Chapter 9: Equal Access Future Transportation Scenarios

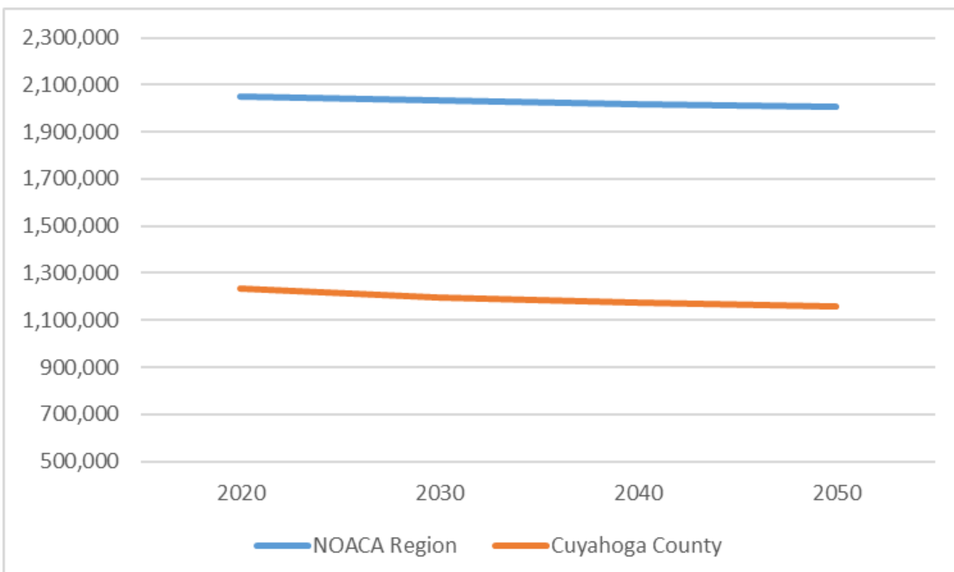
Demographics

The following section presents how population and employment are forecasted to change in Northeast Ohio over the next 30 years. Forecasting demographic and economic trends is primarily based on looking into the past to determine the most likely pattern for the future. This trend analysis assists planners and decision-makers in developing and evaluating various land use and transportation planning scenarios.

Population (2020-2050)

The population forecasts follow a similar trajectory as the historic population trends between 2010 and 2018. This results in a regional loss of over 43,000 residents between 2020 and 2050, which is a decrease of 2%. Similar to the historic population data, the forecasts indicate that Cuyahoga County will continue to be the main source of the population losses for the NOACA region, losing an additional 6% of its population (-77,000) during that same period.

Figure 9-1. Population Forecasts for Cuyahoga County and NOACA Region (2020-2050)



Source: NOACA Population Forecasts, April 2020

Table 9-1. Population Forecasts by County and NOACA Region (2020-2050)

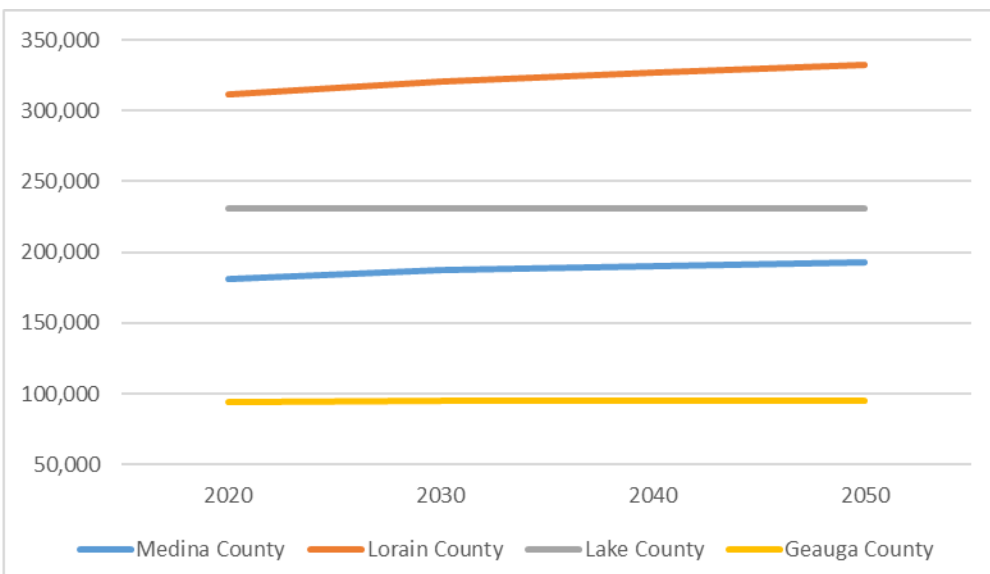
Geography	2020	2030	2040	2050	Change 2020-2030	Change 2030-2040	Change 2040-2050	Change 2020-2050	% Change 2020-2030	% Change 2030-2040	% Change 2040-2050	% Change 2010-2050
Cuyahoga County	1,234,791	1,198,982	1,172,604	1,157,360	-35,809	-26,378	-15,244	-77,430	**-2.9%**	**-2.2%**	**-1.3%**	**-6.3%**
Geauga County	94,192	94,851	95,135	95,231	659	285	95	1,039	**0.7%**	**0.3%**	**0.1%**	**1.1%**
Lake County	230,632	230,817	230,955	231,048	185	138	92	415	**0.1%**	**0.1%**	**0.0%**	**0.2%**
Lorain County	311,487	320,209	327,253	332,162	8,722	7,045	4,909	20,675	**2.8%**	**2.2%**	**1.5%**	**6.6%**
Medina County	180,850	186,998	190,551	192,933	6,149	3,553	2,382	12,084	**3.4%**	**1.9%**	**1.3%**	**6.7%**
NOACA Region	2,051,951	2,031,857	2,016,500	2,008,734	-20,095	-15,357	-7,766	-43,217	**-1.0%**	**-0.8%**	**-0.4%**	**-2.1%**

Source: NOACA Population Forecasts, April 2020

As was apparent in the past population trends, the four outer counties of the NOACA region are the main source of population gains. Much of this future growth occurring in the outer counties of the NOACA region is forecasted to occur in Medina and Lorain counties. Between 2020 and 2050, Medina County is forecasted to grow at approximately 7% during that period, which is an increase in over 12,000 population. Lorain County's rate of growth during the same forecast period is also approximately 7%. The populations of Geauga and Lake Counties are forecasted to stay relatively flat over the course of the next 30 years, with Geauga County increasing by 1% and Lake County remaining essentially the same. Taken together though, the population growth in the collar counties do not outweigh the population loss in Cuyahoga County, resulting in a negative growth rate for the region.

Between 1990 and 2018, the rate of population change in all 5 counties of the NOACA region was decreasing over each decade. This pattern is forecasted to continue into the future, with each county seeing less and less change each decade out to 2050. Between 2020 and 2030, Cuyahoga's population loss is forecasted to be 3%, but between 2040 and 2050, that rate drops to only 1%. Both Medina County and Lorain County's growth rate between 2020 and 2030 is approximately3%, but then drops to approximately1% between 2040 and 2050. Geauga and Lake Counties both see their growth rates approach 0% by 2050. These trends indicate that the region is slowly approaching a period of little-to-no growth in all counties of the region by 2050.

