Long-Range EV Micro-Climate™ Plan for Central Puget Sound & Olympia Areas, Washington

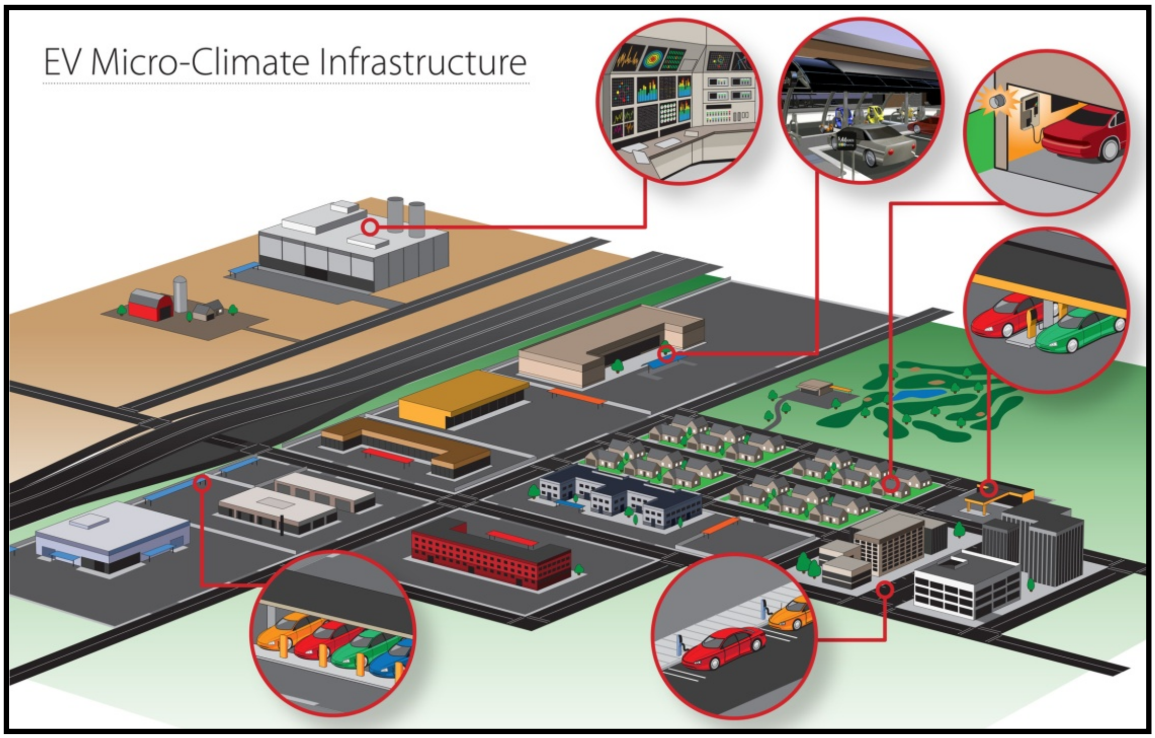

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Table of Contents

Table of Figures

Table of Tables

1 Executive Summary

ECOtality NA was awarded a grant in 2009 by the U.S. Department of Energy (DOE) to embark on The EV Project, which has a current total value of approximately $230 million in grants and matching funds. ECOtality NA is partnering with Nissan North America, General Motors, and several other companies to deploy thousands of electric vehicles and nearly 15,000 charging systems to support them. These charging systems will be installed in strategic markets in six states: Arizona, California, Oregon, Tennessee, Texas, and Washington, as well as the District of Columbia.

Electric Transportation Engineering Corporation (eTec), doing business as ECOtality North America (NA), has been involved in every North American EV initiative since 1989. ECOtality NA developed the EV Micro-Climate™ as an integrated turn-key program to ensure an area is well equipped with the needed infrastructure to support the consumer adoption of electric transportation.

In 2011, ECOtality North America will use its EV Micro-Climate Plan™ to locate The EV Project's 1,200 publicly available Level 2 charging stations and 22 DC Fast Charge stations for the Central Puget Sound and Olympia areas. Level 2 charging stations provide 11 – 26 miles of range per hour of charge time. DC fast charge stations provide as much as 40 miles of range in ten minutes of charging.

ECOtality North America worked closely with the Puget Sound Regional Council's Electric Vehicle Infrastructure (EVI) Siting Analysis Project as it developed information on travel patterns, area destinations, and Geographic Information System (GIS) layers useful in analyzing the Central Puget Sound Region for density and distribution of charging stations.

The EV Micro-Climate™ Density Model is developed using PSRC EVI data. The EV Project will deploy approximately 750 of the 1,200 publicly available Level 2 charging stations in the urban centers identified by the Density Model in quantities determined by how each center ranked in the Density Model. The remaining 450 will be deployed to destinations outside of urban centers. Appendix A provides details from the Density Model for sixteen Central Puget Sound urban centers and the Olympia area.

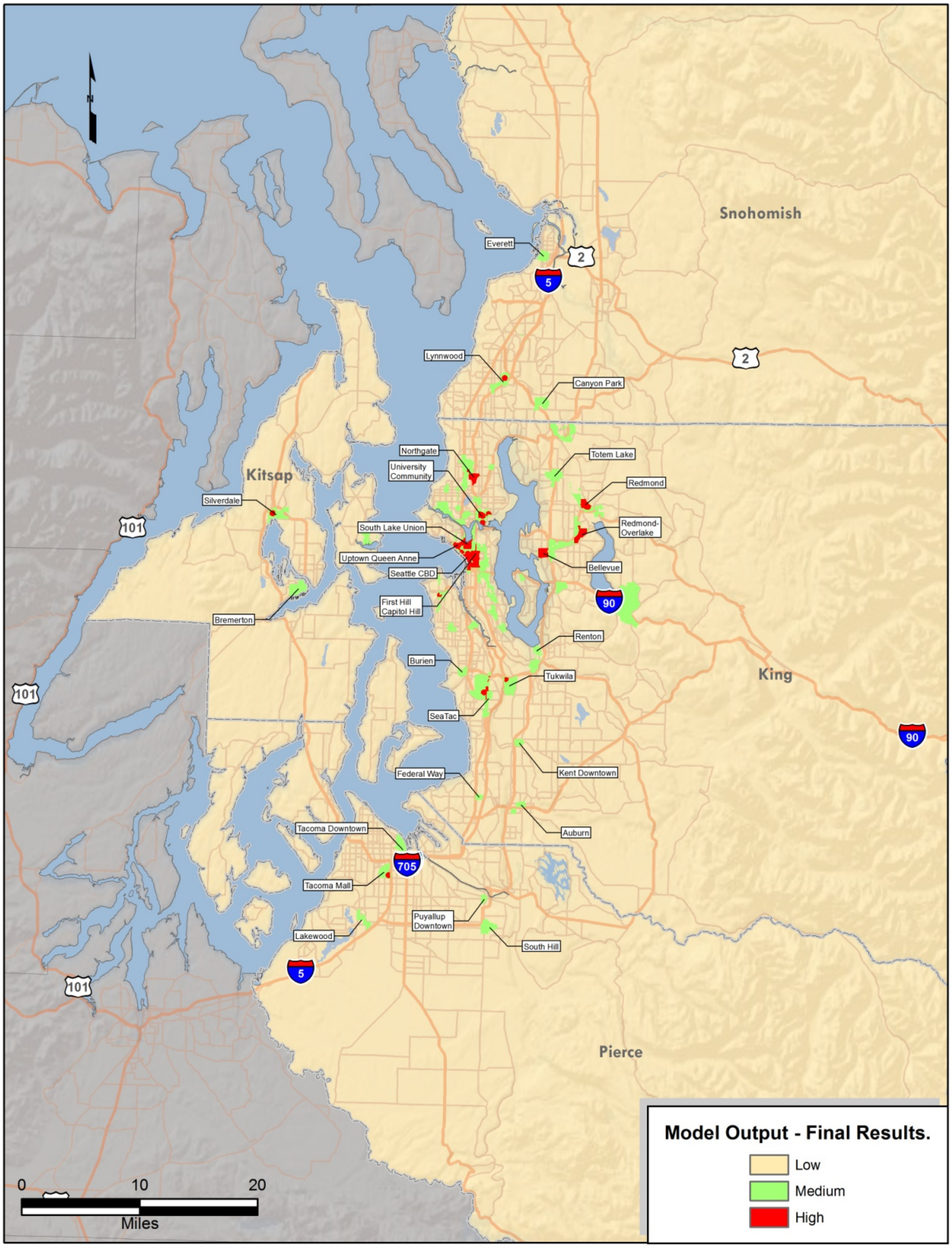

Figure 1-1 EV Micro-Climate™ Density Model Output for the Central Puget Sound Area

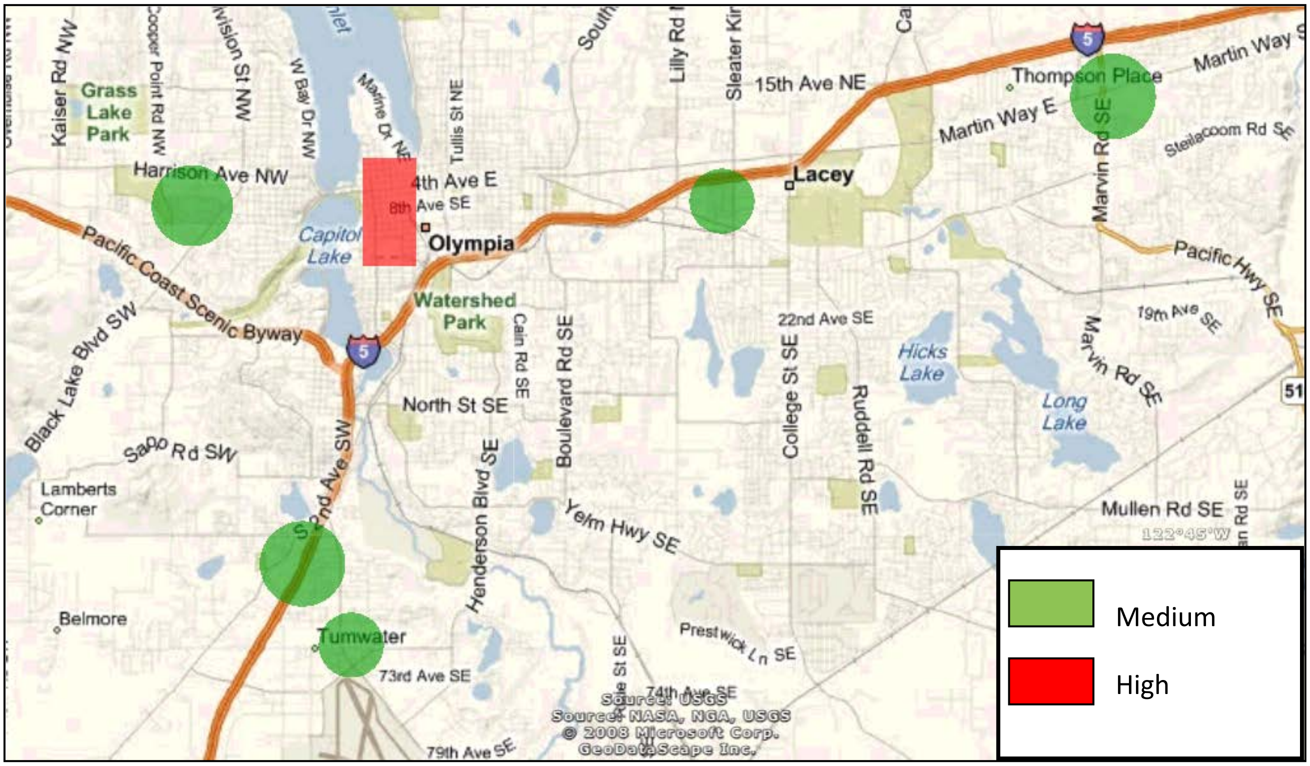

Figure 1-2 EV Micro-Climate™ Density Map for the Olympia Area

DC fast chargers have three major functions within a rich electric vehicle charging infrastructure:

- To support destination travel,
- To enable worry-free travel throughout the metropolitan region, and
- To enable corridor travel.

High ranked centers identified in the EV Micro-Climate™ Density Model indicate locations for DC Fast Chargers to support destination travel. State routes in the Metropolitan Transportation System are analyzed for high, medium, and low annual average traffic count segments (illustrated by red, green, and yellow respectively). For major corridor travel, exits along I-5, I-405, and I-90 interstate highways are analyzed for ease of access to nearby commercial areas, which tend to have sufficient grid capacity.

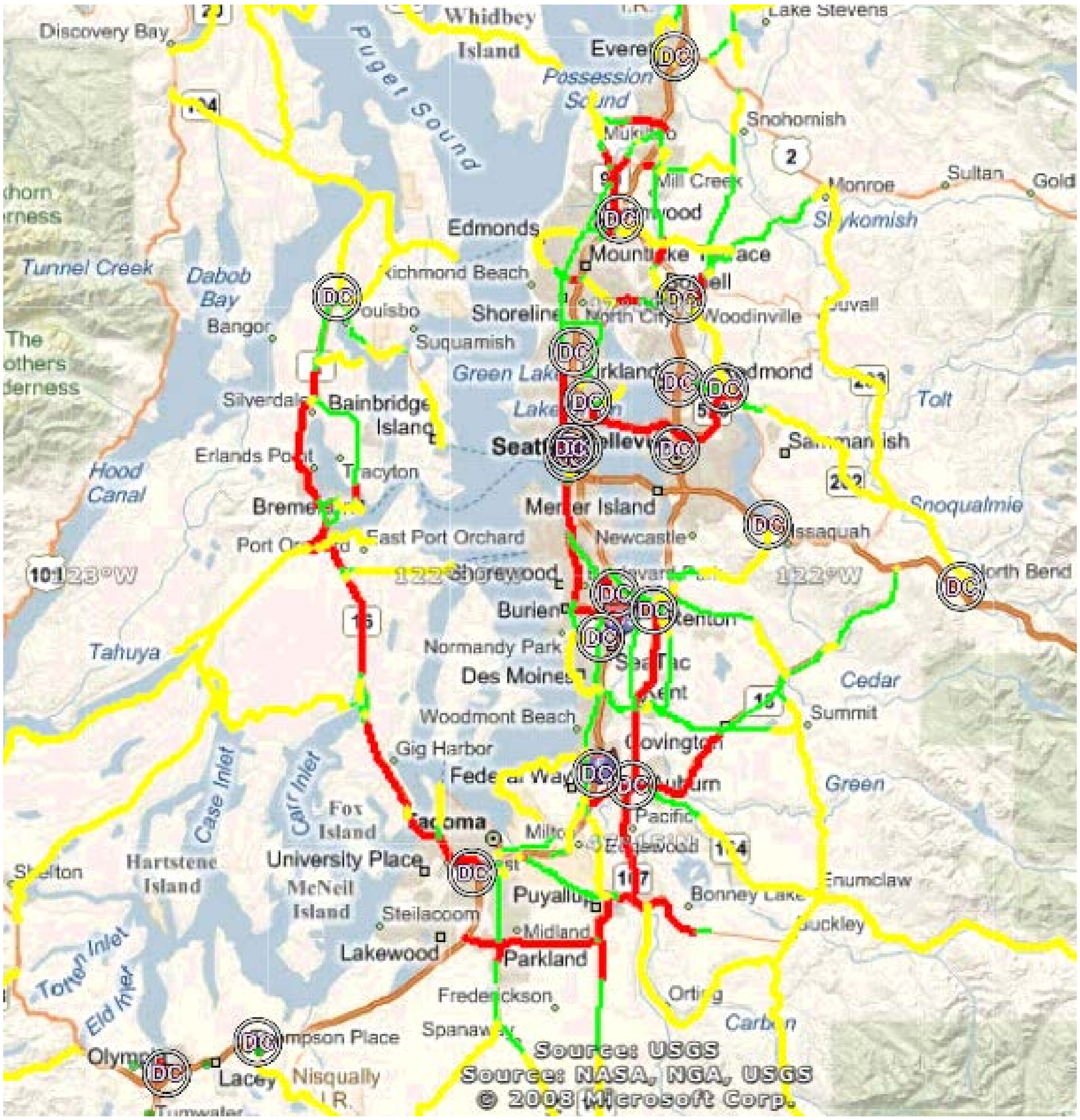

Figure 1-3 Potential DC Fast Charge Areas - Central Puget Sound and Olympia Areas

2 Introduction

Electric Transportation Engineering Corporation (eTec), doing business as ECOtality North America (NA), has been involved in every North American EV initiative since 1989. ECOtality NA developed the EV Micro-Climate™ as an integrated turn-key program to ensure an area is well equipped with the needed infrastructure to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provides a blueprint to create a rich EV infrastructure – that is, one with ample public charging stations for the number of EVs to be served.

On August 5, 2009, ECOtality NA was awarded a $99.8 million grant from the U.S. Department of Energy (DOE) to embark on the EV Project. The matching cost share from ECOtality NA and its partners provides a total project budget of $199.6 million. In June 2010, the DOE expanded the EV Project to include another automotive manufacturer and additional locations, for a total project budget of approximately $230 million.

ECOtality NA is partnering with Nissan North America, General Motors, and several other companies to deploy up to 5,700 zero-emission EVs (the Nissan LEAF), 2,600 Extended Range Electric Vehicles (EREV) (the Chevrolet Volt), and nearly 15,000 charging systems to support them. These charging systems will be deployed in strategic markets in six states: Arizona, California, Oregon, Tennessee, Texas, and Washington, as well as the District of Columbia.

