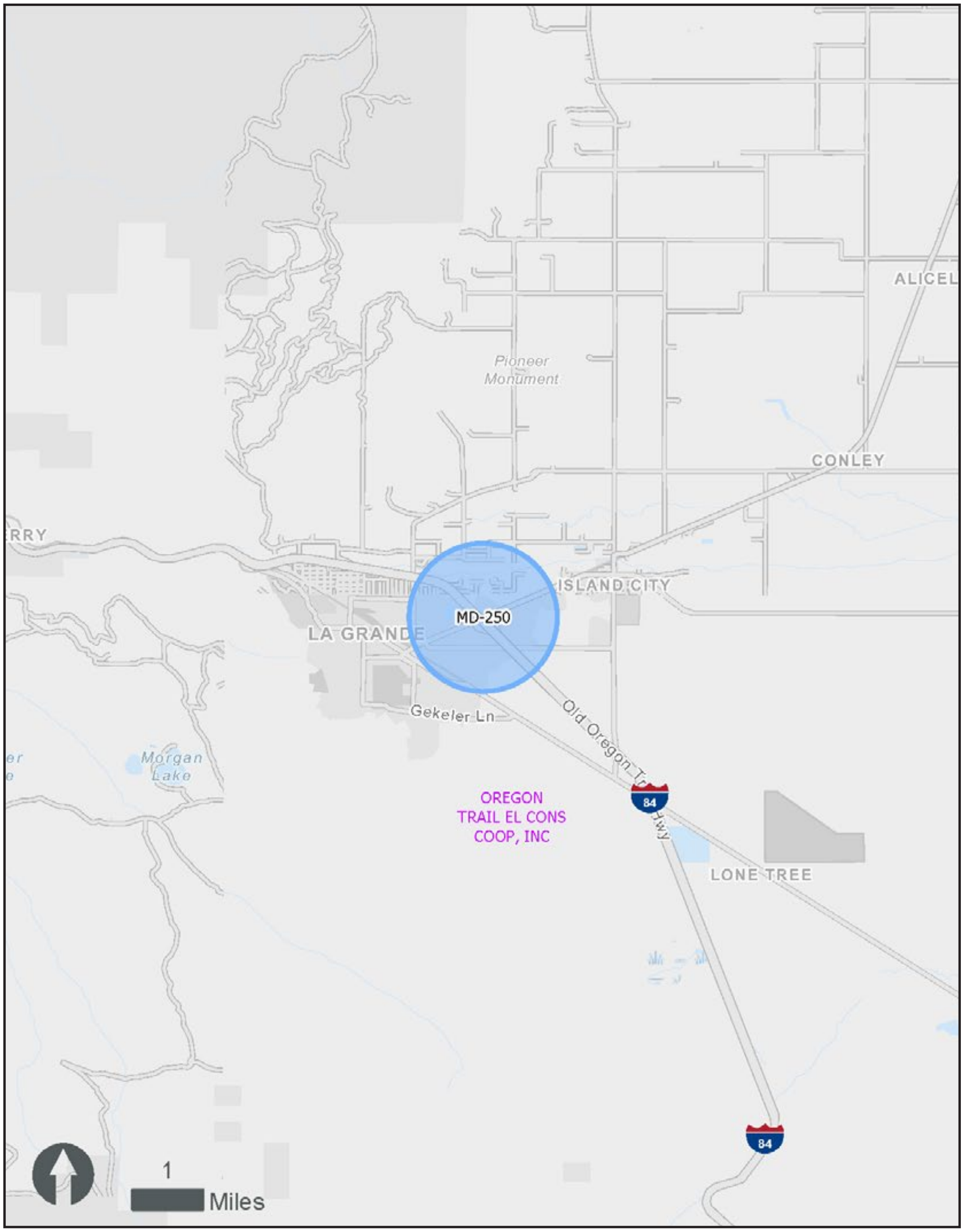
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

UMATILLA ELECTRIC COOP ASSN, PACIFICORP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-55: I-80 Proposed Charging Locations MD/HD-200