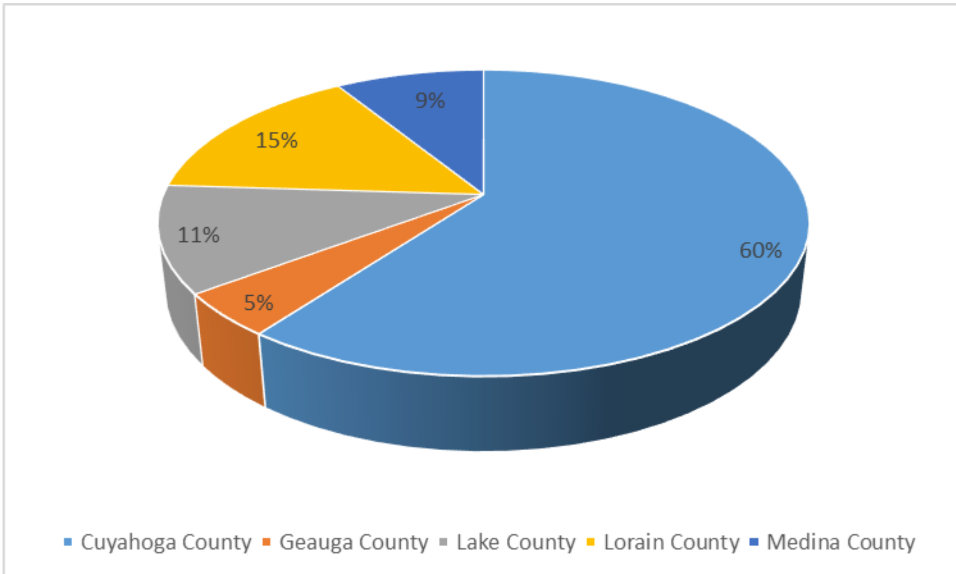
Figure 9-2. Population Forecasts for Geauga, Lake, Lorain and Medina Counties (2020-2050)



Source: NOACA Population Forecasts, April 2020

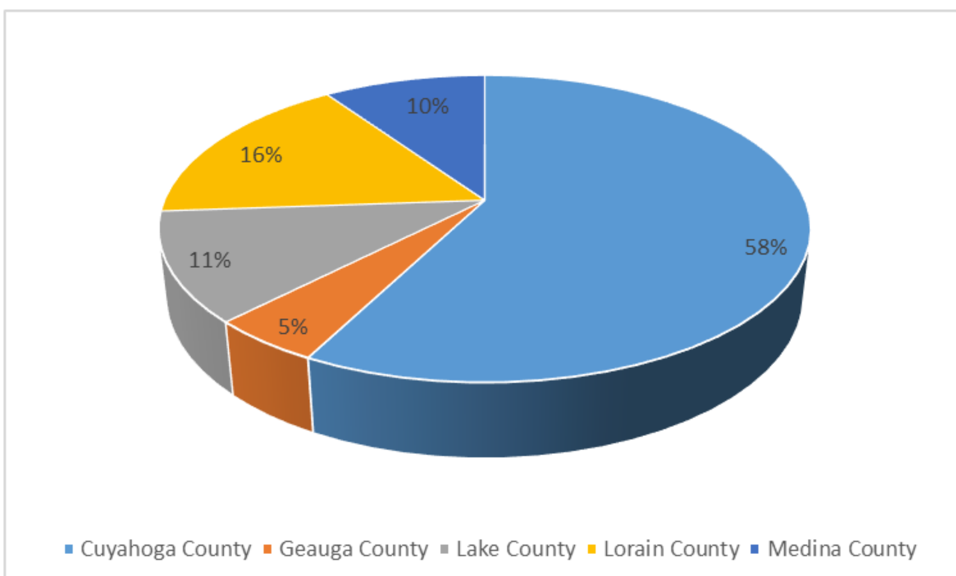
Examining the county shares of the regional population shows that the pattern of population redistribution throughout the NOACA region also continues out to 2050. In the 2018 ACS data, Cuyahoga County accounted for 60% of the regional population, and the outer counties accounted for 40% of the regional population. By 2050, Cuyahoga County is forecasted to drop to 58% of the regional population, and the outer counties are forecasted to grow to 42% of the regional population.