The EV Project will collect and analyze data to characterize vehicle use in diverse topographic and climatic conditions, evaluate the effectiveness of charge infrastructure, and conduct trials of various revenue systems for commercial and public charge infrastructure. The ultimate goal of The EV Project is to take the lessons learned from the deployment of these first 8,300 electric vehicles (EVs), and the charging infrastructure supporting them, to enable the streamlined deployment of the next five million EVs.

ECOtality introduced the EV Micro-Climate™ process in Washington in January 2010 with its first Central Puget Sound Advisory Team meeting.

The *Electric Vehicle Charging Infrastructure Deployment Guidelines for the Central Puget Sound* were completed in May 2010. The Guidelines were developed with local stakeholders, including governmental organizations and jurisdictions, non-profit organizations, utilities, private-sector businesses, automotive manufacturers, and private end-users. The Guidelines are intended to create a common knowledge base of EV requirements for stakeholders involved in the development of EV charging infrastructure. Electric vehicles have unique requirements that differ from internal combustion engine vehicles, and many stakeholders are currently not familiar with these requirements. Deployment Guidelines develop a foundation for implementation of EV charging infrastructure, including topics such as information on technology, charging scenarios, codes and standards, and utility integration.

3 Electric Vehicles and Electric Vehicle Charging Station Background

3.1 Electric Vehicle Types

Battery Electric Vehicle (BEV)
Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available onboard the vehicle. The Nissan LEAF is an example of a BEV. Refueling the BEV is accomplished by connection to the electrical grid through a connector that is designed specifically for that purpose.

Plug-in Hybrid Electric Vehicle (PHEV)
PHEVs are powered by two energy sources. The typical PHEV configuration utilizes a battery and an internal combustion engine (ICE) powered by either gasoline or diesel. Manufacturers of PHEVs use different strategies in combining the battery and ICE. Some vehicles, such as the Chevrolet Volt, utilize the battery only for the first 40 miles, with the ICE providing generating power for the duration of the vehicle range. Others may use the battery power for sustaining motion and the ICE for acceleration or higher energy demands at highway speeds. Frequently, the vehicles employing the former strategy gain a designation such as PHEV-20 to indicate that the first 20 miles are battery only. Other terms related to PHEVs may include Range Extended Electric Vehicle (REEV) or Extended Range Electric Vehicle (EREV). The Chevrolet Volt is an example of an EREV.

3.2 EV Batteries

Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost. From an infrastructure standpoint, it is important to consider that as battery costs are driven down over time, the auto companies will increase the size of the battery packs, and thus the range of electric vehicles.

Relative Battery Capacity
Battery size or capacity is measured in kilowatt hours (kWh). Battery capacity for electric vehicles will range from as little as 3 kWh to as high as 40 kWh or more. Typically, PHEVs will have smaller battery packs because they have more than one fuel source. BEVs rely completely on the battery pack's storage for both range and acceleration, and therefore require a much larger battery pack than a PHEV for the same size vehicle.

3.3 Electric Vehicle Charging Stations

An EV charging station, more correctly called "electric vehicle supply equipment" (EVSE) provides for the safe transfer of energy between the electric utility power supply and the electric vehicle. PHEVs and BEVs require the EVSE in order to charge the vehicle's on-board battery. With increasing sales of EVs into the automotive market, a corresponding deployment of charging equipment will be required. This section identifies the equipment that will be available to serve the EV market.

During the 1990s, there was no consensus on EV inlet and connector design. Both conductive and inductive types of connectors were designed and in both cases, different designs of each type were provided by automakers. At the present time, however, the Society of Automotive Engineers (SAE) has agreed that all vehicles sold by automakers in the United States will conform to a single connector design, known as the *J1772 Standard*.[1]

Figure 3-1 J1772 Connector

Figure 3-2 J1772 Inlet (right side)

The J1772 connector and EV inlet will be used for both Level 1 and 2 charging levels, as described below.

In 1991, the Infrastructure Working Council (IWC) was formed by the Electric Power Research Institute (EPRI) to establish consensus on several aspects of EV charging. Level 1, Level 2, and Level 3 charging levels were defined by the IWC, along with the corresponding functionality requirements and safety systems. Since that time, the term Level 3 has been superseded by more descriptive terms; "DC Fast Charging" is used in this document and in the industry.

[1] While the J1772 Standard will be utilized by all automakers in the United States, it is not necessarily the standard that will be used in other countries. This standard is the subject of a harmonization project with the Canadian Codes.

3.4 Level 1 and Level 2 Charging

The Level 1 method uses a standard 120 volts AC (VAC) branch circuit, which is the lowest common voltage level found in both residential and commercial buildings. Typical voltage ratings are from 110 – 120 volts AC. Typical amp ratings for these receptacles are 15 or 20 amps.

Level 2 is generally considered to be the "primary" and "preferred" method for the EVSE for both private and publicly-available facilities, specifying a single-phase branch circuit with typical voltage ratings from 220 – 240 volts AC. The J1772 approved connector allows for current as high as 80 amps AC (100 amp rated circuit); however, current amperage levels that high are rare. A more typical rating would be 40 amps AC, which allows a maximum current of 32 amps; or as another example, 20 amps AC, which in turn allows a maximum current of 16 amps. This provides approximately 6.6kW or 3.3 kW charge power, respectively, with a 240 VAC circuit. See Table 2-1 for typical recharge times at these levels.

Because charge times can be very long at Level 1 (see Table 2-1), many EV owners will be more interested in Level 2 charging at home and in publicly-available locations. Some EV manufacturers suggest their Level 1 cord set should be used only during unusual circumstances when Level 2 EVSE is not available, such as when parked overnight at a non-owner's home. As the EV battery gains in energy density with longer range on battery only, the effectiveness of the Level 1 equipment for battery recharge will lessen and greater emphasis will be given to Level 2 and DC fast charge.

3.5 Fast Charging

DC fast charging is used for commercial and public applications and is intended to perform in a manner similar to a commercial gasoline service station, in that recharge is rapid. Typically, DC fast charging would provide a 50% recharge in 10 to 15 minutes. DC fast charging typically uses an off-board charger to provide the AC to DC conversion. The vehicle's on-board battery management system controls the off-board charger to deliver DC directly to the battery.

There is currently no US standard for the DC fast charge connector. The Japanese fast charge standard, called CHAdeMO, will be used for vehicles like the Nissan LEAF. The EV Project will be deploying DC fast charge stations

Figure 3-3 Blink DC Fast Charge Station

with two CHAdeMO connectors that will be capable of charging two EVs sequentially (as shown in Figure 3-3). In the future, one of the connectors can be retrofitted if the US develops a different standard.

Electric Vehicle Charging Time

The time required to fully charge an EV battery is a function of the battery size and the amount of electric power (measured in kilowatts (kW)) that an electrical circuit can deliver to the battery. Larger circuits, as measured by voltage and amperage, will deliver more kW. The common 110-120 volts AC (VAC), 15 amp circuit will deliver at maximum 1.1 kW to a battery. A 220-240 VAC, 40 amp circuit (similar to the circuit used for household appliances like dryers and ovens) will deliver at maximum 6 kW to a battery. This maximum current may be further limited by the vehicle's on-board battery management system. Table 2-1 provides information on several different on-road highway speed electric vehicles, their battery pack size, and charge times at different power levels to replenish a fully depleted battery, assuming the onboard battery management system allows each power level.

Table 3-1: EV Charge Times

		Circuit Size and Power in kW Delivered to Battery			
EV Configuration	**Battery Size (kWh)**	**120 VAC, 15 amp 1.2 kW**	**120 VAC, 20 amp 1.6 kW**	**240 VAC, 40 amp 6.5 kW**	**480 VAC, 85 amp 60 kW**
PHEV-10	**4**	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	**8**	6 h 40 m	5 h	1 h 15 m	n/a
PHEV-40	**16**	13 h 20 m	10 h	2 h 30 m	16 m
BEV	**24**	20 h	15 h	3 h 40 m	24 m
BEV	**35**	29 h 10 m	21 h 50 m	5 h 20 m	35 m
PHEV Bus	**50**	n/a	n/a	7 h 40 m	50 m

Note: Power delivered to the battery is calculated as follows: 120VAC x 12Amps x.85 eff.; 120VAC x 16Amps x .85 eff.; 240VAC x 32 Amps x.85 eff.; 480VAC x √3 x 85 Amps x .85 eff. (Limited to 60 kW maximum output.)

Another way to compare EVSE power levels is to consider what range extension may be achieved during a charge period. Table 2-2 provides a comparison based upon a vehicle efficiency of 4 miles/kWh of charge. It is important to note that the number of miles achieved per charge time is independent of battery size.

Table 3-2: Miles Achieved per Charge Time

Miles Achieved per Charge Time*					
	Circuit Size and Power in kW Delivered to Battery**				
Charge Time	**Level 1 120 VAC, 15 amp 1.2 kW**	**Level 1 120 VAC, 20 amp 1.6 kW**	**Level 2 240 VAC, 20 amp 3.3 kW**	**Level 2 240 VAC, 40 amp 6.5 kW*****	**DC Fast 480 VAC, 85 amp 60 kW**
10 min	0.8	1.1	2.2	4.3	40
15 min	1.2	1.6	3.3	6.5	>50****
30 min	2.4	3.2	6.6	13	>50****
1 hour	4.8	6.4	13.2	26	>50****

* Vehicle efficiency 4 miles/kWh.

** EVSE efficiency assumed at 85%.

*** Vehicles such as model year 2011 Nissan LEAF have chargers rated only for 3.3 kW, so even though Level 2 40 amp EVSE will produce 6.5 kW, the vehicle can only use 3.3 kW.

**** Battery is at or near full charge, depending upon initial state.

Because of Level 1's limited miles achieved per charge time, it is not recommended for publicly available charging. Level 2 charging will provide higher amounts of range for the one to two hours of parking typical for publicly available charging stations.

3.6 Charging Station Locations

The EV Micro-Climate™ Plan provides guidance for choosing locations for charging stations. The focus of The EV Project is on building out a rich infrastructure of publicly available infrastructure in commercial and public locations. The following is a discussion of locations for publicly available charging. Also discussed is workplace charging and the potential role it might play in charging infrastructure.

3.6.1 Commercial EVSE

"Commercial EVSE" refers to those units placed in retail or privately-owned locations (other than residences) that are publicly available. EVSE in these locations will focus on Level 2 and DC Fast Charging. Locations sought for Level 2 will be those locations where the EV owner is likely to remain for a substantial period of time. That means that these will be destinations for the EV driver for which "purposeful" trips are made. The US National Household Travel Survey found such destinations to include daycare, religious activities, school, medical or dental appointments, shopping, errands, social gatherings, recreation, family or personal, transporting someone, and meals. Night clubs, sporting events, museums, shopping malls, theaters, government offices, attorneys' offices, and numerous other places where people may park for one to three hours or longer could also easily added. Revenue methods will be employed for retail owners to charge a fee for providing the charging service.

3.6.2 Public EVSE

"Public EVSE" refers to equipment placed on public-owned land that is publicly available. These locations will be those where the EV owner is likely to remain for a substantial period of time, and can include government buildings, public parking lots, curbside parking, airport visitor parking, museums, etc.

3.6.3 Workplace EVSE

Employers and office building managers may install EVSE to encourage employees to purchase EVs, to promote green certification of facilities and to accommodate EV owners without off-street parking or who live in multi-family dwellings that do not or will not allow private charging systems. There are a number of questions for employers who wish to provide EVSE for employee use that indicate workplace charging may be challenging to achieve in large numbers.

LEED Certification and Public Relations
Installation of workplace EVSE contributes to qualification for Leadership in Energy & Environmental Design (LEED) certification. LEED is an internationally-recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across several metrics.[2]

Employee Benefits
A question for the employer will be whether or not to provide free charging. The employer will either charge the employee for the use of the equipment or if providing charging at no cost, potentially create a 1099 taxable benefit.

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[2] U.S. Green Building Council,www.usgbc.org

Experience has shown that if the employer provides EVSE use without charging a fee, employees will conduct the majority of their EV charges at the workplace rather than at home.

Workplace Charging Options

There are three possible workplace charging station installation scenarios: dedicated, open, and valet. Providing dedicated Level 2 EVSE for each employee with an EV can quickly become very expensive. Few parking facilities have electrical panels that can handle the load of numerous Level 2 EVSEs before an electrical upgrade is required. One option for a dedicated parking scenario is to provide Level 1 EVSE instead. If an employee is parked for eight hours, Level 1 charging may be sufficient and this equipment is less expensive.

Providing electrical vehicle charging on an open basis will require coordination among drivers to accommodate those that need a charge. Level 1 EVSE is not recommended for this scenario because of its very low charge return.

In downtown office buildings, valet parking may be offered as a service by building management. Valet parking provides an easy means to assure that an employee receives a fully-charged vehicle at the end of the day. In addition, several vehicles can be cycled through one Level 2 EVSE.

Electrical Load

Modern EVs will allow the driver to start the air conditioning or heater for 20 minutes remotely. It will be very convenient for people to pre-condition their vehicle before leaving work so that they have comfort on the way home without depleting the battery. On a wide scale, putting this load on the grid during a peak time can pose a challenge that will likely requiring utility planning and demand response programs.

The Future of Workplace Charging

Transportation studies show that most roundtrip commutes are well within the projected range of EVs, so aside from those who may live at a significant distance or have no designated overnight vehicle parking location, workplace charging for most employees is a convenience and not a necessity.

The requirement to evaluate the benefits provided to employees versus the desire to avoid providing free charging will likely require fee-based charging at work that will naturally limit the access to those who actually need the charge. Supply and demand then will limit the number of EVSE stations the employer will install. It is anticipated that publicly available charging will have a much higher impact on vehicle charging than workplace charging.

4 Two-Year Planning Horizon: the EV Micro-Climate™ Plan

Most recharging of electric vehicles will occur overnight at the owner's residence. However, studies of consumer attitudes towards electric vehicles point to the need for publicly available charging stations to make the transition to electric transportation successful.

> "Even though EVs meet the daily range requirements of most drivers, range anxiety is pervasive. Customers want to be able to charge at home and have the convenience of rapid charging stations (i.e., have the same experience as buying gas)." [3]

Beginning in 2011, EVs will be on the roads in Washington State and will need publicly available EVSE. In terms of numbers, most EVs entering Washington State in 2011 will be Nissan LEAFs, which is the primary vehicle being supported by the EV Project. By late 2011 and 2012, many other manufacturers are expected to deliver vehicles to Washington State that will also be able to use the J1772 connector associated with Level 2 charging. A more limited number of vehicles will be equipped to utilize the DC Fast Charge units, because no U.S. national standard has been adopted for this charging level.

In 2011, The EV Project will install 1,200 publicly available Level 2 charging stations and 22 DC fast charge stations (with two connectors each) in the Central Puget Sound and Olympia areas (see Figure 4-1).

[3] Deloitte Research, *Gaining Traction, A Customer View of Electric Vehicle Mass Adoption in the US Automotive Market*, January 2010

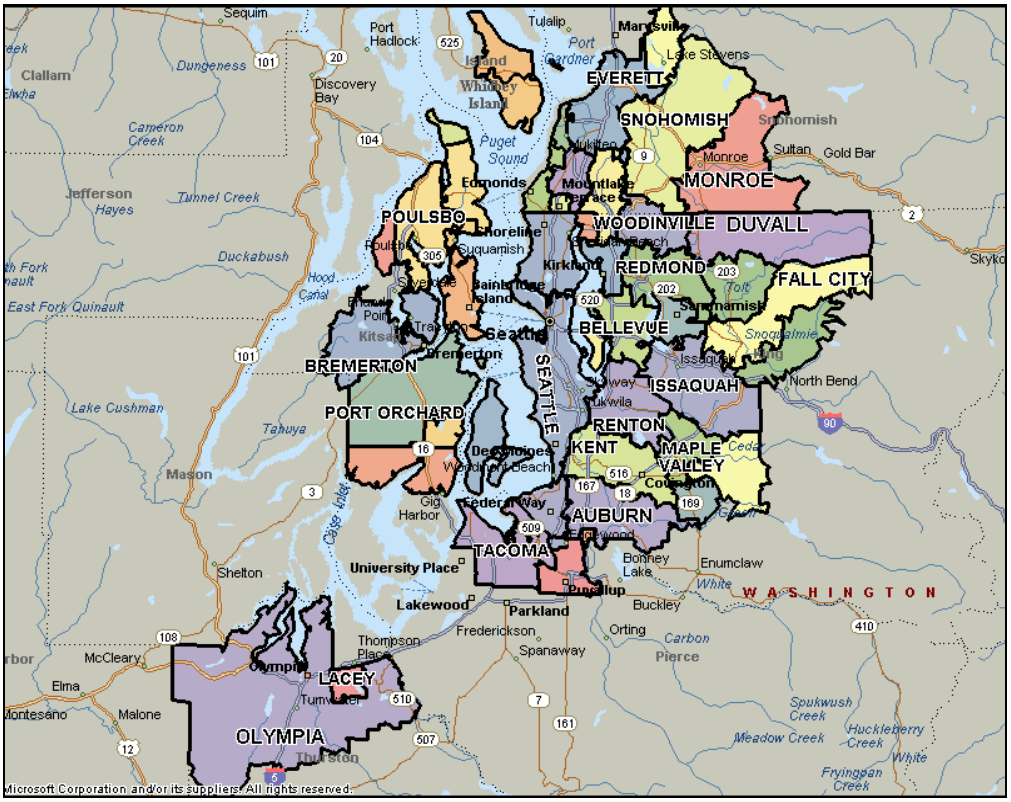

Figure 4-1 The EV Project Participation and Infrastructure Boundaries

5 EV Micro-Climate™ Planning

5.1 Process Overview

EV Micro-Climate™ Planning focuses on four major factors for developing publicly available charging infrastructure: geographic coverage, destination planning, refueling stations, and rich infrastructure.