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

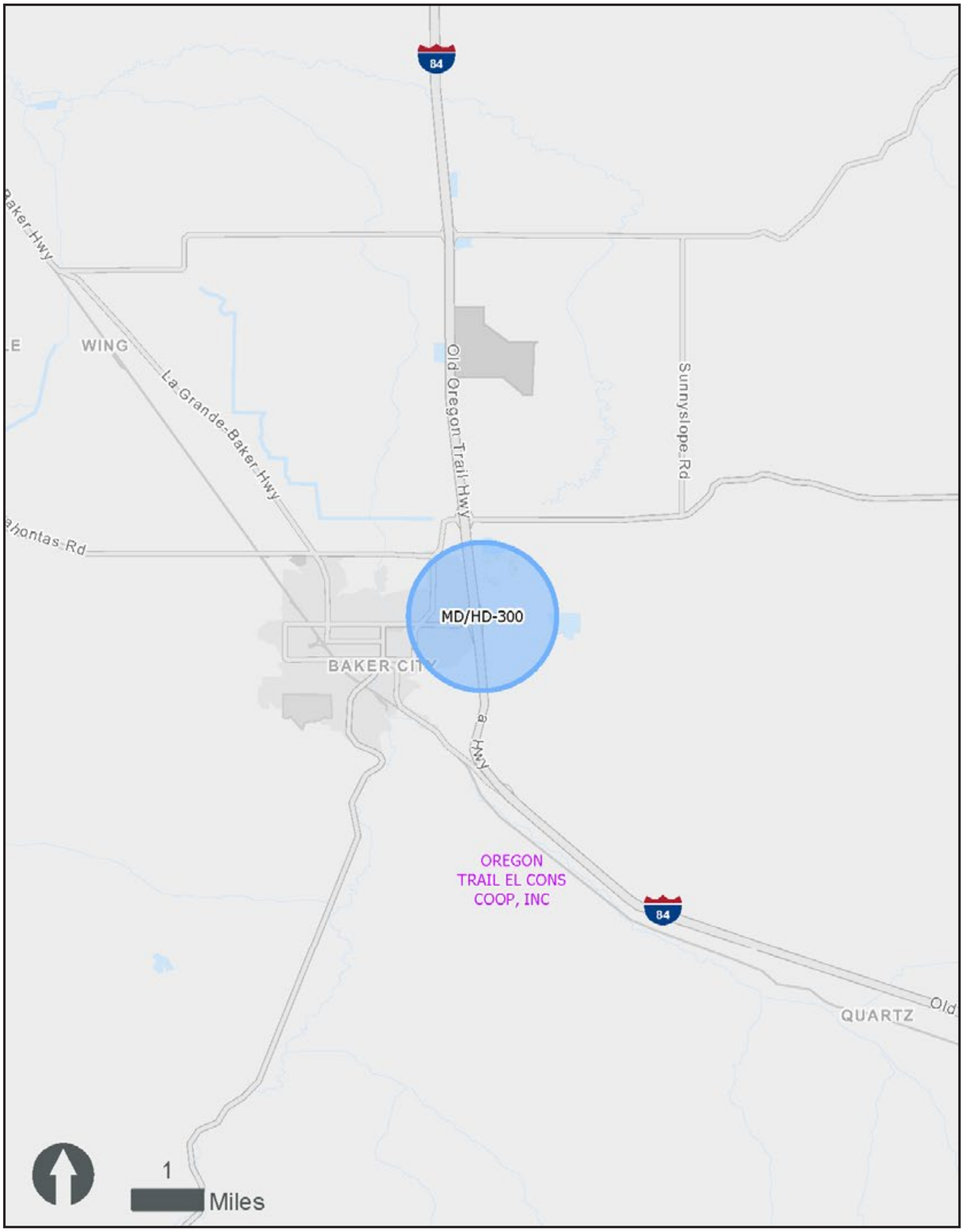
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

OREGON TRAIL EL CONS COOP, INC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-56: I-80 Proposed Charging Locations MD-250