Figure 9-3. County Share of Regional Population 2020



Source: NOACA Population Forecasts, April 2020

Figure 9-4. County Share of Regional Population 2050

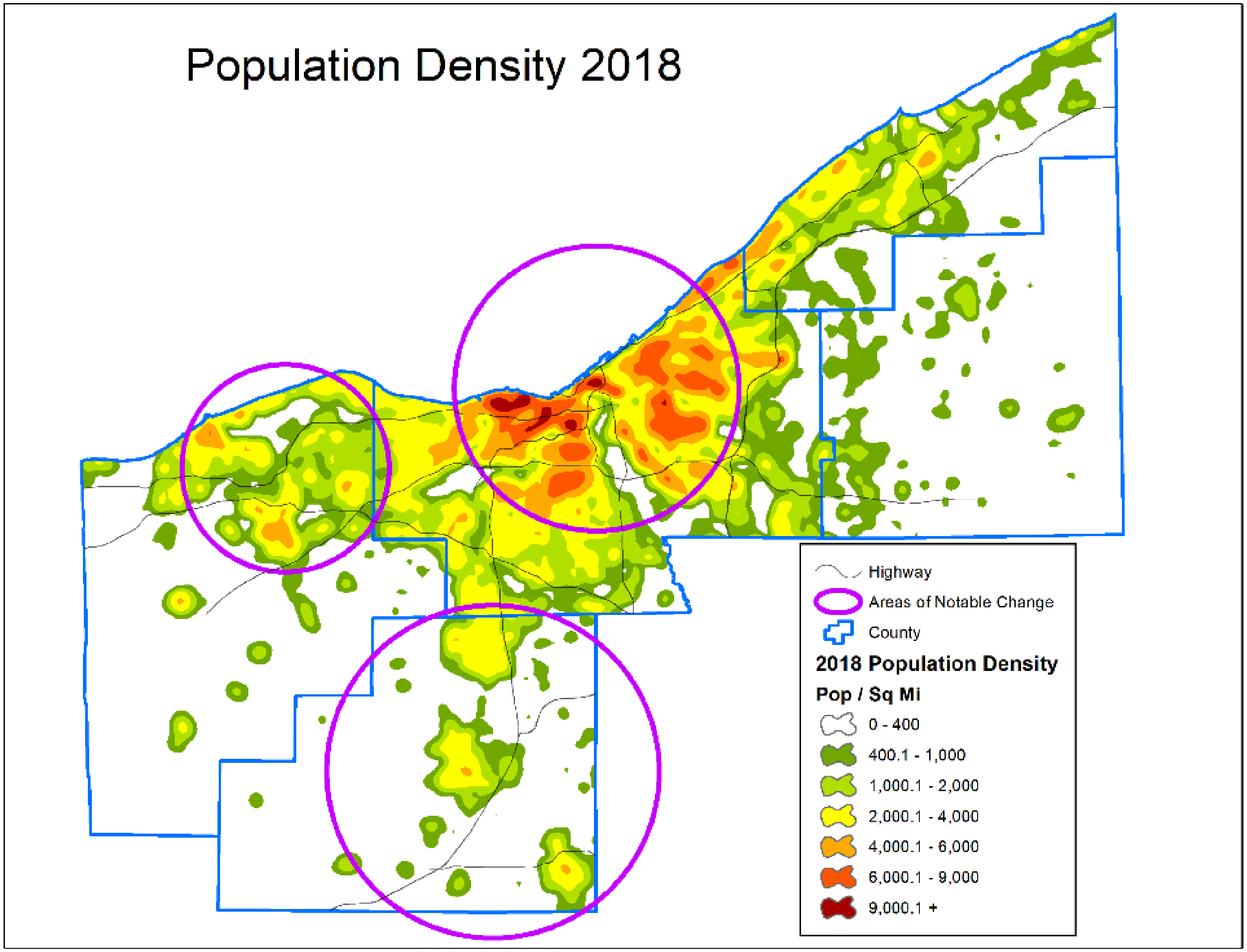


Source: NOACA Population Forecasts, April 2020

Population Density (2018-2050)

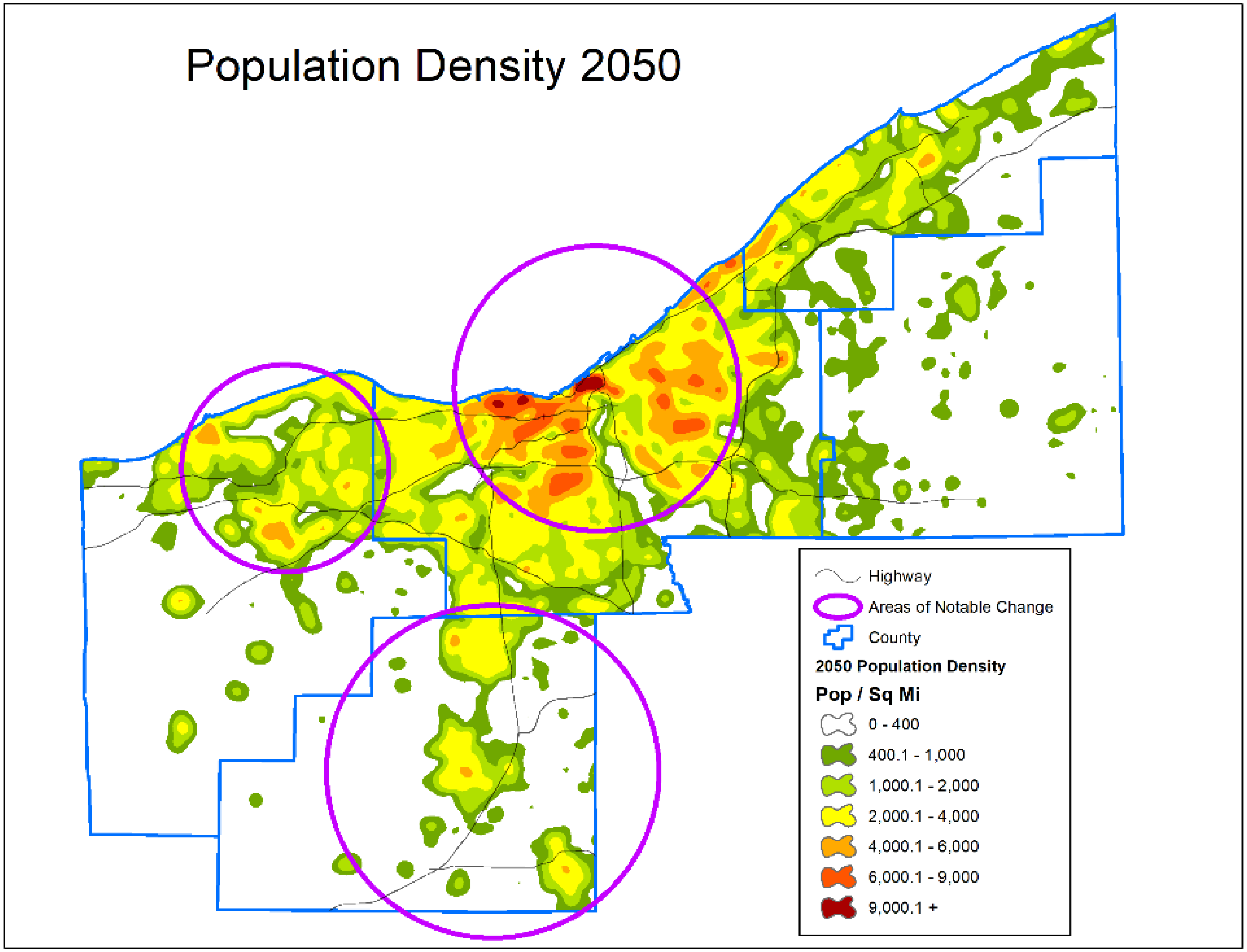
Future population density at the sub-county level in 2050 shows much of the same trends apparent during the period between 2000 and 2018. The urban core of Cuyahoga County is forecasted to lose population, while downtown and near west side neighborhoods continue to grow. In northeast Lorain County, density levels are forecasted to continue to increase, as housing development will continue to replace former agricultural lands. Medina County's density growth out to 2050 is a bit subdued compared to the period between 2000 and 2018. Lake and Geauga counties stay relatively similar in their density patterns out to 2050, and this follows the forecasted trend of little-to-no growth at the county level.

Figure 9-5. Regional Population Density (2018)



Source: NOACA Analysis of forecasted Census block data utilizing the Ohio Development Services Agency's (ODSA) county population forecasts (2013).

Figure 9-6. Regional Population Density (2050)

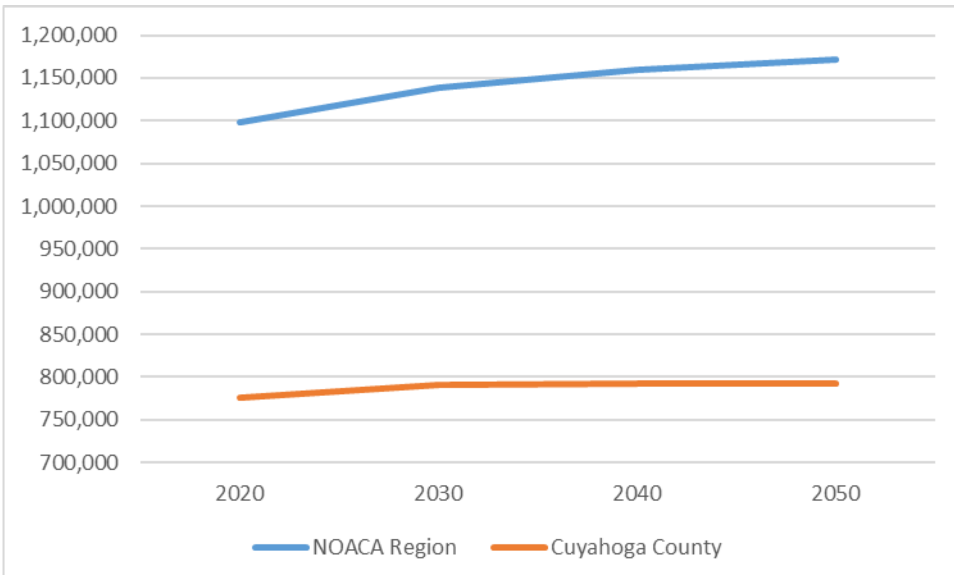


Source: NOACA Analysis of forecasted Census block data utilizing NOACA county population forecasts (April 2020).