Geographic Coverage
Geographic coverage is provided by zones that define the appropriate density of EVSE. For urban planning, three zones of increasing EVSE density are projected, with the city center or specific regional destinations having the highest density of EVSE.

Destination Planning
For destination planning, the metropolitan area is canvassed to determine the number of potential destinations and the number of EVSE that would be installed at each venue.

Refueling Stations
Deloitte Research indicates that there is a comfort level in the public with the availability of gas stations.[4] Their study shows that the convenience of publicly-available EVSE should at a minimum match the convenience of gas stations.

Rich Infrastructure
The acceptance of EVs by the general public will require a readily available EVSE infrastructure. The EV owner will be comfortable with densely-distributed Level 2 equipment. Indeed, the visibility of this equipment will encourage others to consider purchasing an EV when they next choose a new car. In the early years of vehicle deployment, the ratio of publicly-available EVSE to the number of deployed EVs likely will be much higher than it might be in a mature market.

[4] Deloitte Research, *Gaining Traction, A Customer View of Electric Vehicle Mass Adoption in the US Automotive Market*, January 2010

6 EV Micro-Climate™ Density Model for the Central Puget Sound Area

6.1 Methods

ECOtality NA worked closely with the Puget Sound Regional Council's (PSRC) Electric Vehicle Infrastructure (EVI) Siting Analysis Project as it developed information on travel patterns, area destinations and Geographic Information System (GIS) layers useful in analyzing the Central Puget Sound Region for density and distribution of charging stations. PSRC's EVI Siting Analysis Project partners included the City of Seattle, City of Bellevue, King County, the Clean Cities Coalition, ECOtality NA, and other stakeholders.

The PSRC EVI Siting Analysis work consisted of two parts:

- Origin-Destination (O-D) analysis of travel patterns
- Analysis of regional destinations and urban centers

The EV Micro-Climate™ Density Model is developed using PSRC EVI data. For the EV Project, 60% to 66% of the 1,200 publicly available Level 2 charging stations will be deployed in the urban centers identified by the Density Model.

Multivariate analysis was used to develop the EV Micro-Climate™ Density Model. Multivariate analysis is a structured approach to use data and value judgments about that data to reach decisions. To conduct multivariate analysis for the Density Model, GIS layers in Table 5-1 were assigned different weights, with higher weights increasing the influence of the layer on the Density Model. GIS software was used to combine the weighted layers and output a model with low, medium, and high densities for the Central Puget Sound area.

Table 6-1: GIS Layers - Central Puget Sound Area

GIS Layer	Source
Target Drivers Non-Work Destination Trips	PSRC
Regional Destinations	PSRC
Regional Growth Centers	PSRC
All Drivers Non-Work Destination Trips	PSRC
Employment Density	PSRC
Household Density (population)	PSRC
Other City and County Centers	Various

6.2 Geographic Information System Layers

The PSRC's origination-destination (O-D) mapping for the EVI Siting Project is an important GIS layer for the Density Model. The O-D analysis used data from the PSRC's regional travel demand model. PSRC's regional travel demand model is a system of mathematical and statistical processes that have been designed to estimate daily travel patterns within the Puget Sound region. For every household in the region, the model estimates how many trips are made each day, where they go, what time of day they travel, which modes they use, and which routes they follow.

PSRC's O-D mapping for the EVI Siting Project utilized Traffic Analysis Zones (TAZs) to describe locations of trip originations and destinations. TAZs are the units of the geographic boundary system used by the PSRC to run and report results from its travel demand model. TAZ boundaries generally, with few exceptions, coincide with census tract boundaries, with each census tract containing between 1 to 9 TAZs. There are a total of 938 TAZs in the region.

Trips are classified according to work and non-work purposes. For the EV Micro-Climate™ analysis, the focus is on non-work destinations because The EV Project is locating publicly available charging infrastructure for short duration, high turnover charging. Workplace parking, and therefore workplace charging, is a long-duration activity.

For the O-D analysis, it was necessary to determine origination TAZs for likely EV drivers. The PSRC found a statistically significant correlation between zip codes with a high number of early LEAF "hand-raisers" (individuals that registered an interest by signing up on the Nissan LEAF website) and zip codes with high numbers of hybrid ownership. Figure 6-1and Figure 6-2 below show results for early "hand-raisers" and households with hybrid vehicle ownership respectively. Areas with high hybrid ownership are areas with highly likely near-term EV ownership.

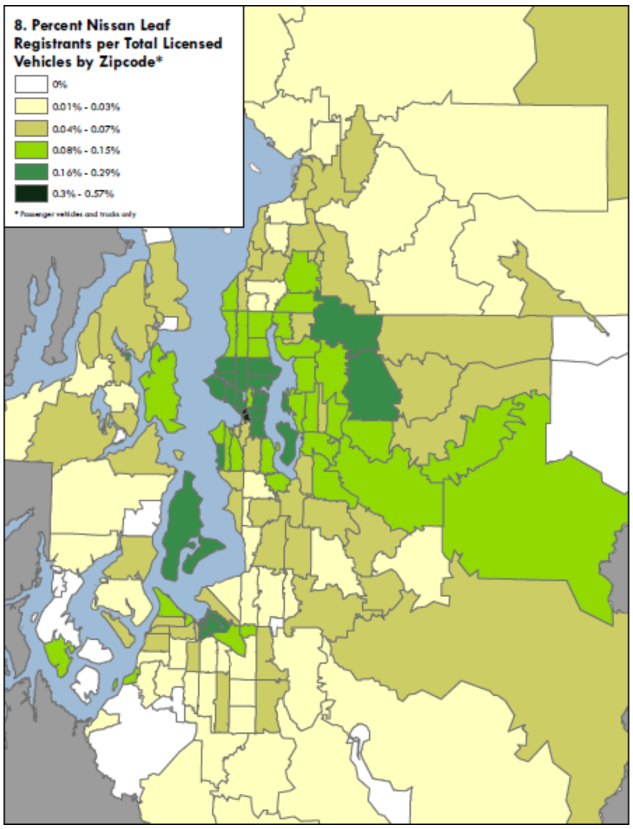

Figure 6-1 Nissan LEAF Hand-Raisers by Zip Code

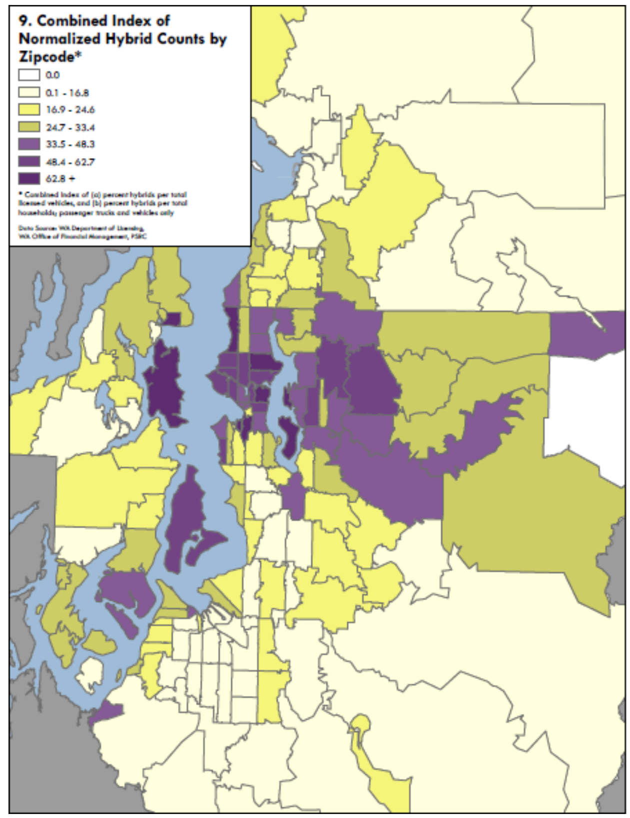

Figure 6-2 Hybrid Counts by Zip Code

Origination TAZs for the PSRC O-D analysis were selected within zip codes that had a high percentage of households with hybrid vehicles. With the selection of origination TAZs, the regional travel demand model was used to determine trip destinations for future EV drivers. Figure 6-3 is the resulting map of non-work destination trip counts for Target Drivers.

Because innovations move from early adopters to the general population over time, we would expect EV ownership to normalize across the population. O-D data from All Drivers O-D analysis was therefore incorporated in the Density Model, as well. Figure 6-4 shows non-work destination trip counts for All Drivers.

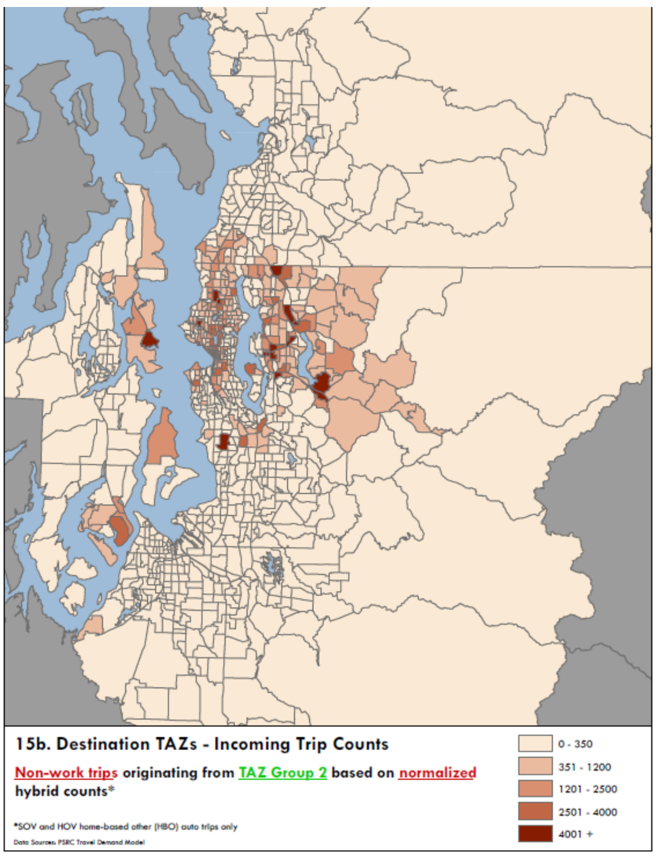

Figure 6-3 Target Drivers Destination TAZs Trip Counts

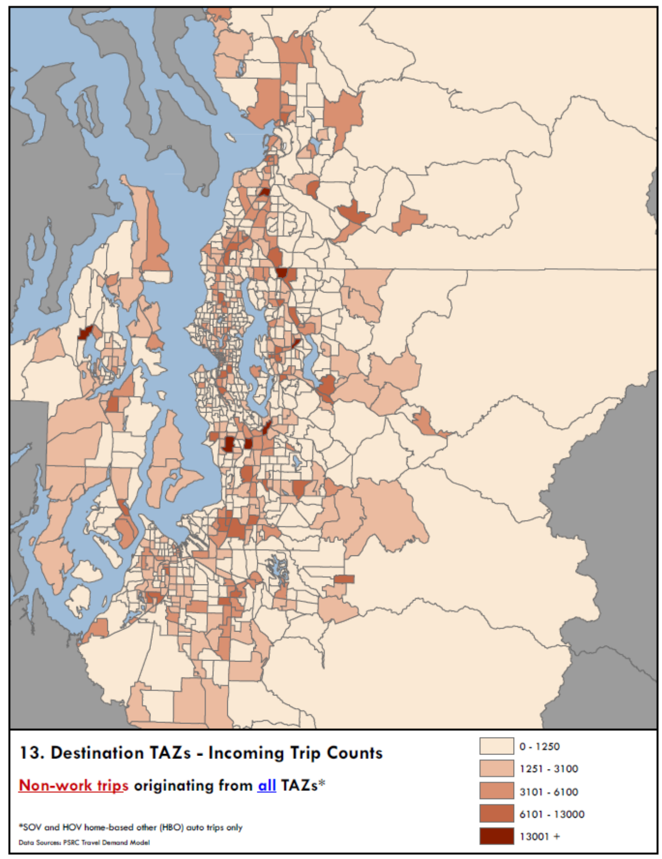

Figure 6-4 All Drivers Destination TAZs Trip Counts

Regional destination information developed by PSRC's 2006 Household Travel Survey ranked destinations by number of trips. This data is incorporated into the Density Model (employment-related destinations such as military bases were excluded).

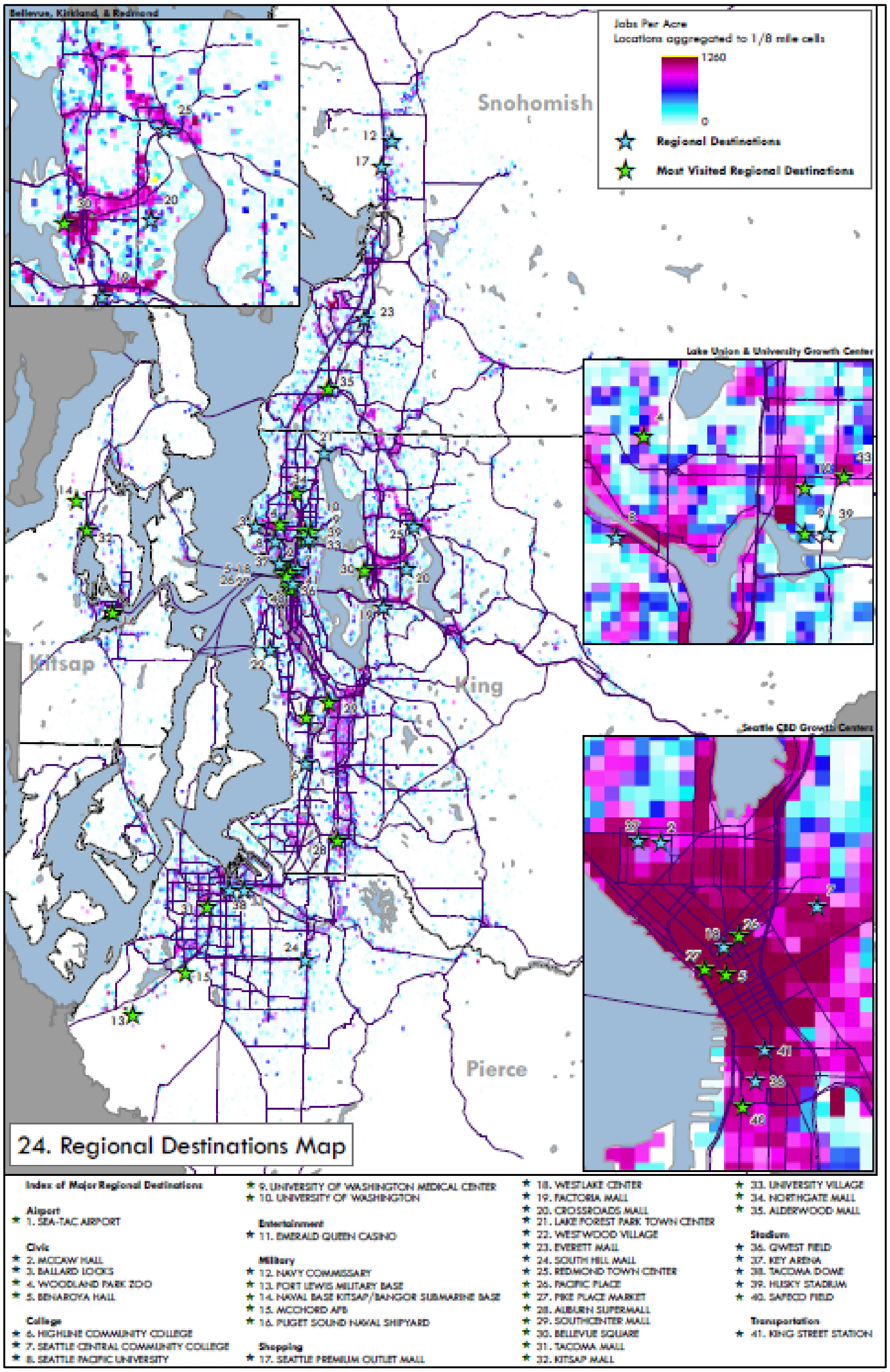

Figure 6-5 Central Puget Sound Regional Destinations

Designated regional growth centers and urban centers are also important layers for the Density Model. Manufacturing and Industrial Centers were not included in the Density Model, as these areas are highly work trip focused.