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017

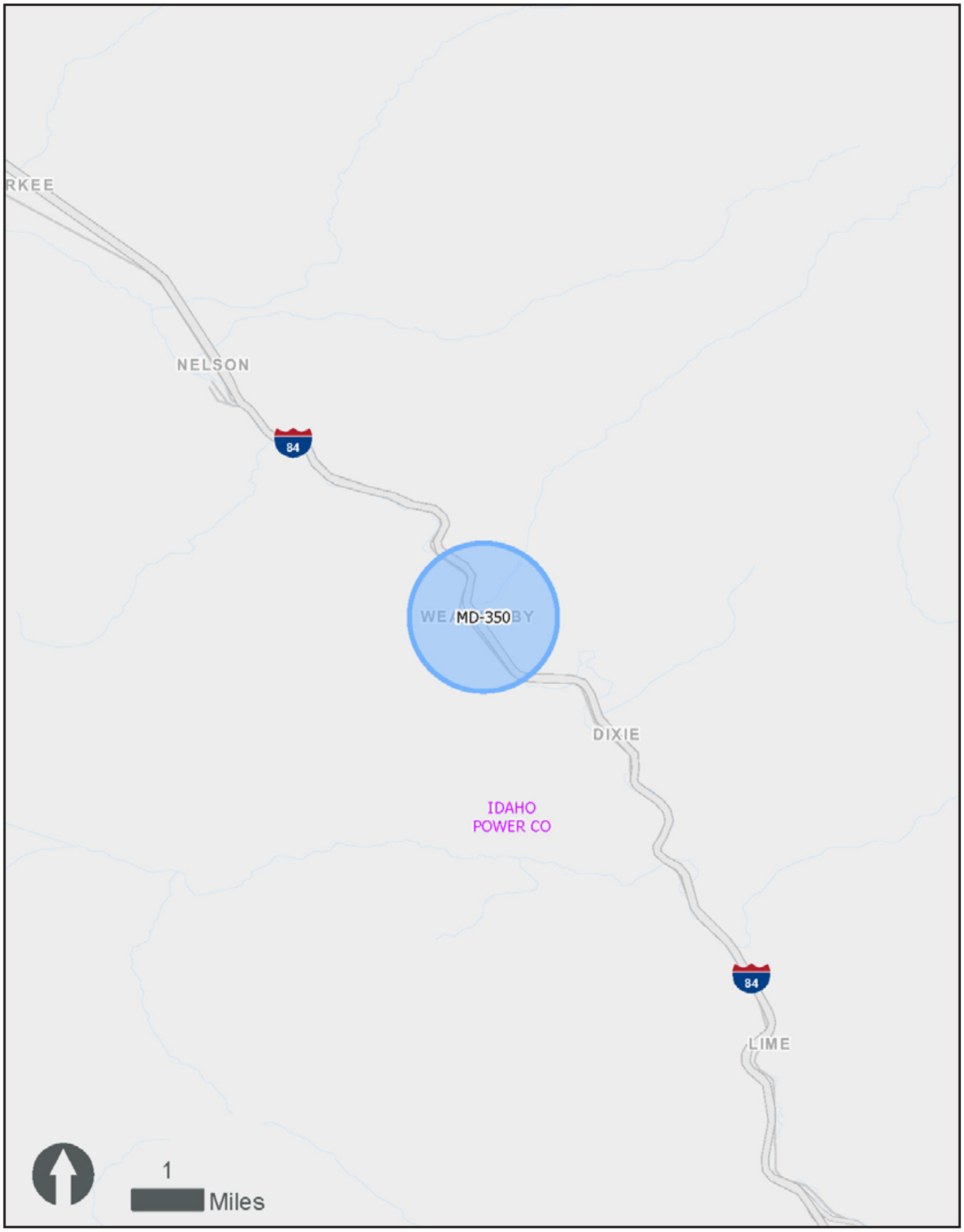
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY

OREGON TRAIL EL CONS COOP, INC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-57: I-80 Proposed Charging Locations MD/HD-300