Employment (2020-2050)

The historic job trends of the NOACA region saw a pattern where Cuyahoga County experienced more job losses and less job gains on a proportional scale than the region over all. This trend continues into the future with the job forecast data. Overall the NOACA region is forecasted to grow to about 1.17 million jobs from 2020 to 2050 at a rate of 7%, while Cuyahoga only grows at a rate of 2% over the same time period.

Figure 9-7. Total Employment Forecasts for Cuyahoga County and NOACA Region (2020-2050)



Source: Moody's Economy.com. Obtained from Team NEO in February 2020.

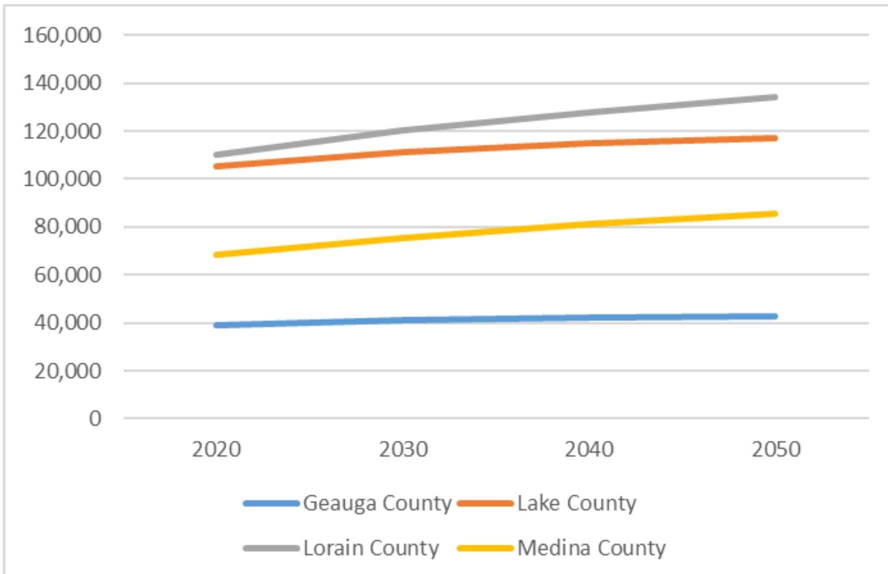
Table 9-2. Total Employment Forecasts by County and NOACA Region (2020-2050)

Geography	2020	2030	2040	2050	Change 2020-2030	Change 2030-2040	Change 2040-2050	Change 2020-2050	% Change 2020-2030	% Change 2030-2040	% Change 2040-2050	% Change 2020-2050
Cuyahoga County	776,178	791,321	792,974	791,900	15,143	1,653	-1,074	15,722	**2.0%**	**0.2%**	**-0.1%**	**2.0%**
Geauga County	38,811	40,969	42,175	42,895	2,158	1,206	720	4,084	**5.6%**	**2.9%**	**1.7%**	**10.5%**
Lake County	105,083	111,229	114,775	116,947	6,146	3,546	2,172	11,864	**5.8%**	**3.2%**	**1.9%**	**11.3%**
Lorain County	109,876	120,189	127,999	134,466	10,313	7,810	6,467	24,590	**9.4%**	**6.5%**	**5.1%**	**22.4%**
Medina County	68,411	75,464	80,995	85,708	7,053	5,531	4,713	17,297	**10.3%**	**7.3%**	**5.8%**	**25.3%**
NOACA Region	1,098,359	1,139,172	1,158,918	1,171,916	40,813	19,746	12,998	73,557	**3.7%**	**1.7%**	**1.1%**	**6.7%**

Source: Moody's Economy.com. Obtained from Team NEO in February 2020.

Forecasted job growth in the 4 outer counties of the NOACA region is fairly consistent from 2020 to 2050. All counties are forecasted to grow at high rates. Out of the approximately 74,000 jobs gained in the NOACA region from 2020 to 2050, the 4 outer counties account for approximately 58,000, which is about 79% of all the growth.

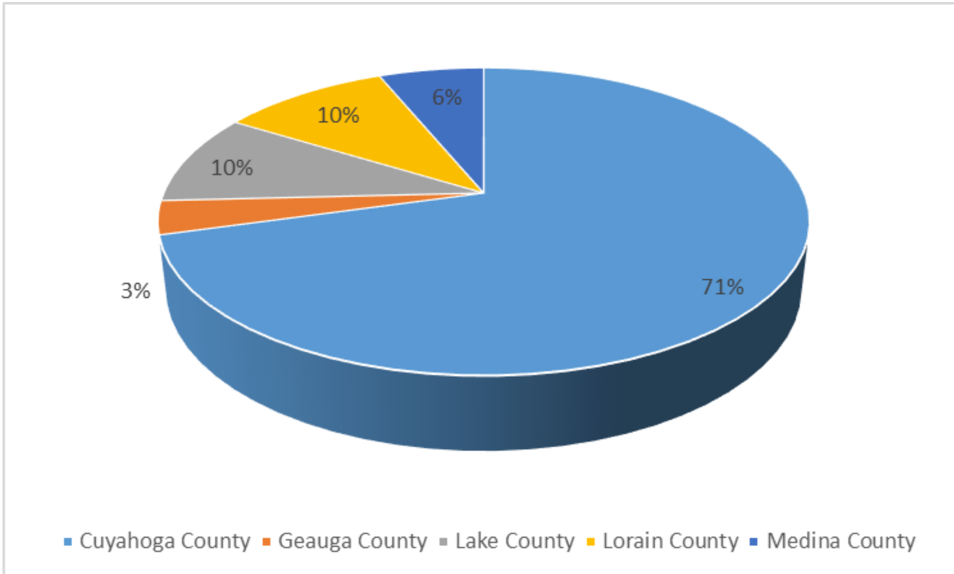
Figure 9-8. Total Employment Forecasts for Geauga, Lake, Lorain and Medina Counties; 2020-2050