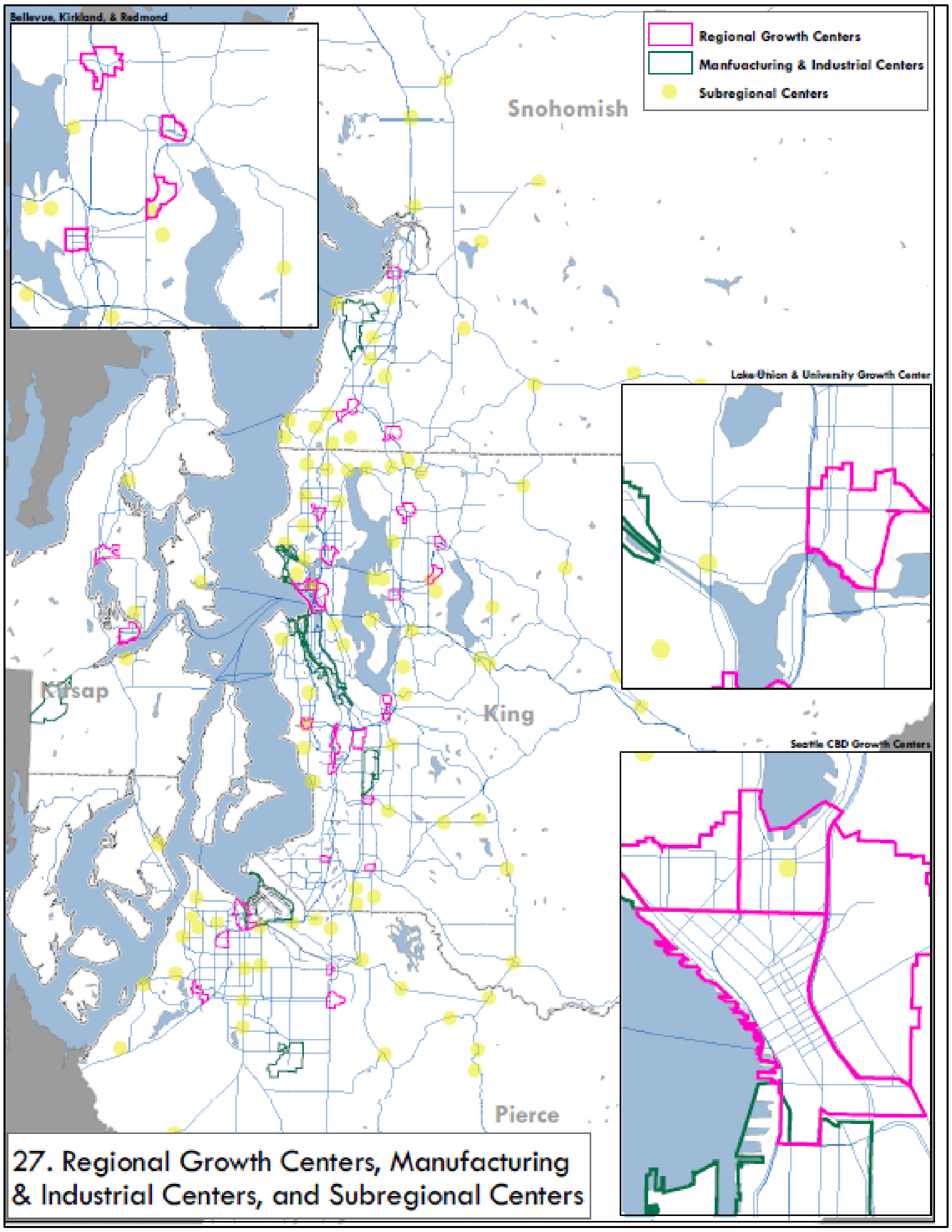

Figure 6-6 Central Puget Sound Regional Growth Centers

The Density Model also includes employment density (Figure 6-7) and household density (Figure 6-8) layers developed by the PSRC.

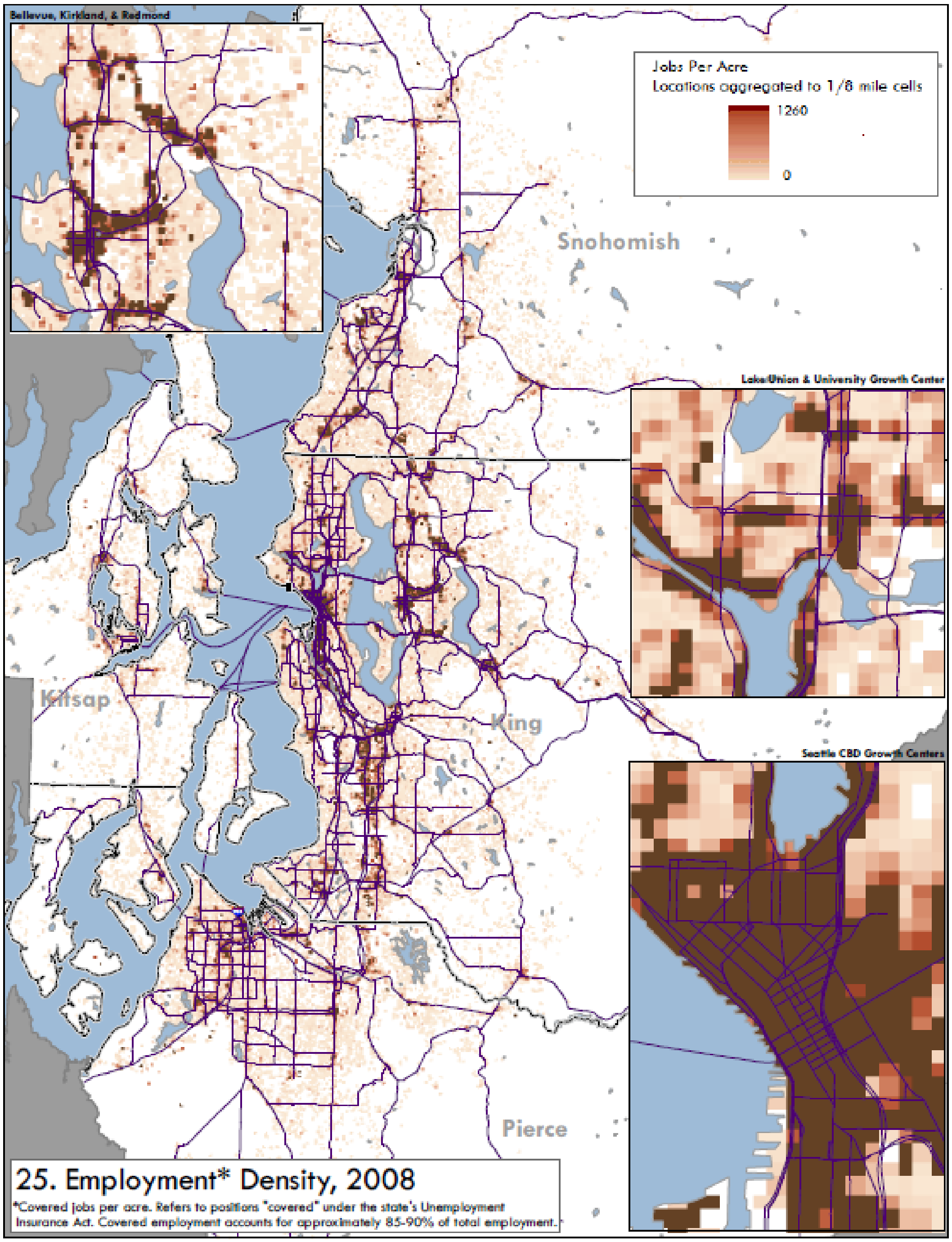

Figure 6-7 Employment Density, 2008

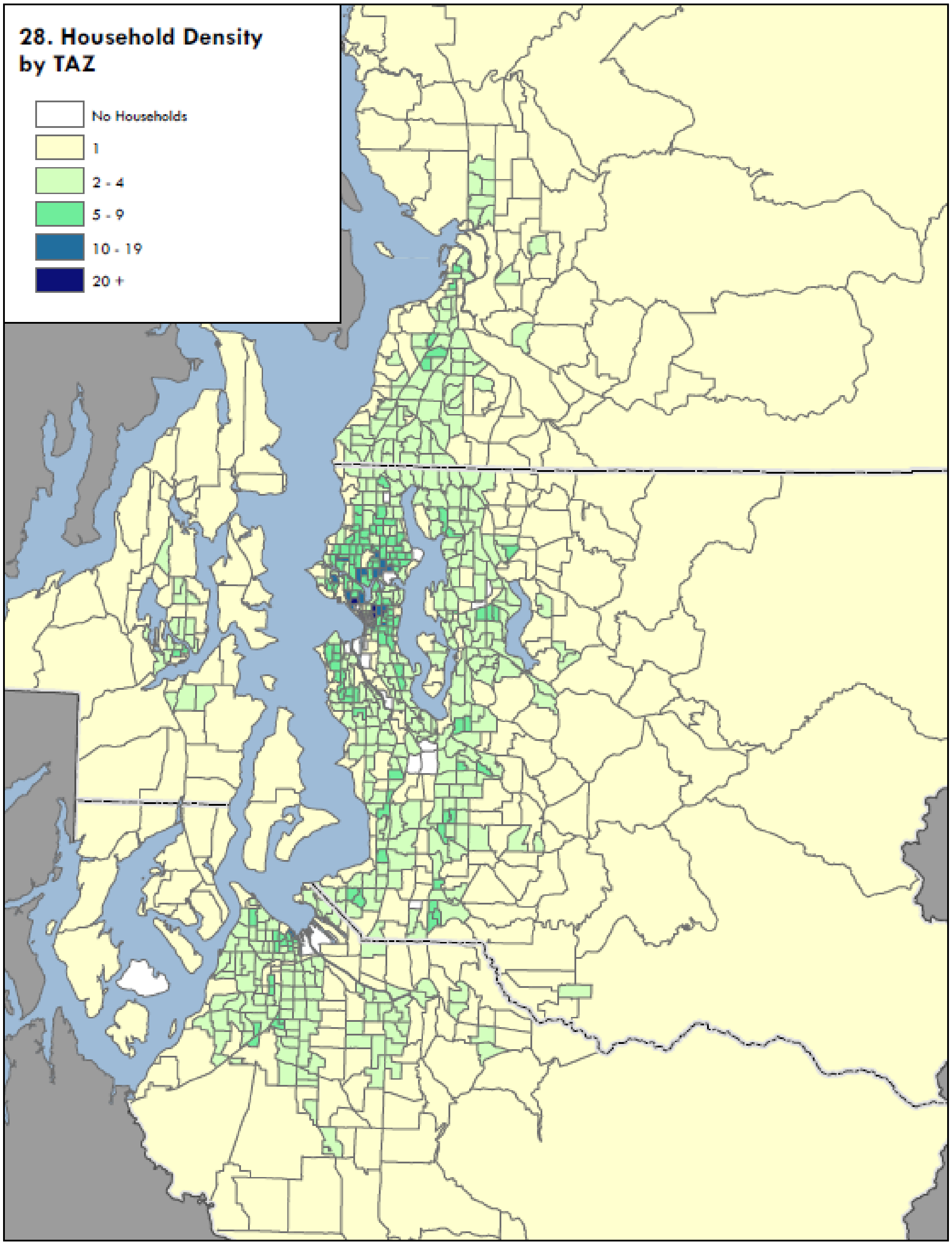

Figure 6-8 Household Density by TAZ

6.3 Density Model Output

Using GIS software, each of the weighted layers is combined to produce Figure 6-9, showing recommended high, medium, and low densities for Level 2 charging stations in the Central Puget Sound area (red, green, and yellow respectively). The EV Project will deploy approximately 750 of the 1,200 publicly-available Level 2 charging stations in the urban centers identified by the Density Model in quantities determined by how each center ranked in the Density Model. The remaining 450 will be deployed to destinations outside of urban centers.

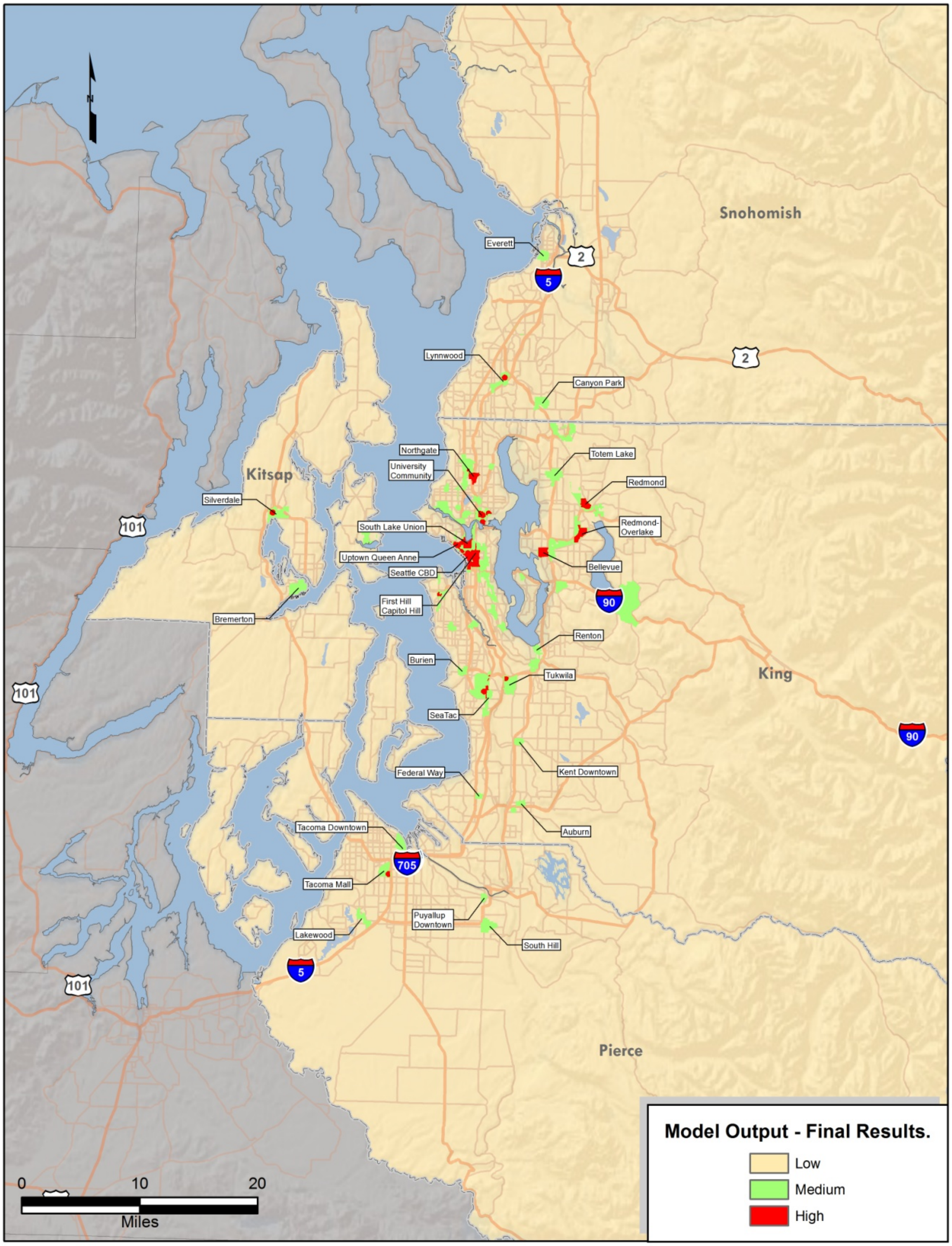

Figure 6-9 Micro-Climate™ Density Model Output

Detail is provided for each urban center in Central Puget Sound and Olympia areas and can be found in Appendix A. For example, Figure 6-10 shows the recommended low, medium, and high charging station density for Seattle's Northgate area.

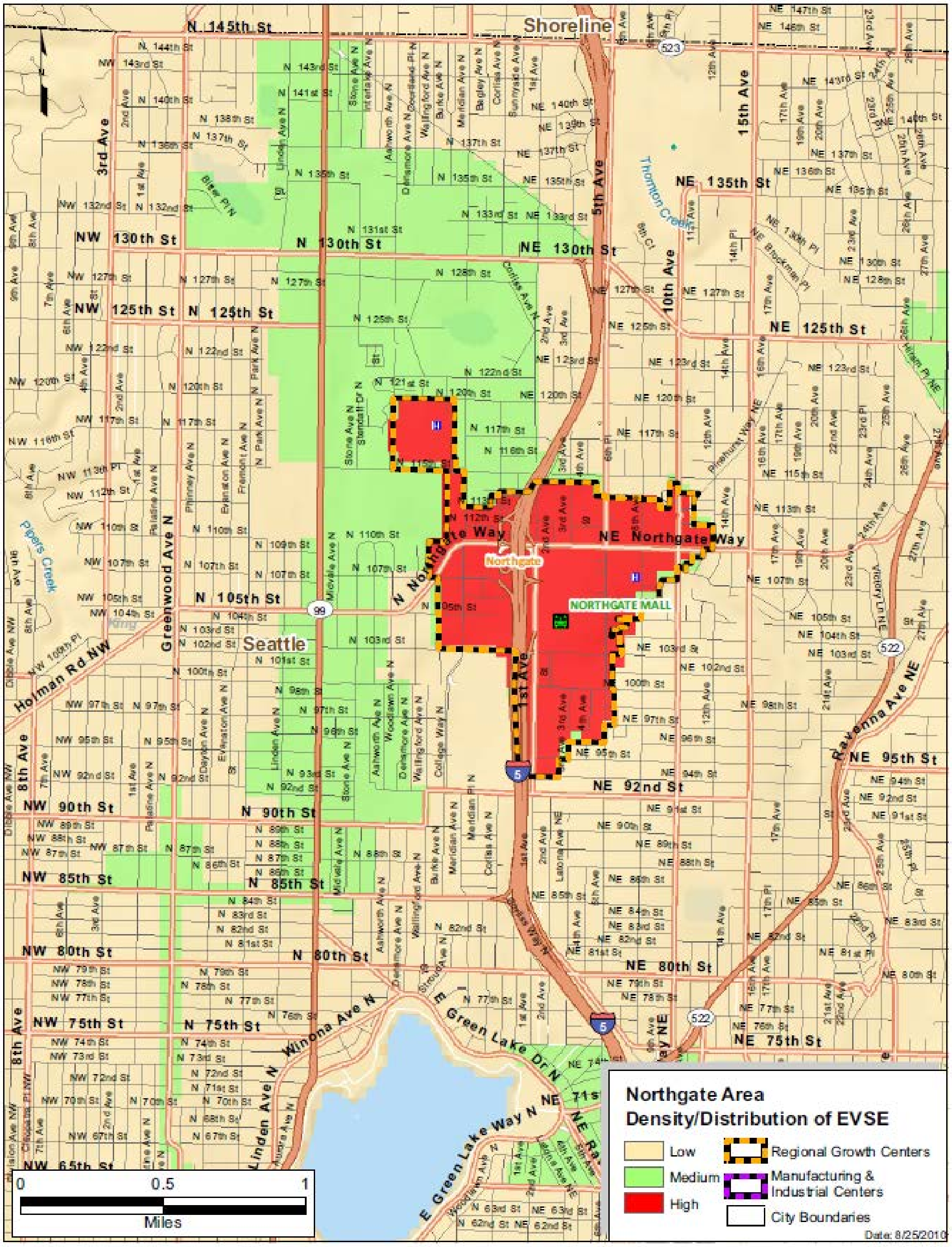

Figure 6-10 Micro-Climate™ Density Model Output – Northgate, Seattle

7 DC Fast Charge Plan

The EV Project will deploy 22 DC fast charge stations in the Central Puget Sound and Olympia areas. Each DC fast charge station will be able to charge two EVs sequentially.