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

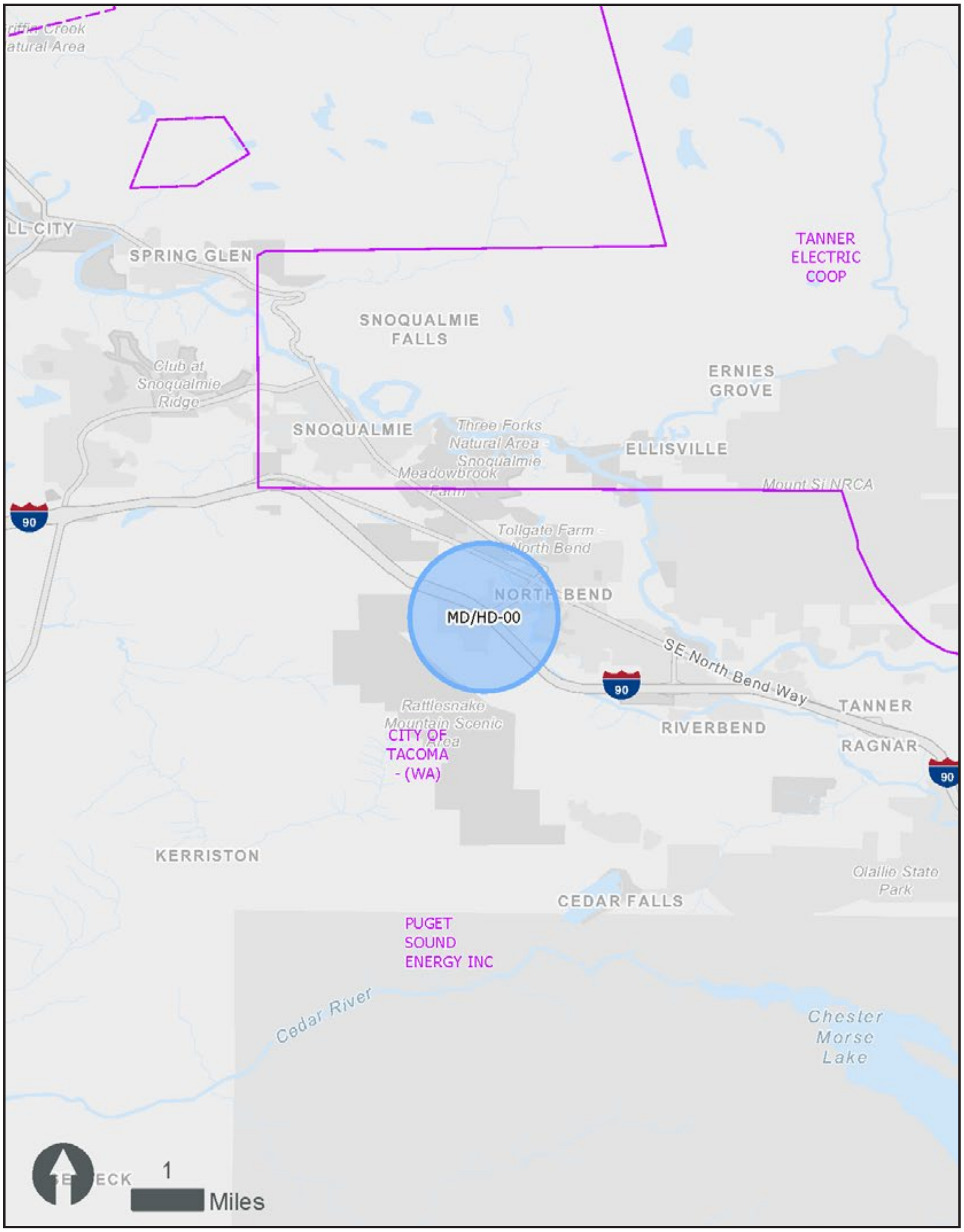
Truck Volume 2017

≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
IDAHO POWER CO

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-58: I-80 Proposed Charging Locations MD-350



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017

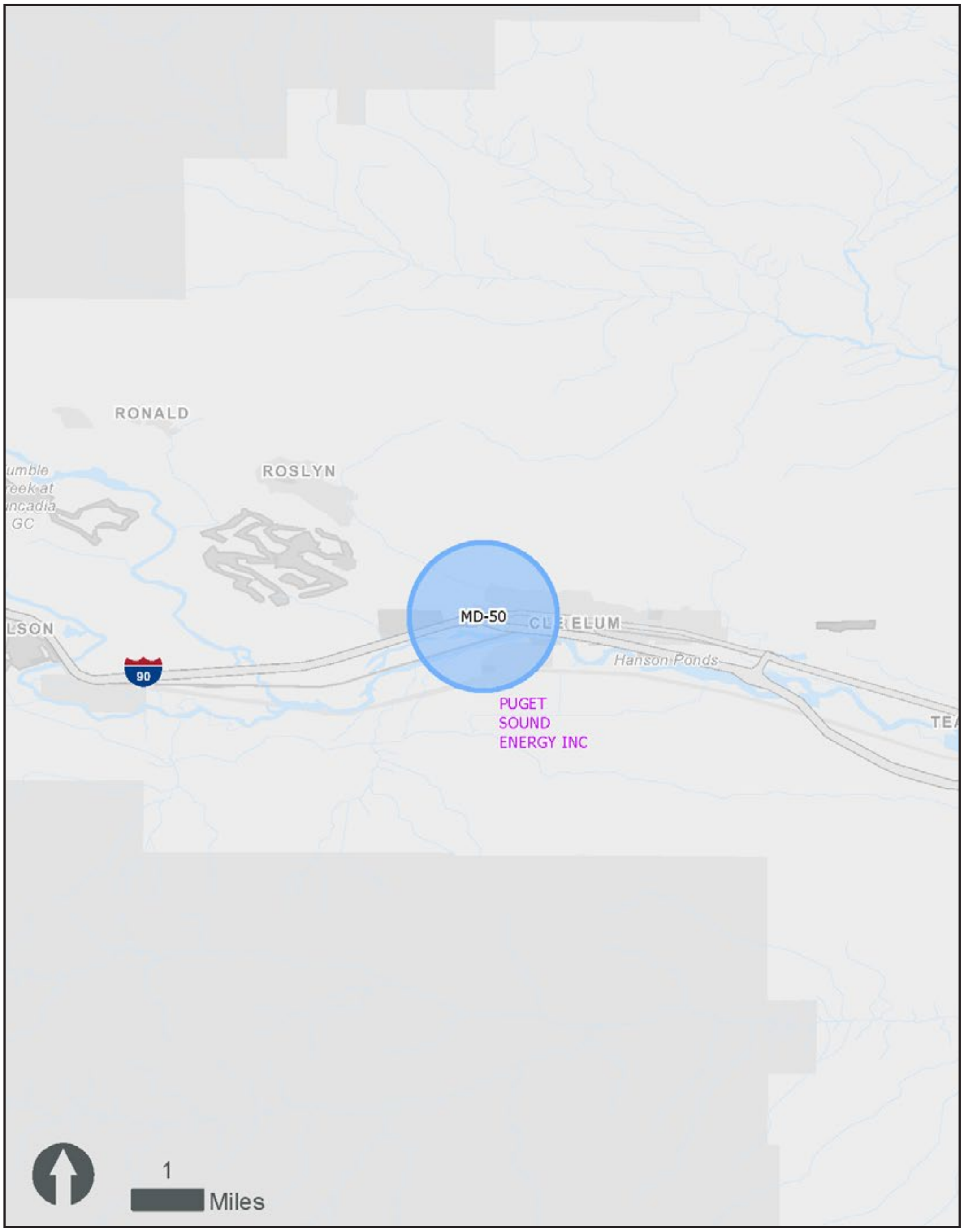
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUGET SOUND ENERGY INC, CITY OF TACOMA - (WA), TANNER ELECTRIC COOP