Source: Moody's Economy.com. Obtained from Team NEO in February 2020

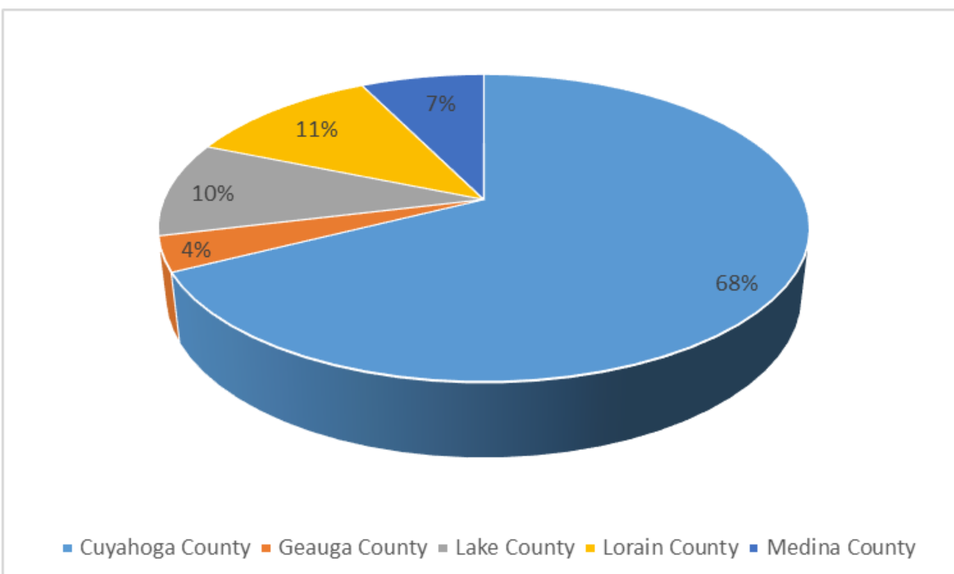
Since the baseline scenario projects Cuyahoga County to grow at such a small rate compared to the outer four counties of the NOACA region from 2020 to 2050, it continues to see its percentage share of total jobs in the region decrease. In 2019, 71% of the jobs in the region were located in Cuyahoga County, and 29% in the outer four counties. By 2050, Cuyahoga County's share is forecasted to drop to 68%, and the four outer counties are forecasted to collectively increase to 32% of all jobs in the region.

Figure 9-9: County Share of Regional Jobs 2020



Source: Moody's Economy.com. Obtained from Team NEO in February 2020

Figure 9-10. County Share of Regional Jobs 2050

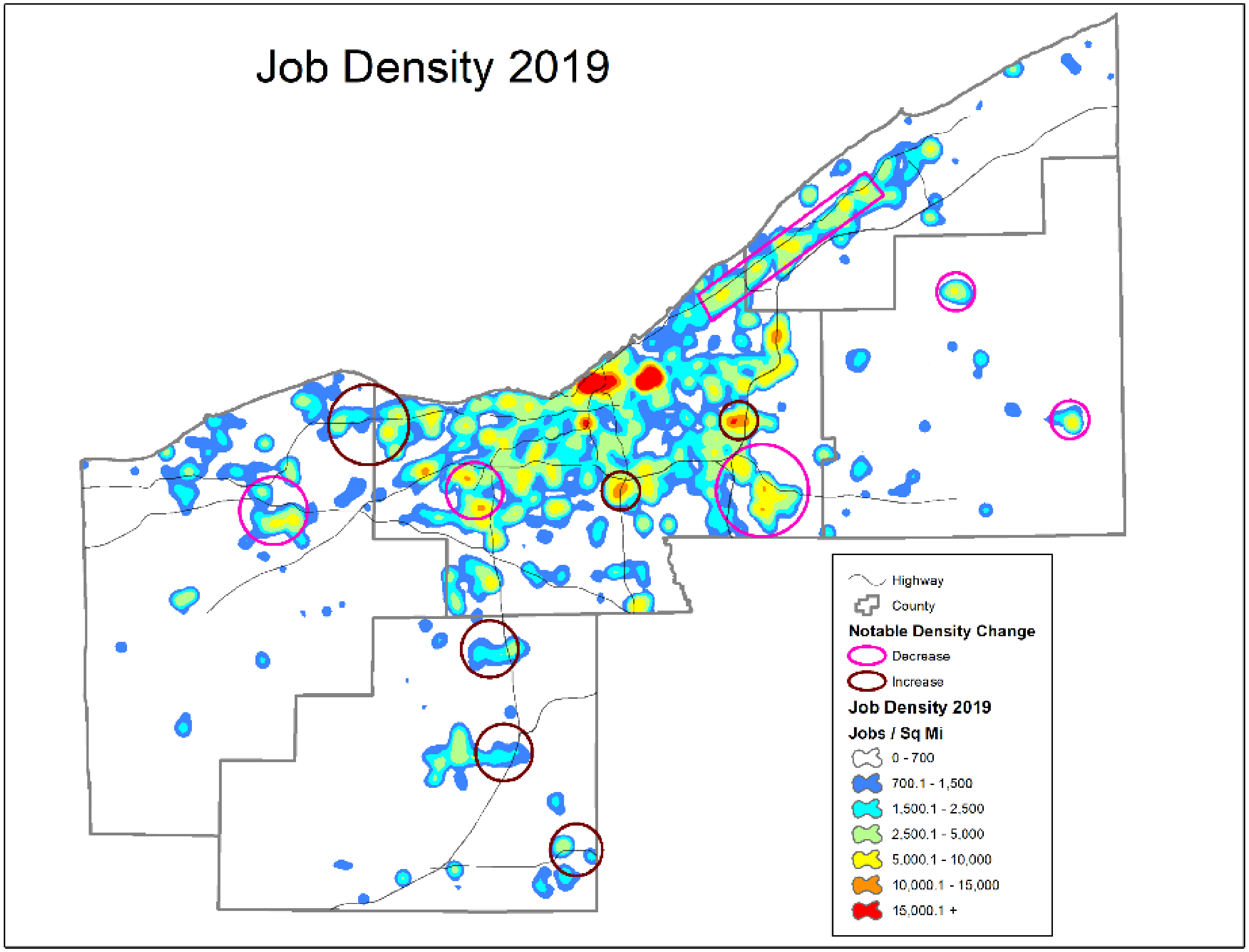


Source: Moody's Economy.com. Obtained from Team NEO in February 2020.