Table 2-2 outlines the recharge capabilities of DC fast charging. It reduces the battery recharge time from hours to minutes. For many BEVs, receiving 50% battery recharge in 20 minutes is very significant. A charge opportunity lasting 10 minutes can extend the range of a BEV by 25 miles. That short a recharge time can easily be tolerated by the EV driver to gain the benefit of the range extension.

DC fast chargers have three major functions within a rich electric vehicle charging infrastructure:

- To enable corridor travel,
- To support destination travel, and
- To enable worry free travel throughout the metropolitan region.

The network of DC fast chargers will offer EV drivers the ability to conduct longer trips on major roads through the area. ECOtality is coordinating with state-sponsored efforts in both Oregon and Washington to provide DC fast charging along I-5 from Oregon's California border to Vancouver BC. While this EV Micro-Climate™ Plan includes the portion of I-5 from Everett to Olympia that will be serviced by the EV Project, additional DC fast chargers will be added from Everett north and Tumwater south to complete the system.

DC fast charging can have a significant effect on drivers in relieving "range anxiety." With the knowledge that there is a facility nearby that can deliver a significant charge in a short period of time, the driver is more comfortable using the full range of the vehicle. Without this safety net, the driver is more concerned about maintaining the vehicle battery at a higher state of charge. Thus the availability of DC fast charging will go a long way in the promotion of EVs. There is some question, however, whether the availability of the DC fast charging actually causes a higher usage of the equipment. A safety net is only needed in rare conditions. Consequently, it may be that once established, a network of DC fast chargers may be sufficient for a substantial time into the future.

For example, if a driver takes her 100-mile range EV equipped with a DC fast charge inlet from Olympia to the University of Washington (65 miles one-way) for a two-hour visit and parks at a Level 2 charger, she will only gain 22 to 26 miles of range – not a sufficient amount of range for the return trip[5]. A nearby DC fast charger will allow for rapid topping off of the battery for the return trip. Additional DC fast charger stations along I-5 south from Seattle assure that there is a safety net that will enable the driver to make the return trip.

7.1 Design Characteristics and Grid Impact

DC fast chargers require a higher power level than Level 2 EVSE units. 480-volt, three-phase AC is standard, although some equipment can use 208-volt, three-phase, and up to 575 volts AC. To provide a significant recharge, it is expected most DC fast chargers would be 50 or 60 kW, which would draw about 80 amps maximum at 480 volts AC. Equipment of this size can have an impact on the local electric utility grid. Because of the significant potential impact on the electrical grid, the electric utility company will provide vital input on DC fast charging locations.

7.2 Location Considerations

The rapid recharge capability of DC fast charging makes it ideal for locations where the consumer will stop for a relatively short period of time, typically 15 to 30 minutes. DC fast charging will not generally be used for completing the charge in a vehicle, but rather to provide a substantial recharge quickly. While DC fast charge stations may be a destination in themselves, they will likely be placed in existing locations where customers are likely to linger for this amount of time. Locations such as coffee shops, convenience stores, and rest stops serve as some examples.

7.3 Methods

High ranked centers identified in the Density Model indicate locations for DC fast chargers to support destination travel.

State Routes in the Metropolitan Transportation System are analyzed for high, medium, and low annual average traffic count segments (illustrated by red, green, and yellow, respectively, in Figure 7-1). Exits along the I-5, I-405, and I-90 highways are analyzed for ease of access to nearby commercial areas, which tend to have sufficient grid capacity. Locations along state routes and interstates are also analyzed for providing a safety net for metropolitan region travel.

[5] The Model Year 2011 Nissan LEAF is equipped with a charger rated at 3.3 kW. A vehicle with a 6.6 kW rated charger will gain 44 to 52 miles in two hours.

7.4 DC Fast Charge Potential Areas

Figure 7-1 illustrates possible DC fast charge areas for The EV Project. Actual DC fast charge sites will be selected based on cost, availability of power, and ability to fulfill the needs for DC fast charging at given destination, corridor and area locations.

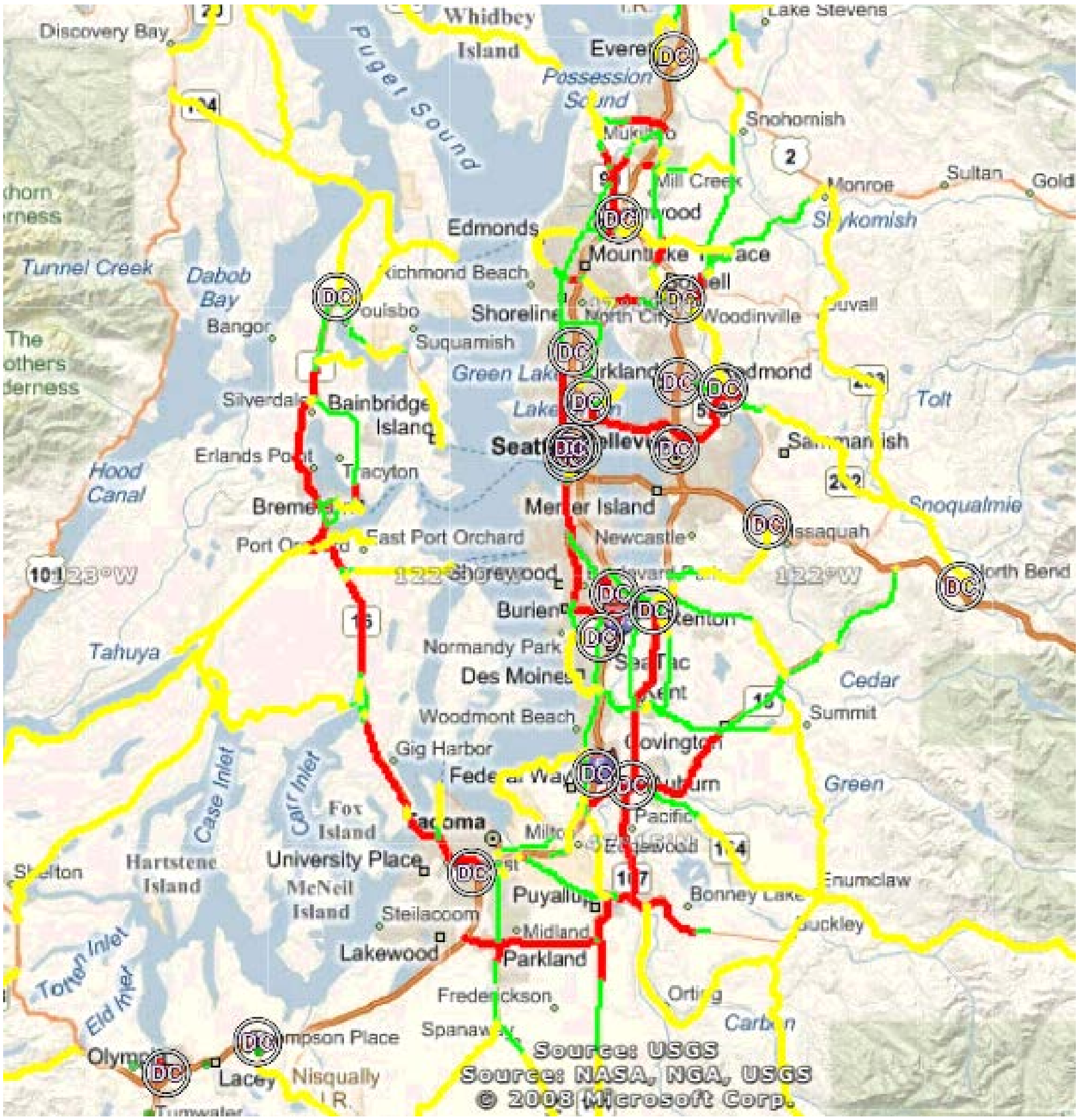

Figure 7-1 Potential DC Fast Charge Areas - Central Puget Sound and Olympia Areas