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-59: I-90 Proposed Charging Locations MD/HD-0



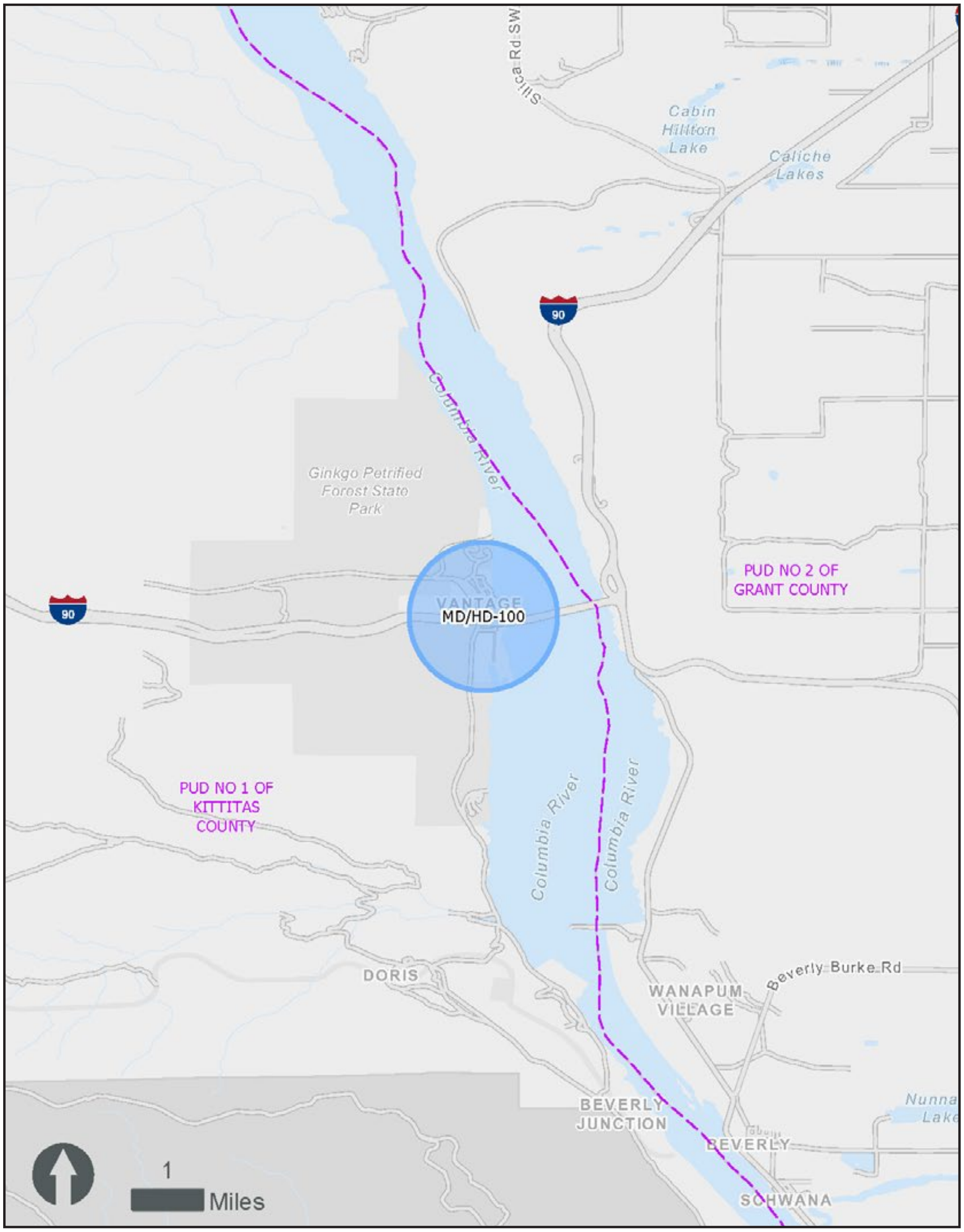
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
PUGET SOUND ENERGY INC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-60: I-90 Proposed Charging Locations MD-50