Employment Density (2019-2050)

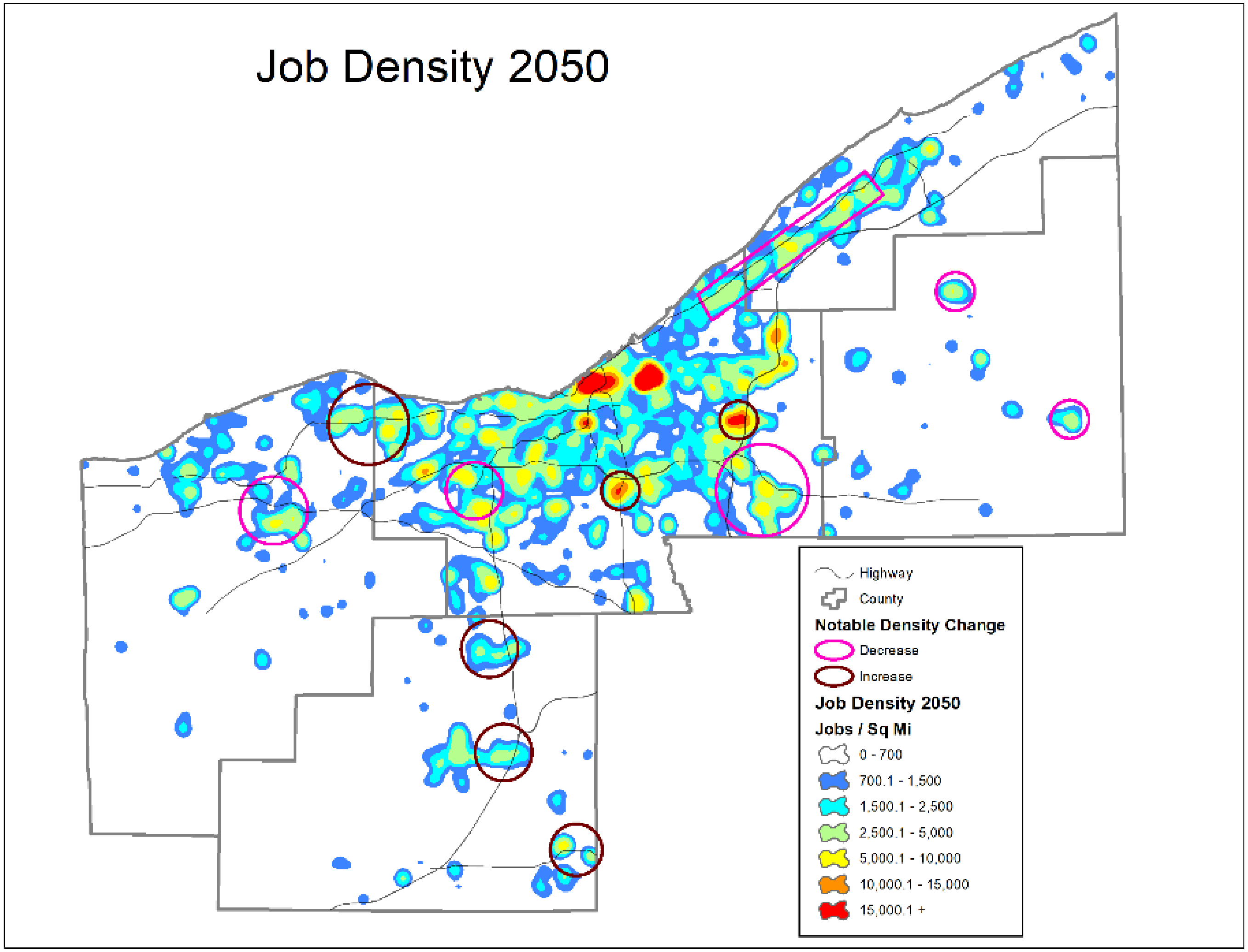
Forecasted job density trends follow a different pattern from what occurred during the period between 2010 and 2019. During those 9 years, there was a high amount of job growth throughout the region and in all sectors of the economy due to the rebound from the great recession of 2008/2009. Between 2019 and 2050, forecasts revert back to the pattern of basic jobs being replaced by service jobs, which was apparent prior to the economic recovery of the 2010s. This trend has great implications at the local level in areas that have a high concentration of basic jobs and a high concentration of service jobs. Areas with high levels of basic jobs, such as the Cleveland Hopkins airport area, Elyria, and Solon, are all forecasted to lose jobs and job density as basic jobs are lost in the future economy. Areas with high levels of service jobs, such as Avon, Medina, and Chagrin Highlands all are forecasted to see increases in their total number of jobs and density levels as the NOACA region shifts to a more service-based economy. Similar to past trends, downtown Cleveland and University Circle maintain the highest levels of job density in the region and will remain the largest employment centers in the region for the foreseeable future.

Figure 9-11. Regional Job Density (2019)



Source: NOACA-forecasted data based on the Quarterly Census of Employment and Wages (QCEW) 2010 and county forecasts by Moody's Economy.com. QCEW data obtained from the Ohio Department of Transportation (ODOT) in 2012 and Moody's Economy.com data obtained from Team NEO in February 2020.

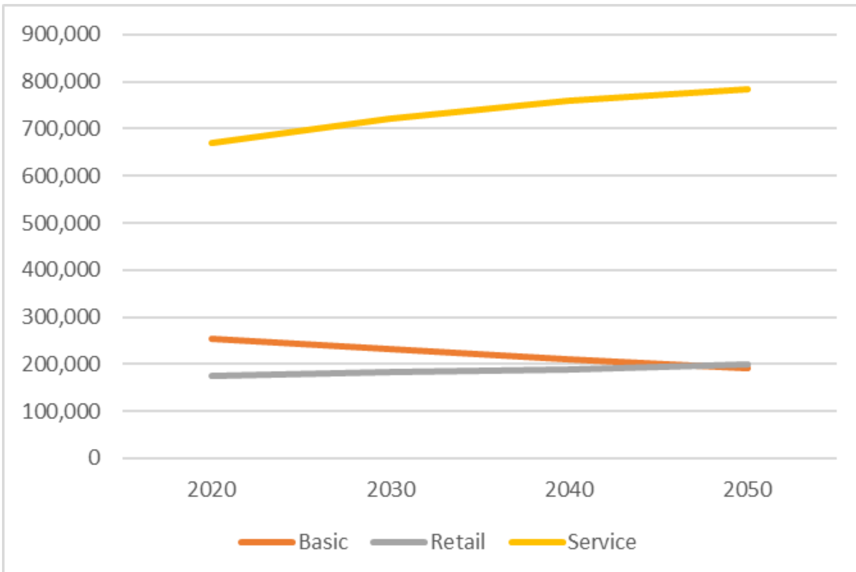
Figure 9-12. Regional Job Density (2050)



Source: NOACA-forecasted data based on the Quarterly Census of Employment and Wages (QCEW) 2010 and county forecasts by Moody's Economy.com. QCEW data obtained from the Ohio Department of Transportation (ODOT) in 2012 and Moody's Economy.com data obtained from Team NEO in February 2020

The shift from basic to service jobs in the NOACA region is a pattern that is forecasted to continue out to 2050. Over the next thirty years, basic job losses are forecasted to be about 63,000 at a decline rate of 25%. Over the same period service jobs are forecasted to grow at 17% which equates to over 113,000 jobs. Unlike the past trend of slight growth in the retail sector, retail jobs are forecasted to grow at a moderate amount, 13% over the next 30 years, which is a growth of over 23,000 jobs.