8 Appendix A: EV Micro-Climate™ Density Model Output for Selected Central Puget Sound and Olympia Area Urban Centers

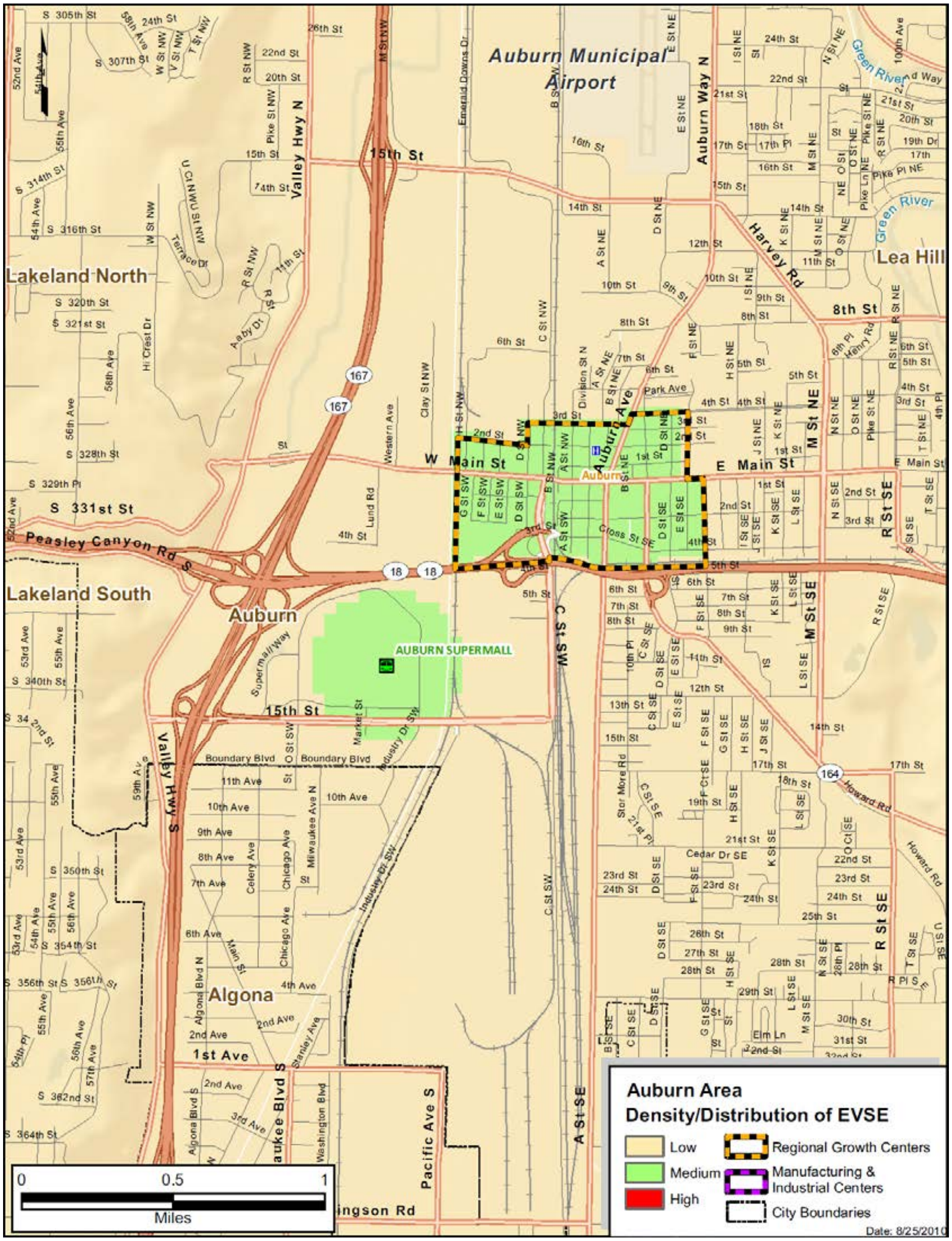

Figure 8-1 Auburn Area

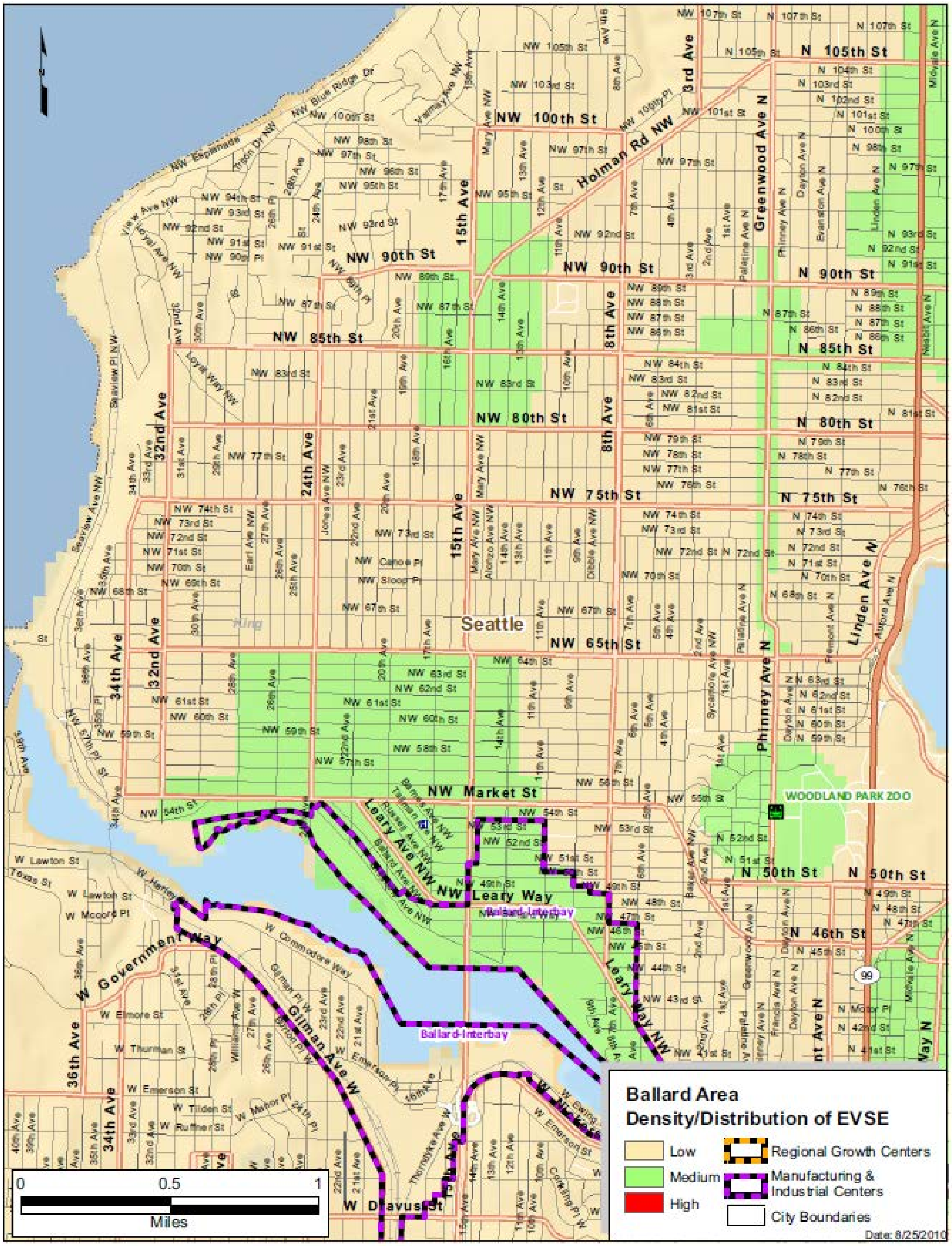

Figure 8-2 Ballard Area

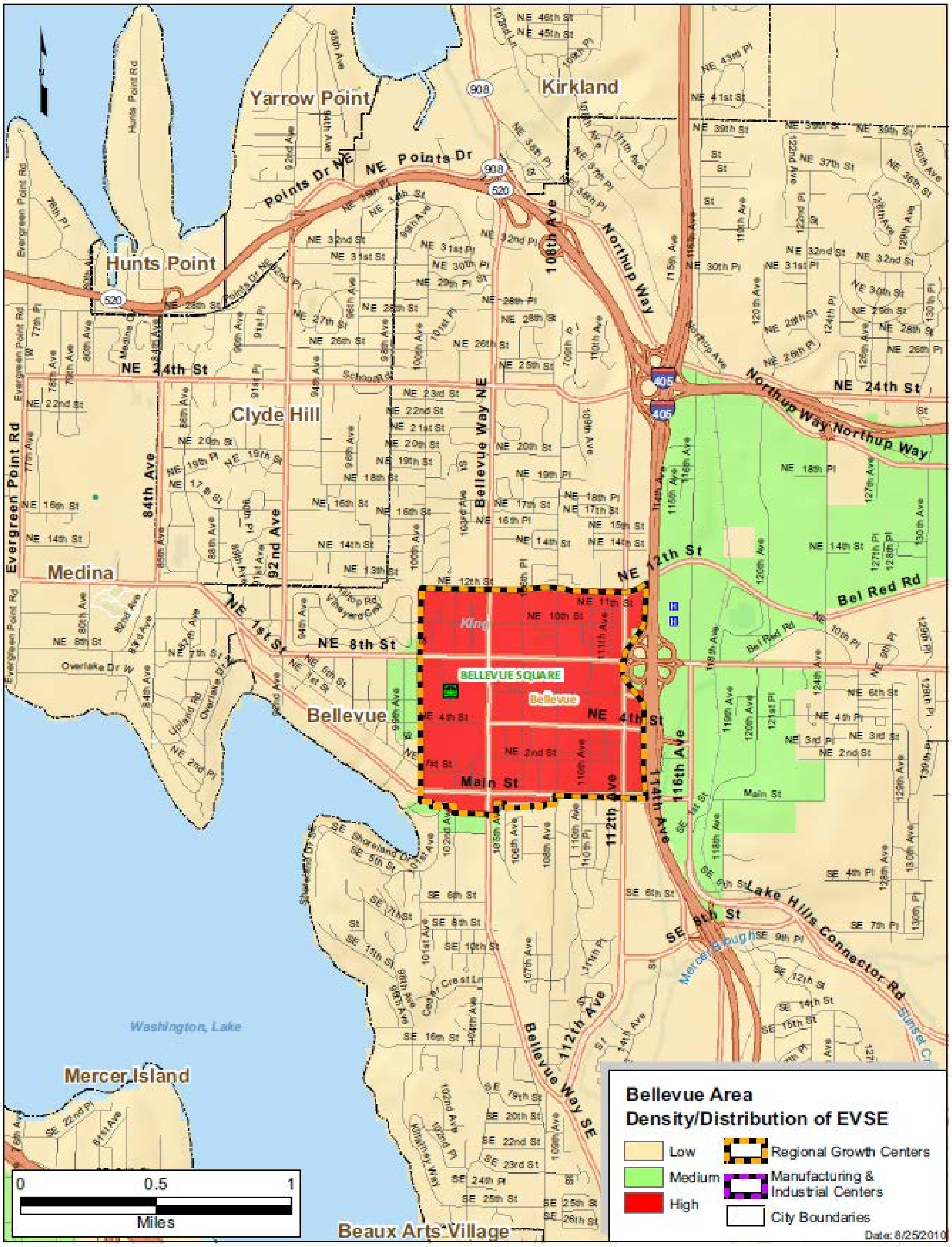

Figure 8-3 Bellevue Area

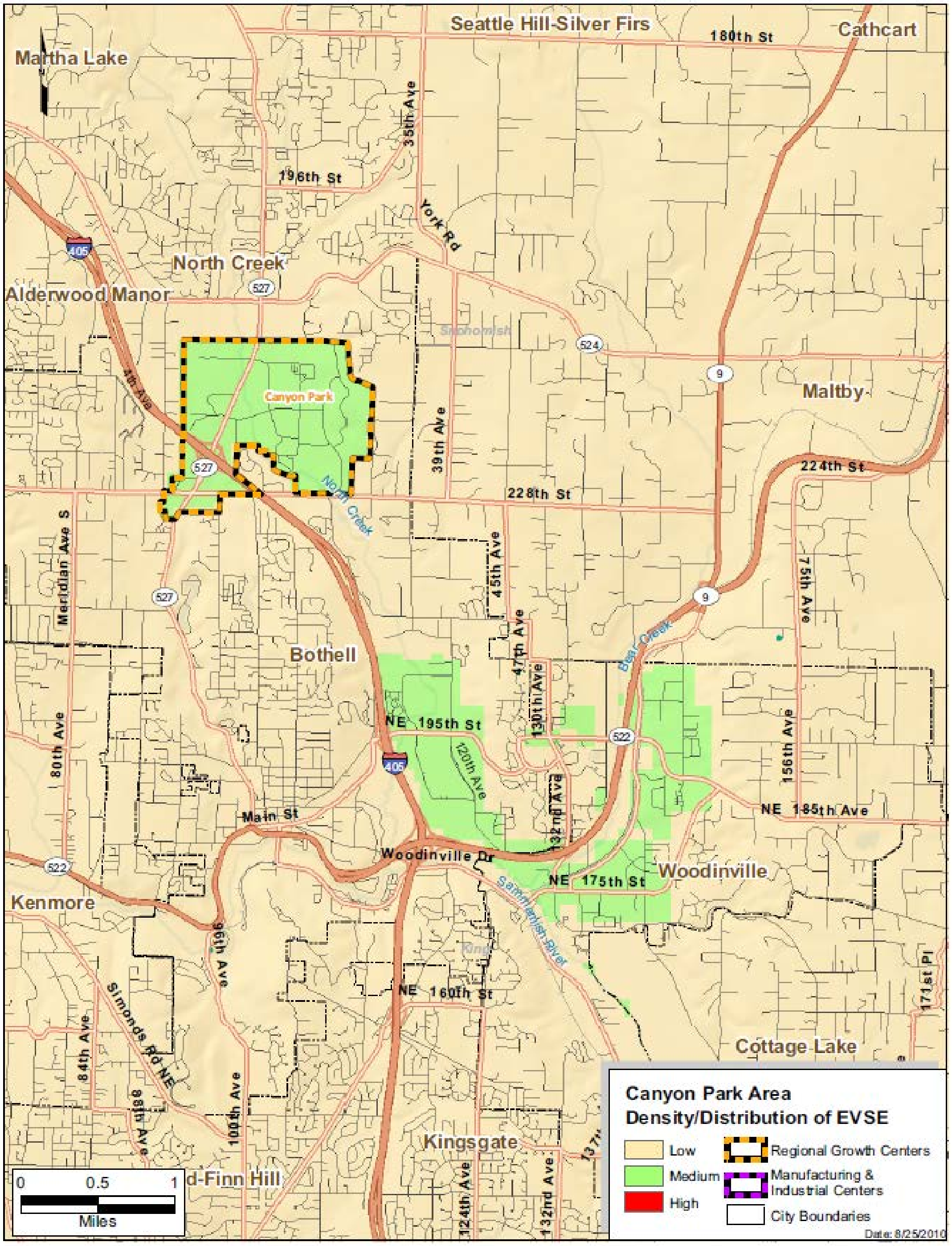

Figure 8-4 Canyon Park – Woodinville Area

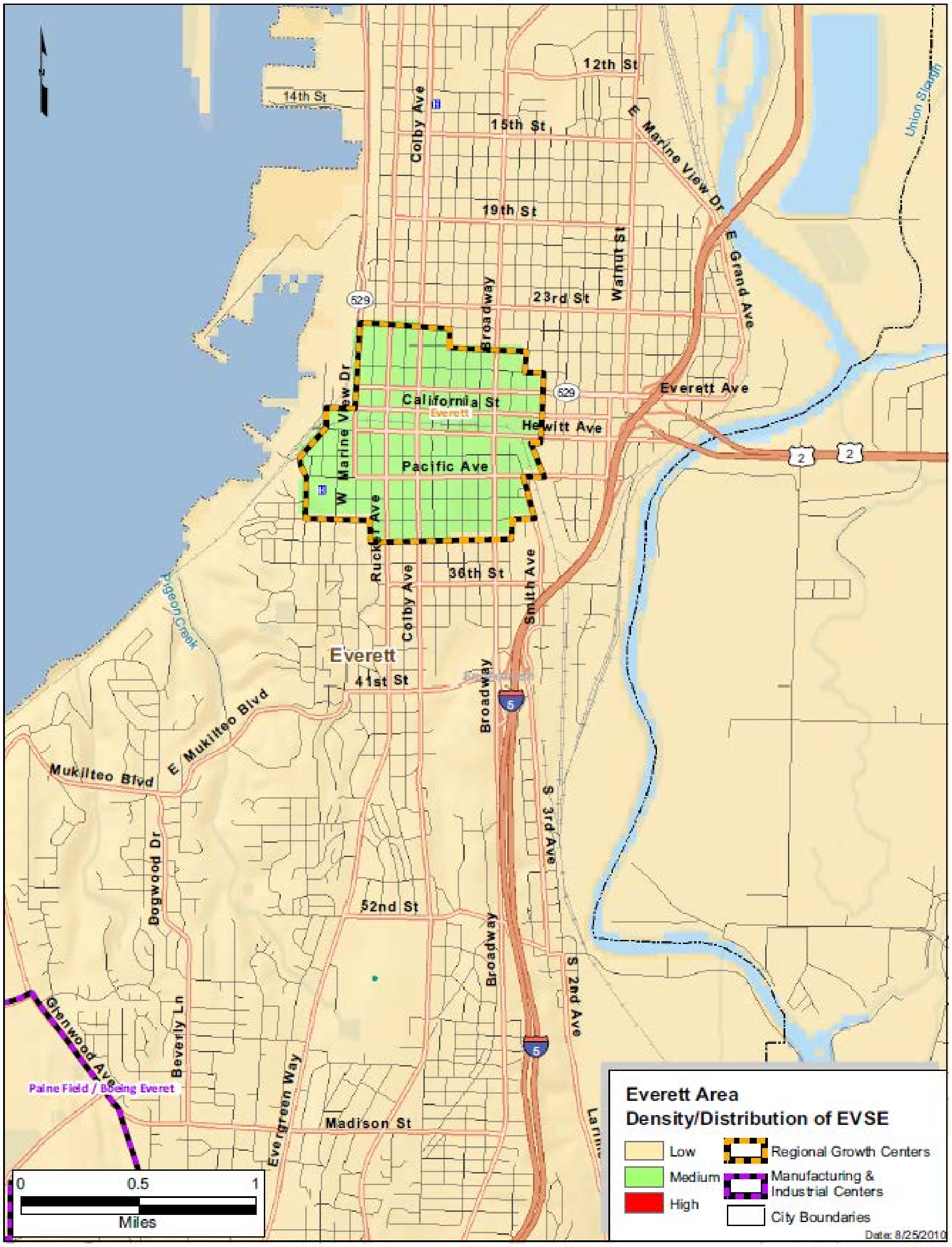

Figure 8-5 Everett Area

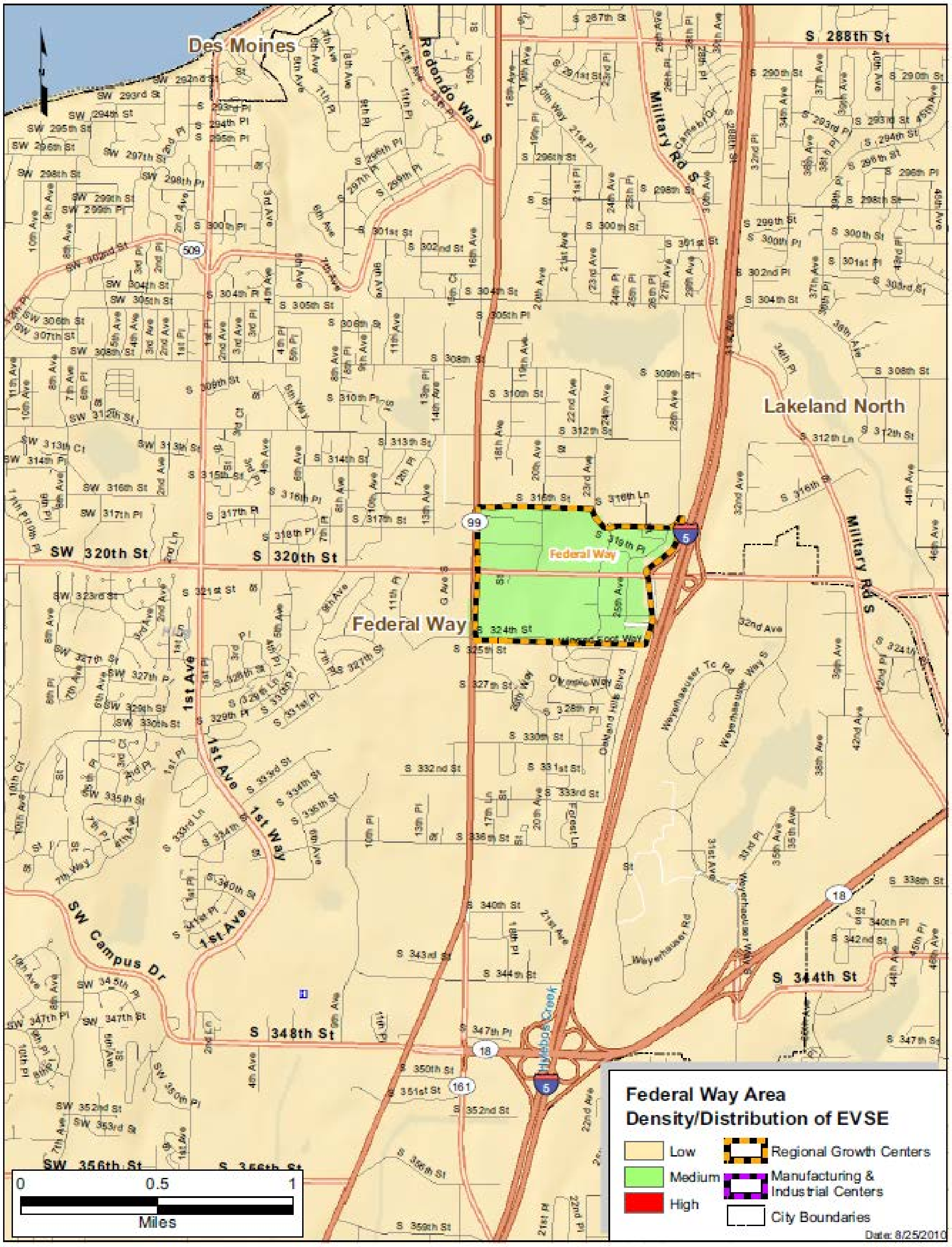

Figure 8-6 Federal Way Area