	WCCTCI Study Area Potential
	Charging Location Truck Parking
P	Location
	Substation
	Electric Retail Service Territories
	Existing DC Fast Charging Public Stations

Truck Volume 2017

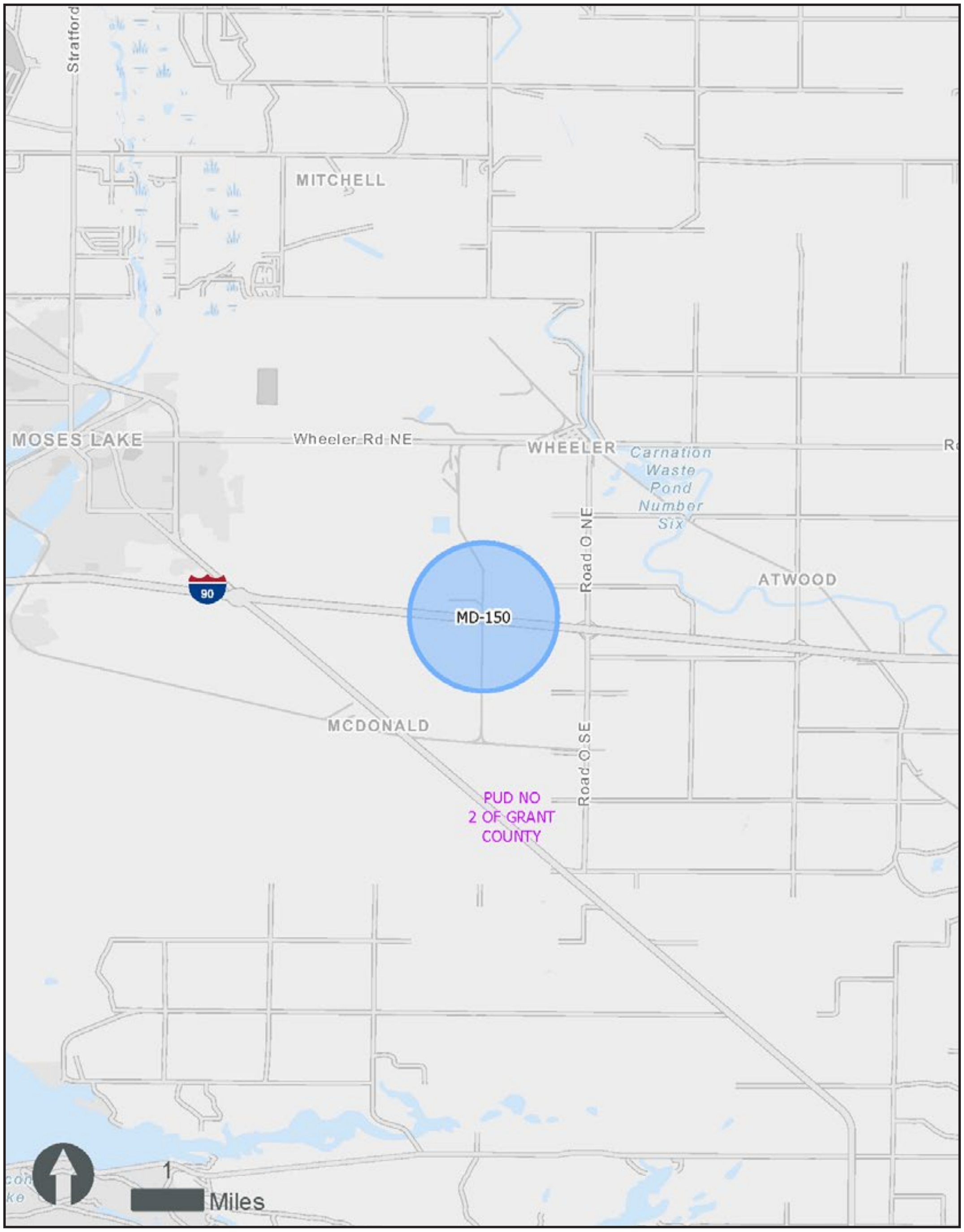
- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