Figure 9-13. Regional Employment Sector Forecasts (2020-2050)



Source: Moody's Economy.com. Obtained from Team NEO in February 2020

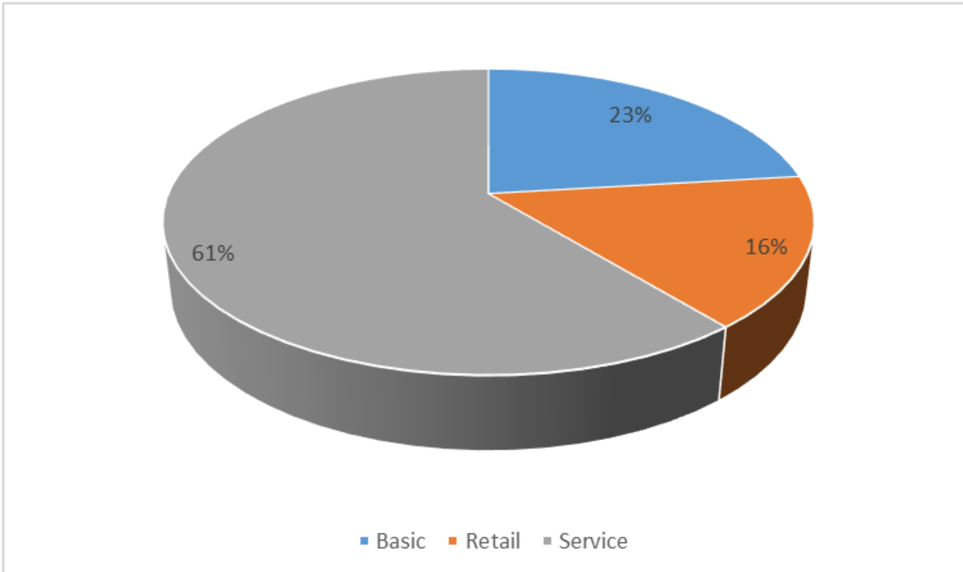
Table 9-3. Regional Employment Forecasts by Sector (2020-2050)

Job Type	2020	2030	2040	2050	Change 2020-2030	Change 2030-2040	Change 2040-2050	Change 2020-2050	% Change 2020-2030	% Change 2030-2040	% Change 2040-2050	% Change 2020-2050
Basic	253,838	232,984	211,365	190,640	-20,854	-21,619	-20,725	-63,198	**-8.2%**	**-9.3%**	**-9.8%**	**-24.9%**
Retail	175,335	183,618	187,760	198,613	8,283	4,142	10,853	23,278	**4.7%**	**2.3%**	**5.8%**	**13.3%**
Service	669,186	722,570	759,793	782,663	53,384	37,223	22,870	113,477	**8.0%**	**5.2%**	**3.0%**	**17.0%**

Source: Moody's Economy.com. Obtained from Team NEO in February 2020

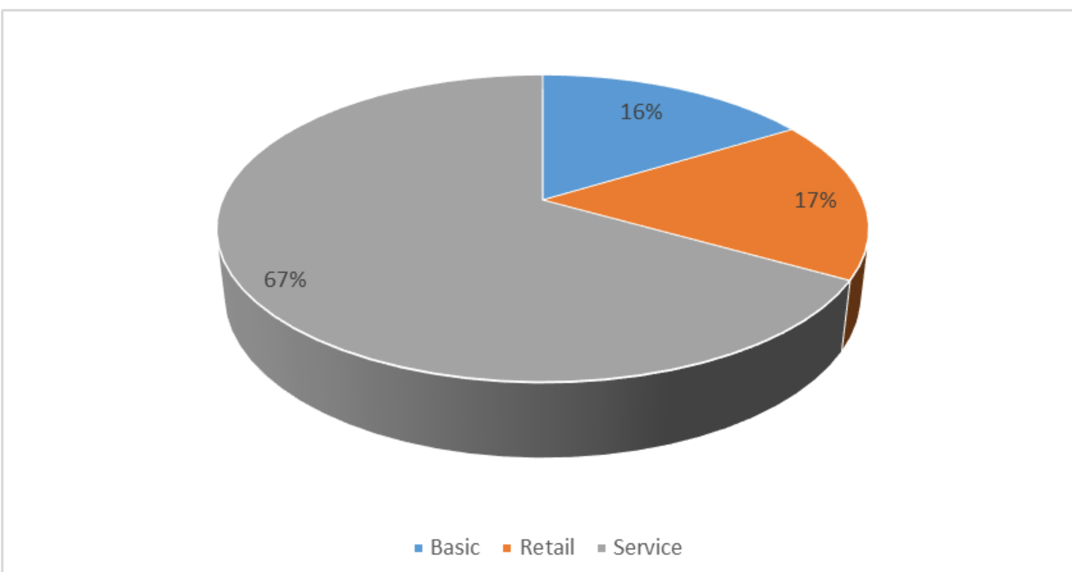
These forecasts of moderate growth of retail jobs and a drastic decline of basic jobs means that by 2050, retail is forecasted to be a larger sector of the regional economy in terms of jobs than the basic sector. In 2050, retail jobs will account for 17% of total jobs, and basic jobs will account for 16%. For basic jobs, this is a drop in industry share from a previous 24% of all jobs in 2019. Similar to the historic trends, the service sector picks up most of the industry share that is lost by the basic sector, increasing from a share of 60% of all jobs in 2019 to 67% of all jobs in 2050. The retail sector stays relatively constant in its share of total regional jobs, only slightly increasing from 16% of all jobs in 2019 to 17% in 2050.

Figure 9-14. Employment Sector Share of Total Regional Jobs 2020



Source: Moody's Economy.com. Obtained from Team NEO in February 2020

Figure 9-15. Employment Sector Share of Total Regional Jobs 2050



Source: Moody's Economy.com. Obtained from Team NEO in February 2020

Transportation Demand and Supply

As discussed in the previous section, there is miniscule or no population growth in the NOACA region. However, continuing with the current transportation planning policies, various metrics indicate that job sprawl will gradually occur and more workers will commute from suburbs to major regional job hubs by single occupancy vehicles. These socioeconomic forecasts, travel behavior envisage and technological advances in transportation provide a platform for proposing different and more equitable plans focusing on moving people and goods rather than automobiles and trucks.

The automobile industry is replacing “Horse Power” with “Processing Power” and there is a little doubt that the Plug-in Hybrid Electric Vehicles (PHEV), Connected and Autonomous Vehicles (CAV), autonomous shuttles and other technology driven advancements are going to fill our highway network sooner than expected. This technology will not replace the existing modes of travel overnight. However, the PHEVs and CAVs will slowly replace the existing conventional cars and eventually all will be traveling in these futuristic vehicles. Traffic signals could be a thing of the past for cars as they will be in constant communication with each other to ensure they smoothly and safety weave through traffic condition. This could free up more space for pedestrian areas and bicycle lanes. This may take one or two decades but it will certainly happen by the planning year of 2050 with new social norms and travel patterns being established. Any future transportation plan should consider these technology advancements in different levels.

Travel Demand Forecasting

Forecasts of future travel are based on the data from;

- Existing travel patterns,
- Population and employment growth,
- Future land use and economic conditions,
- Understanding of how people make travel choices, and
- Future available travel modes

The most critical part of the travel demand forecasts is the travel modes availability. Trips between a given origin and destination are split into trips using automobiles, individually or shared, transit, bikes or just walk. All these indicate that travel forecasting requires large amounts of data for the substantially large uncertainty and predictions will be done under many assumptions.