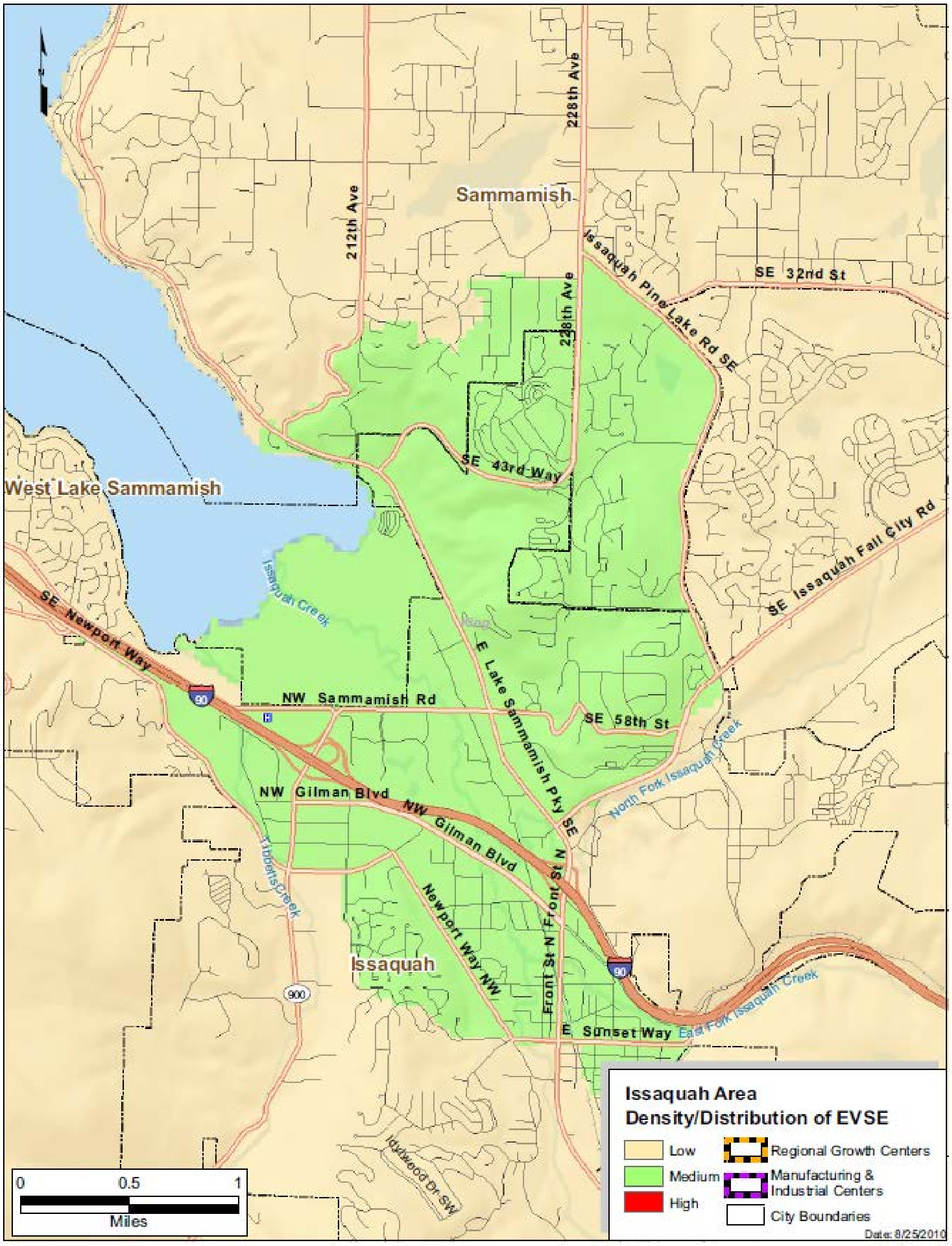

Figure 8-7 Issaquah Area

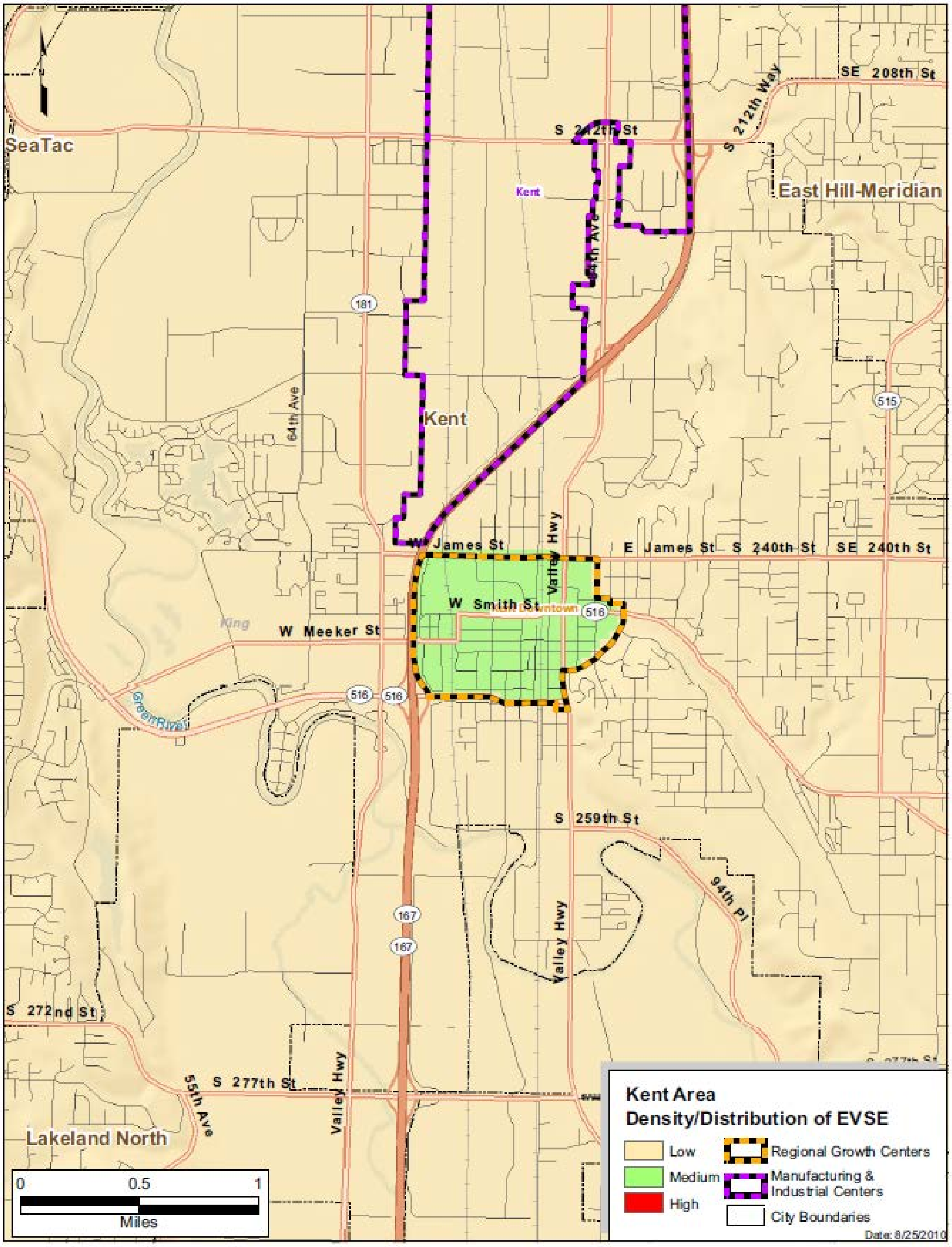

Figure 8-8 Kent Area

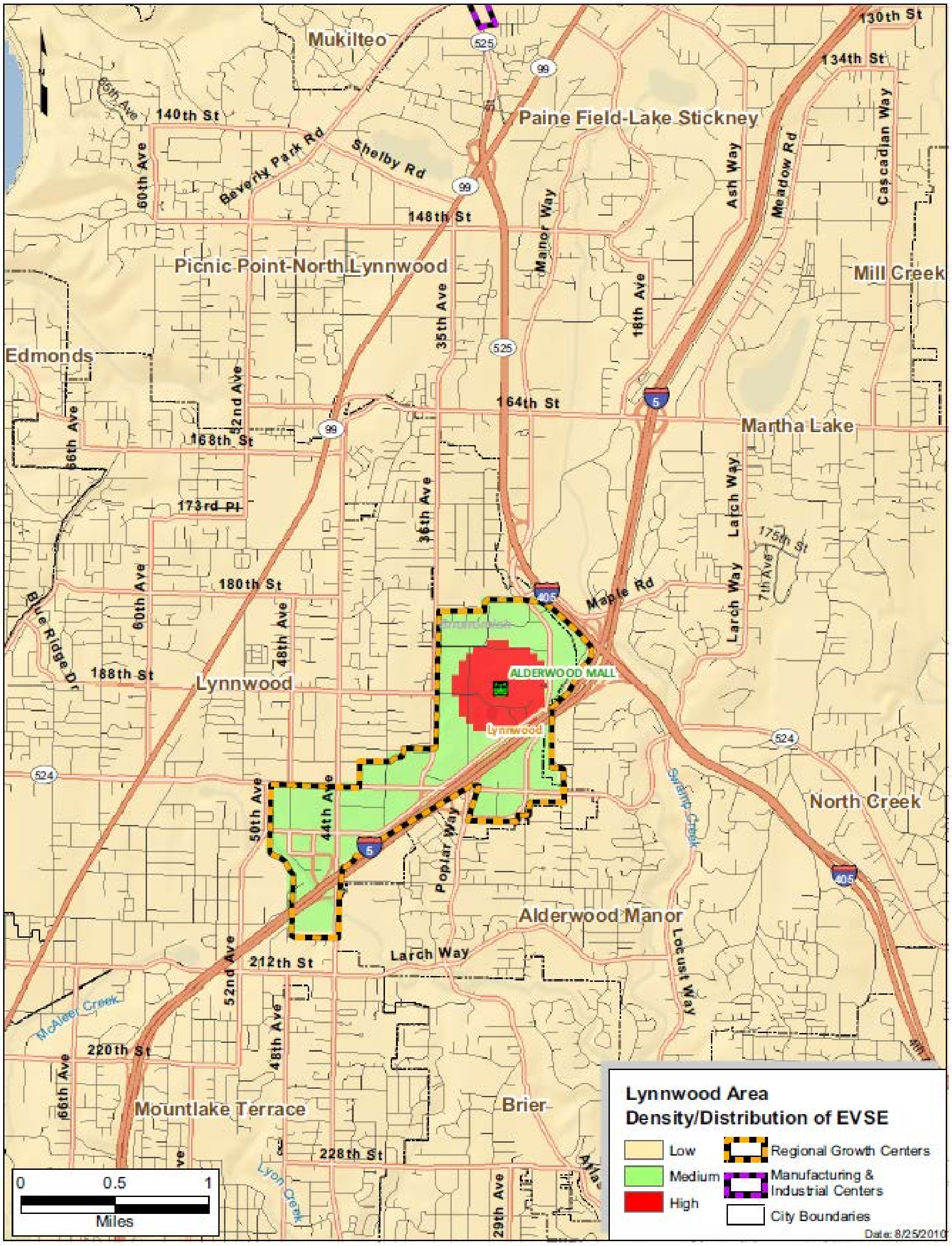

Figure 8-9 Lynnwood Area

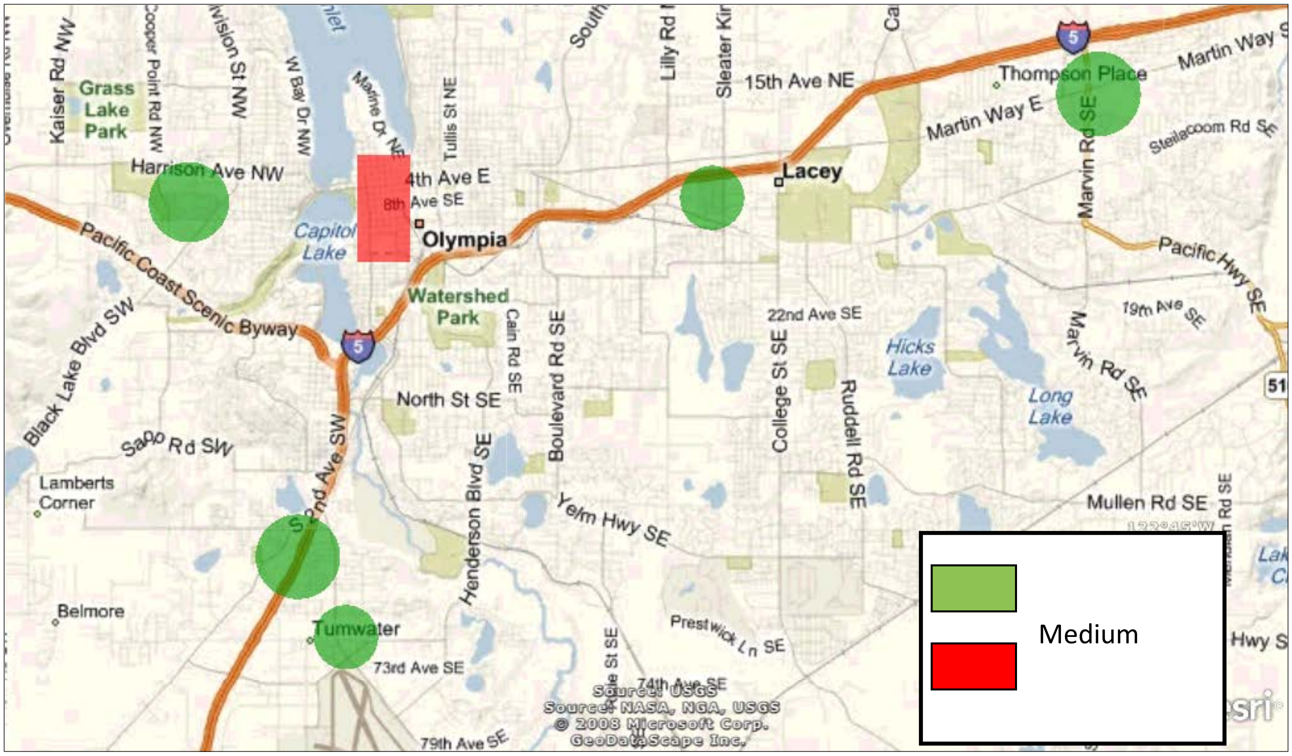

Figure 8-10 Olympia Area

NOTE: The Olympia Area Density Map shown in Figure 8-10 above was produced using the EV Micro-Climate™ planning geographic method, which uses zones of increasing EVSE density projected with the city center or specific regional destinations having the highest density of EVSE.