PUD NO 1 OF KITTITAS COUNTY,
PUD NO 2 OF GRANT COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-61: I-90 Proposed Charging Locations MD/HD-100



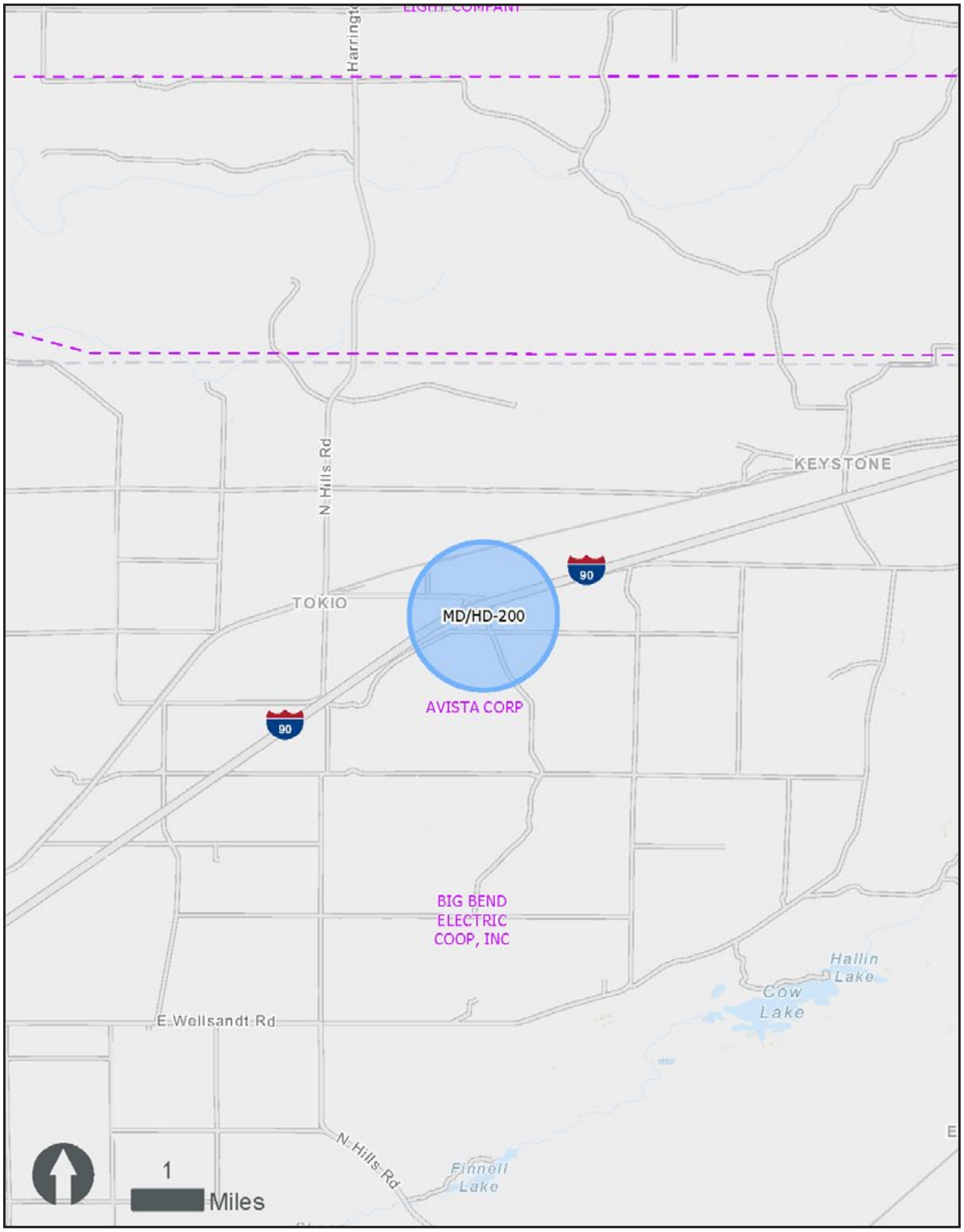
WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging Public Stations

Truck Volume 2017
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY
PUD NO 2 OF GRANT COUNTY

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-62: I-90 Proposed Charging Locations MD-150



WCCTCI Study Area Potential
Charging Location Truck Parking
Location
Substation
Electric Retail Service Territories
Existing DC Fast Charging
Public Stations

Truck Volume 2017

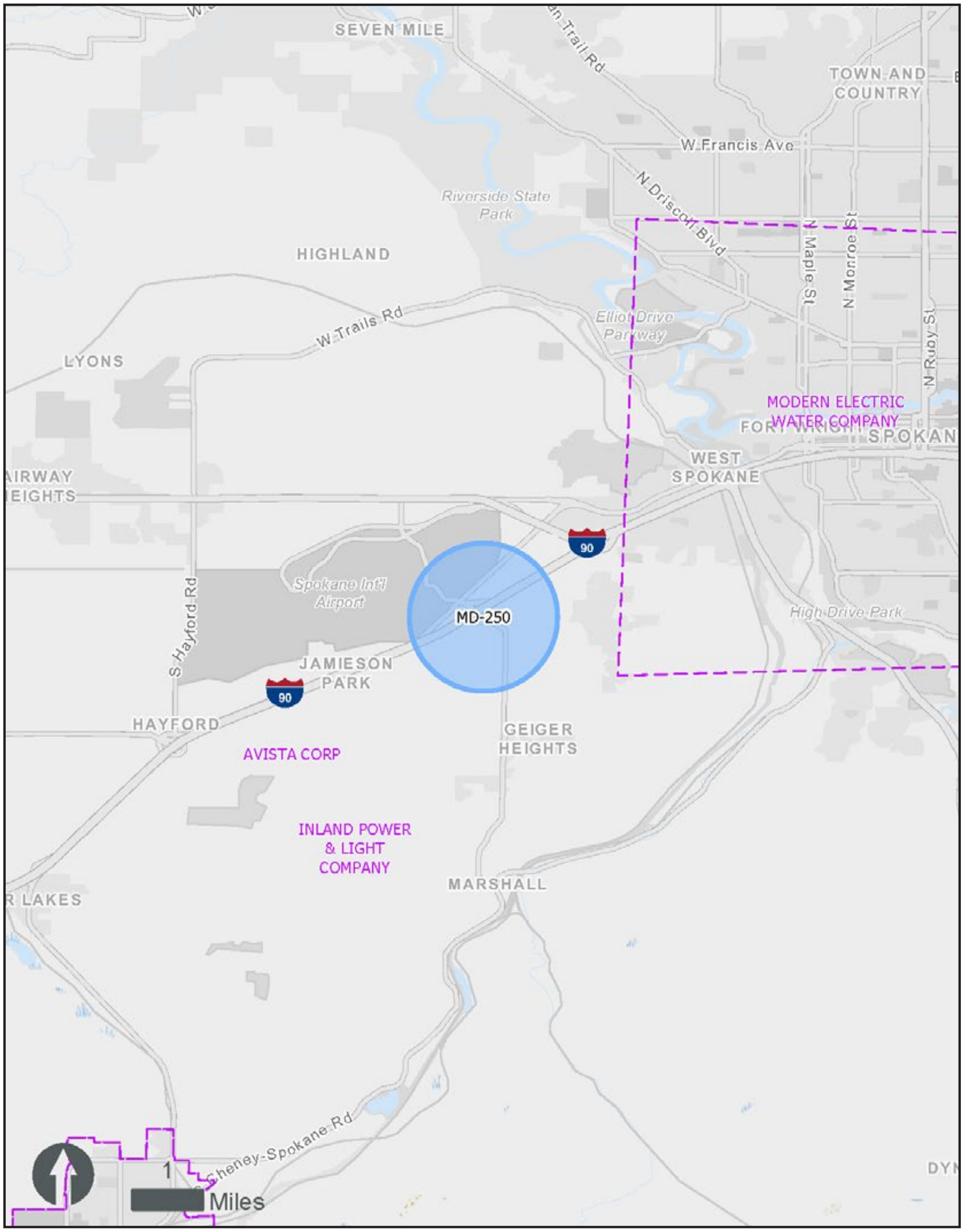
≤ 5000
≤ 10000
≤ 20000
≤ 30000
> 30000

SERVICE TERRITORY

AVISTA CORP,
INLAND POWER & LIGHT COMPANY,
BIG BEND ELECTRIC COOP, INC

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-63: I-90 Proposed Charging Locations MD/HD-200



	WCCTCI Study Area Potential
	Charging Location Truck Parking
P	Location
	Substation
	Electric Retail Service Territories
	Existing DC Fast Charging Public Stations

Truck Volume 2017

- ≤ 5000
- ≤ 10000
- ≤ 20000
- ≤ 30000
- > 30000

SERVICE TERRITORY

AVISTA CORP,
INLAND POWER & LIGHT COMPANY,
MODERN ELECTRIC WATER COMPANY,
CHENEY WA (CITY OF)

Source: HDR, CALSTART, S Curve Strategies, Ross Strategic

Figure B-64: I-90 Proposed Charging Locations MD-250