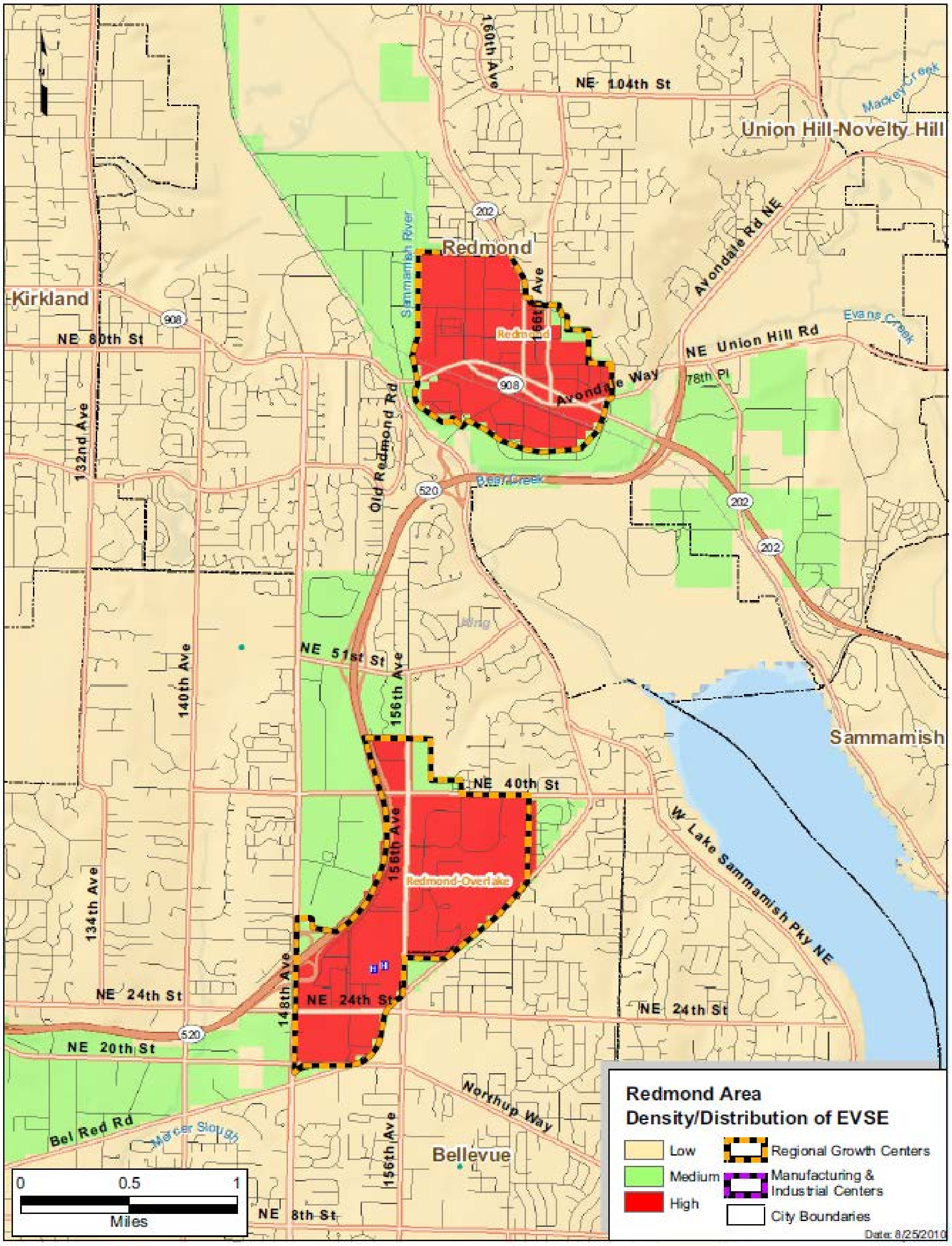

Figure 8-11 Redmond Downtown and Overlake Areas

Figure 8-12 Renton Area

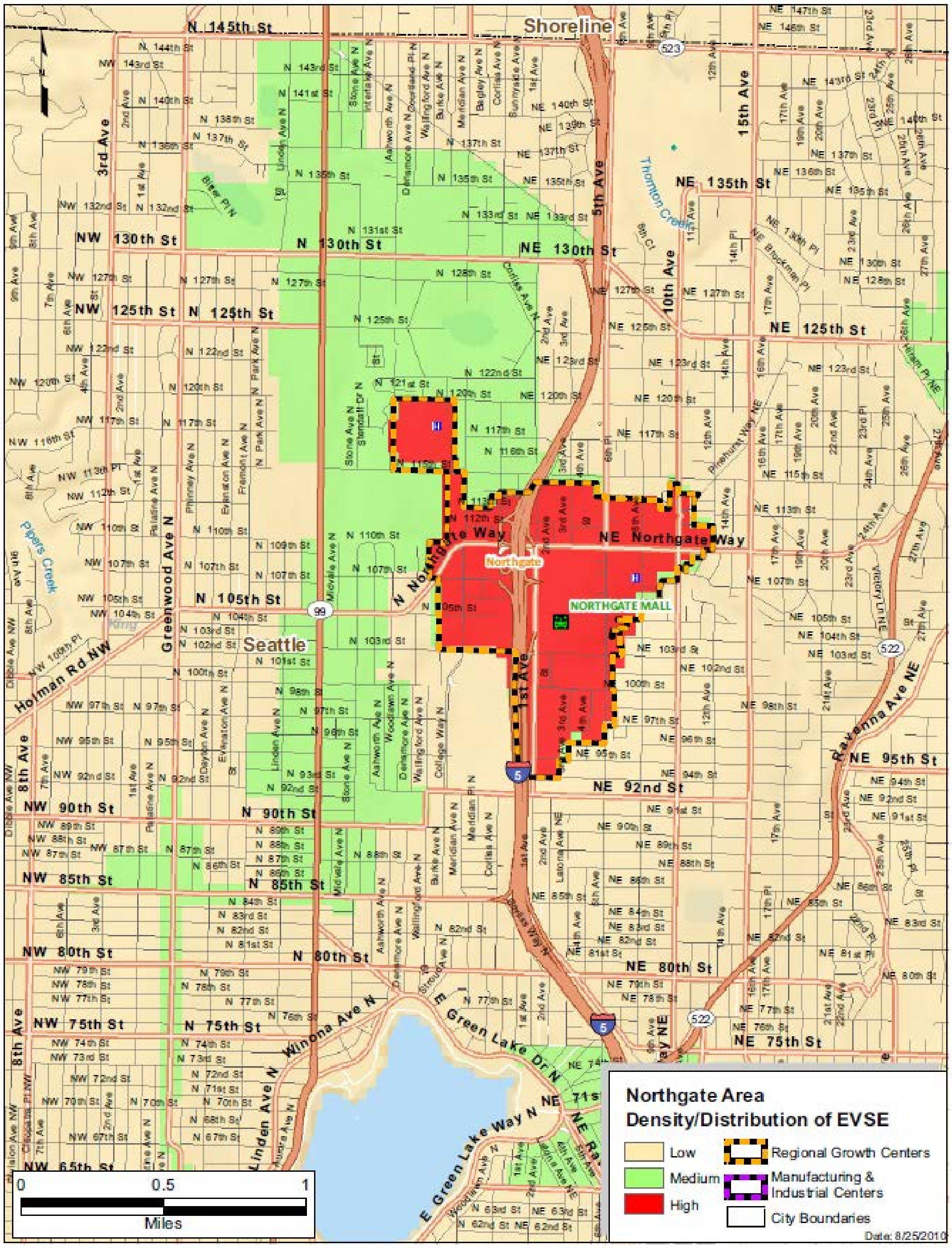

Figure 8-13 Seattle Northgate Area

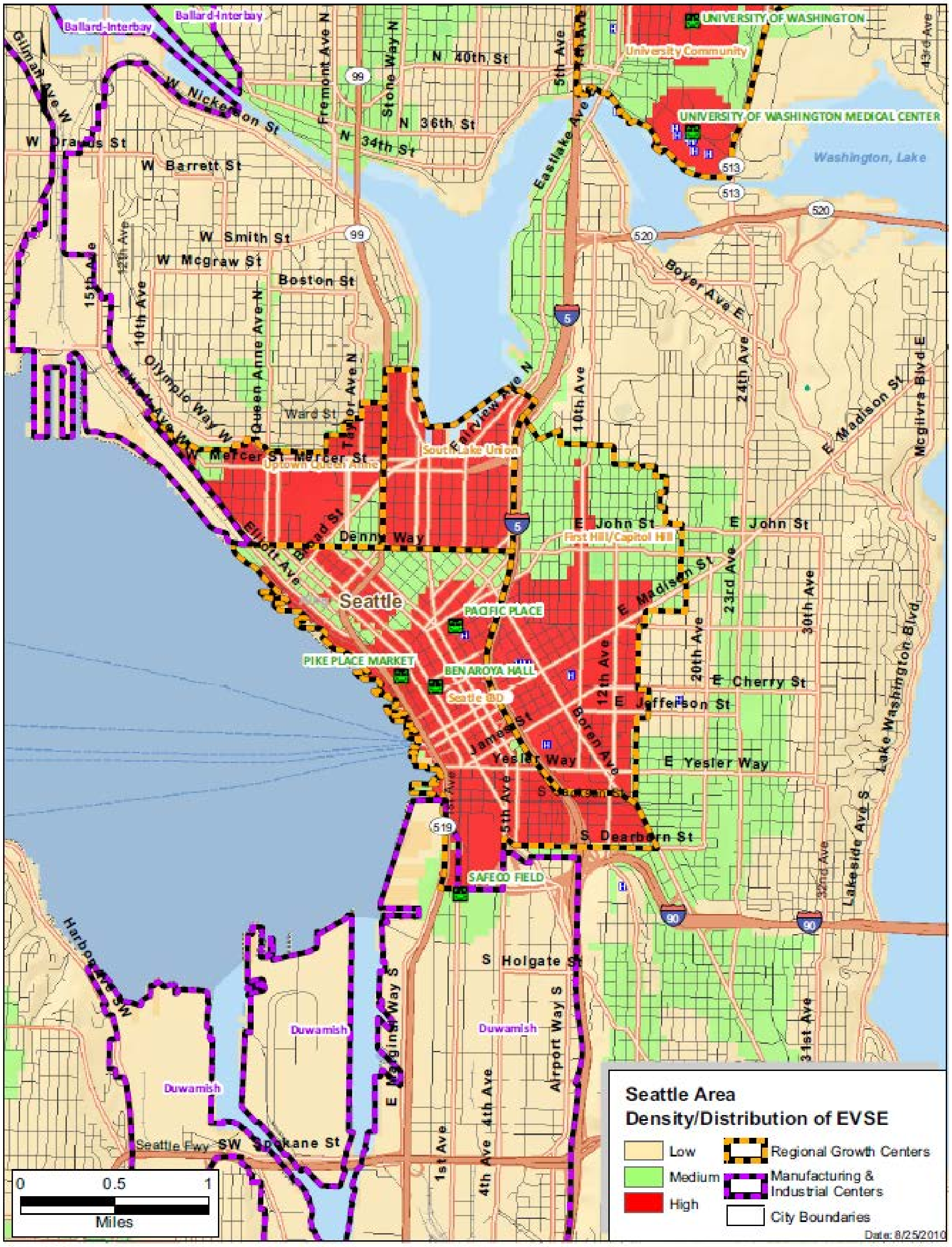

Figure 8-14 Seattle CBD, Uptown Queen Anne and First Hill/Capitol Hill Areas

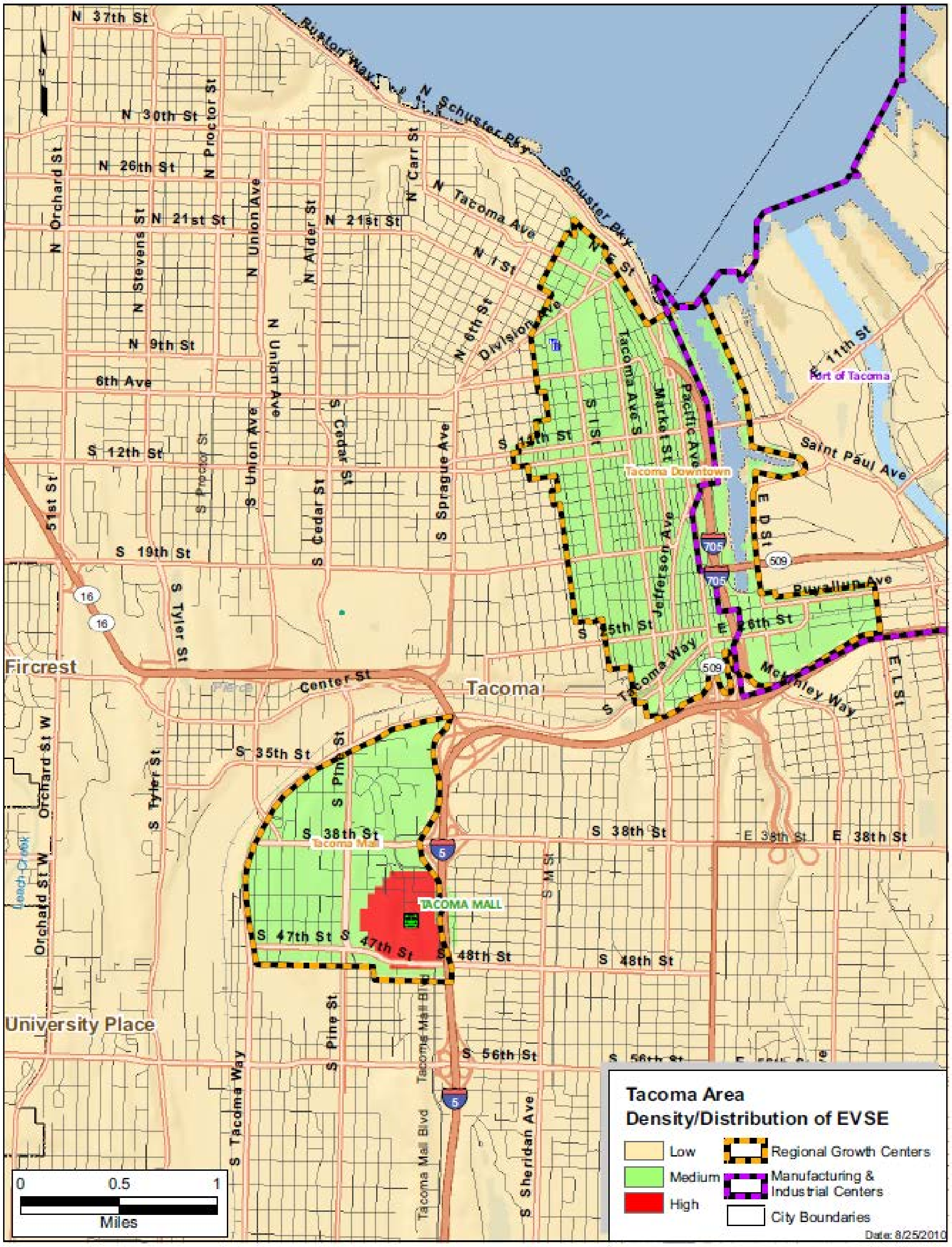

Figure 8-15 Tacoma Downtown and Tacoma Mall Areas

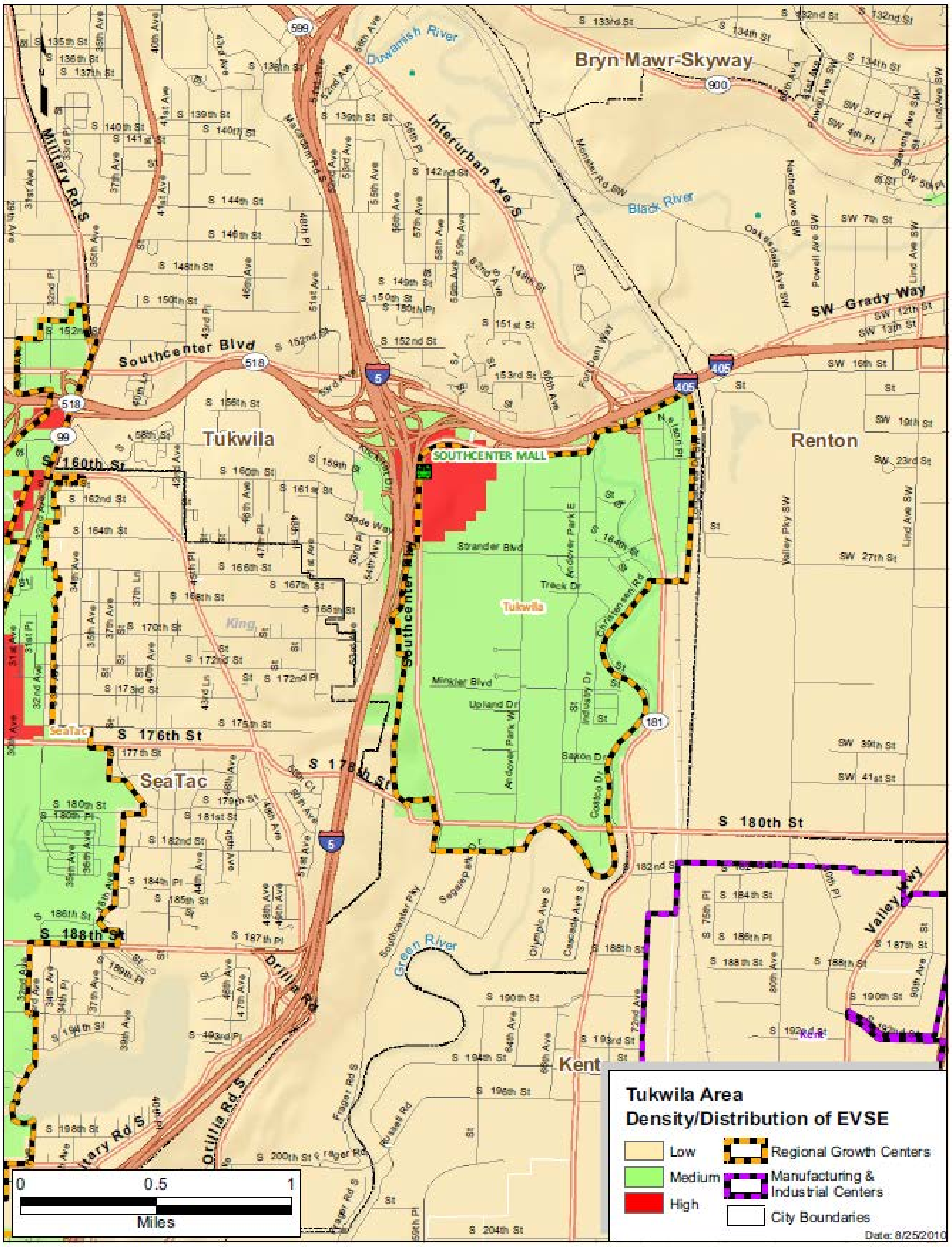

Figure 8-16 Tukwila Area

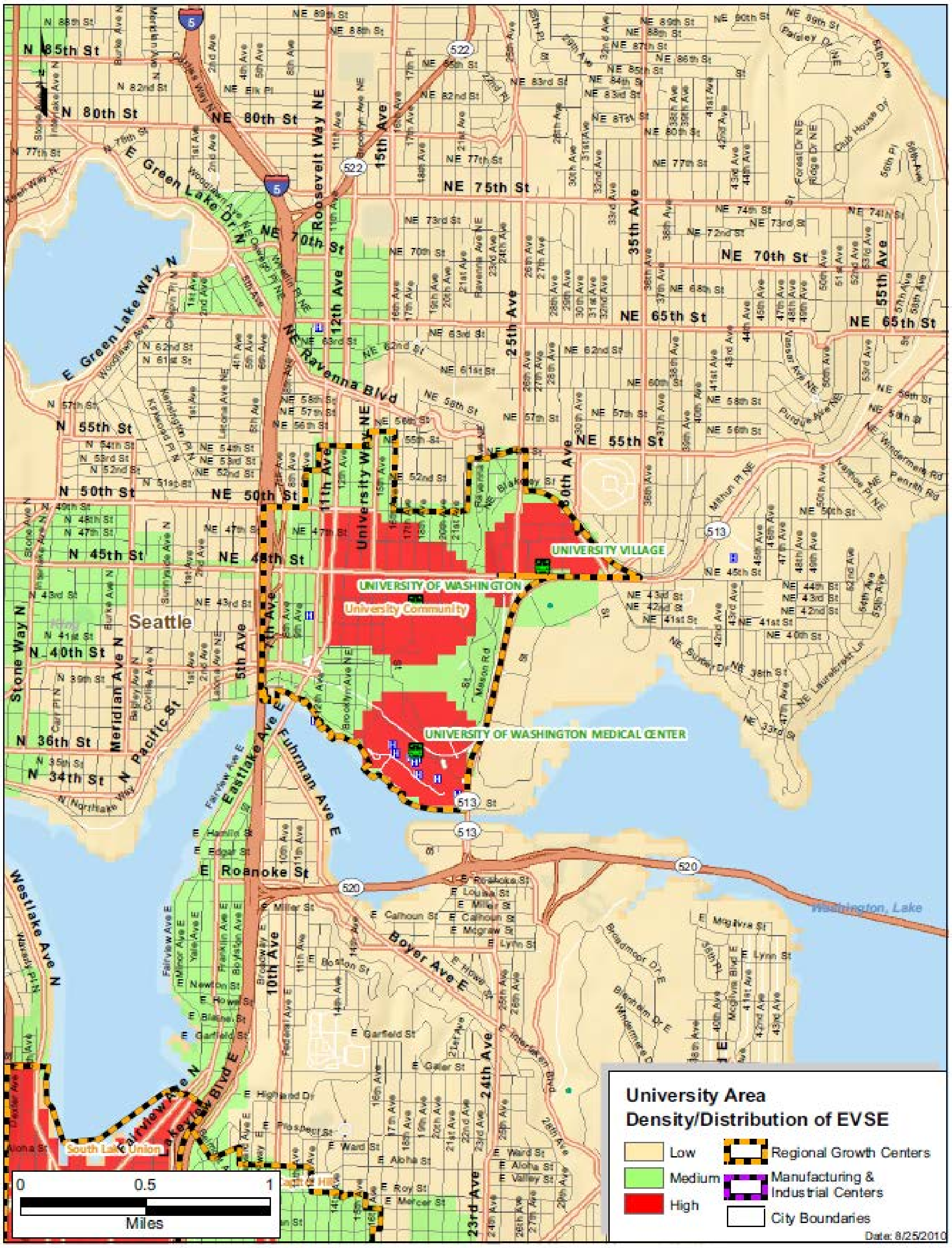

Figure 8-17 University Community Area