Integrating the existing trip rates as travel patterns of the calibrated and validated NOACA travel forecasting model and the estimated future population and employment predicts the following travel characteristics for the planning year of 2050 in the NOACA region:

- Number of households: Almost 840 thousand households
- Daily Person Trips Generated: more than 6.66 million trips
- Average Daily Person Trips per household: Over 7.9 trips

Assumptions regarding future trip rates, household sizes and residential locations, employment centers and their job opportunities, shopping and recreational habits, available travel modes, and traffic congestion and travel times add to the complexity of travel demand models and reduce the accuracy.

Practically, there are many uncertainties in these types of predictions and there is less reliable information, for instance, to say that the current calibrated trip rates will occur three decades from now. One way to mitigate this unreliability is to perform scenario planning. That means adopting several plausible future scenarios and predicting their potential demand. The next sections will discuss the scenario planning approach and the envisaged scenarios.

Supply Side Forecasting

On the supply side, uncertainties and unknowns can also be large, especially the availability of new technologies, their capabilities, costs evolution and respective benefit. Discussing what are not known about the new technologies are as important as what is known. For instance, the safety, reliability, price and commercial availability of CAVs are key parameters when predicting the prevalence of autonomous vehicles. Assuming normative values for the unknown parameters assists dealing with uncertainty effectively and communicating the prediction results.

These uncertainties coincide with possible gradual job displacements, and considering the development of more equitable transportation system makes the planning tasks complicated. This chapter attempts to lay the groundwork for overcoming these complexities and some of the uncertainties.

The current travel modes, in the NOACA region, are automobile, driving alone or sharing ride, public transportation and non-motorized modes including walking and biking. The 2020 scenario of the calibrated and validated NOACA travel forecasting model indicates the following modal split for the current daily person trips:

- Automobile is the dominant mode choice with over 98% share.
- Share of the driving alone is about 60%.
- Transit share is about 1.5 percent.
- Non-motorized mode share is less 0.5 percent.

These mode choice shares illustrate that this region currently is highly automobile dependent and the public transportation provides only a small percentage of the total passenger miles traveled. Therefore, owning an automobile is currently necessary for commuting to work and other trip purposes such as shopping, medical, recreational, etc. in the NOACA region. This limits the activities of households without access to a car which can make the job search experience more stressful.

At this juncture, many citizens, planners, and policy makers are slowly coming to appreciate that each transportation mode has a role to play in meeting travel needs. The need of alternative choices will increase as the roadway network becomes more congested. It is also a fact that more investment in transit increases the ridership leading to a more equitable transportation system.

A discussion of the future regional transportation system cannot move forward without an acknowledgement of the role that technology will play in the way we move around the region, and the resulting infrastructure changes necessary to support it. The next sections review future transportation modes and transportation networks at a high or “30,000 foot” level with the objective of developing scenarios across future modes and projects.

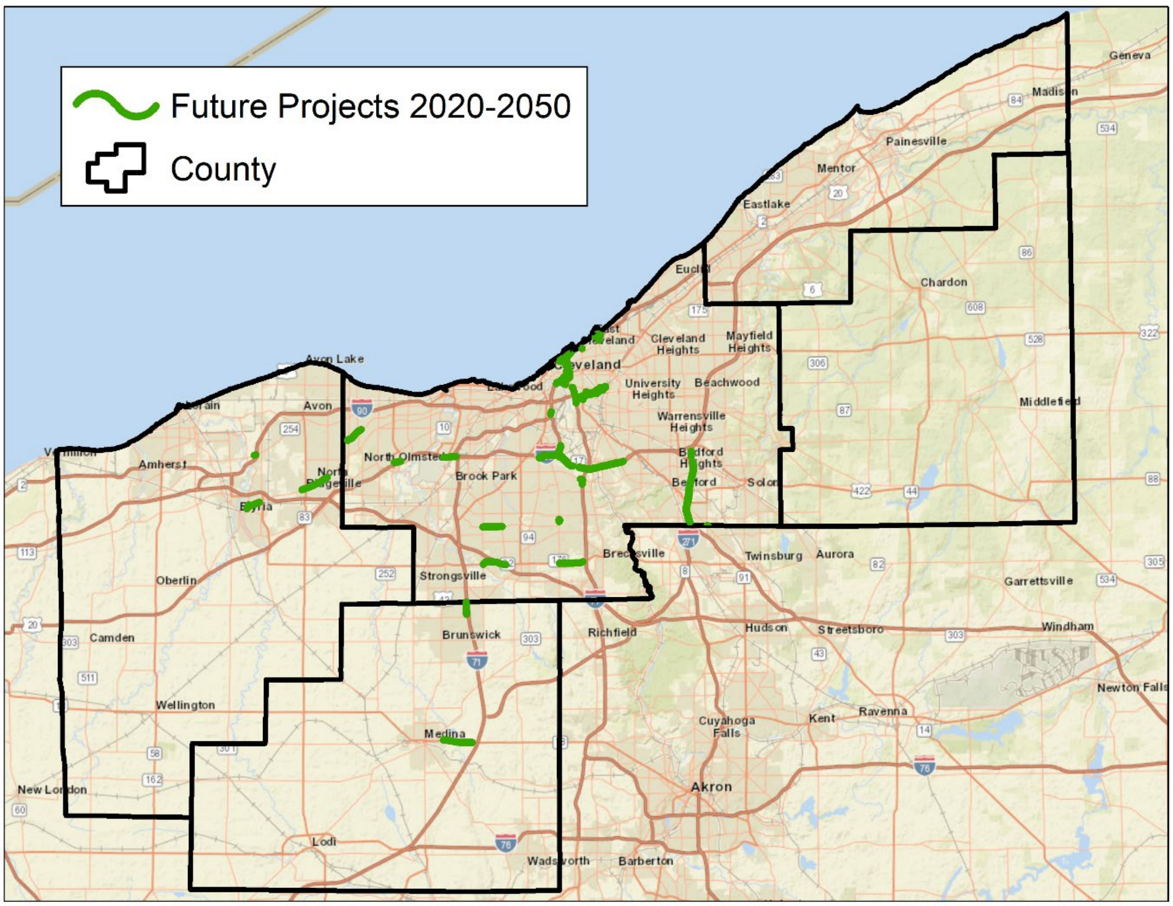
A set of proposed future projects are categorized in terms of infrastructure, service and mode of travel:

- Highway,
- Transit, and
- Facilities for non-motorized modes of travel.

Proposed Highway Capacity Projects

The highway group includes adding capacity to the current highway network. Figure 9.16 shows the locations of proposed highway capacity major projects for the period of 2020 to 2050.

Figure 9-16. Location of Planned Highway Capacity Projects (2020-2050)



Proposed New or Modified Highway Interchanges

A set of partial or full interchanges have been suggested by local governments and ODOT. Figures 9.17 through 9.19 show the locations of these interchanges. The highways will be assessed based on NOACAs interchange policy and scenarios to determine the justification and available funds for new interchanges. The assessment includes a cost benefit for transportation needs as well as regional impacts.

Figure 9-17. Locations of Proposed Interchanges

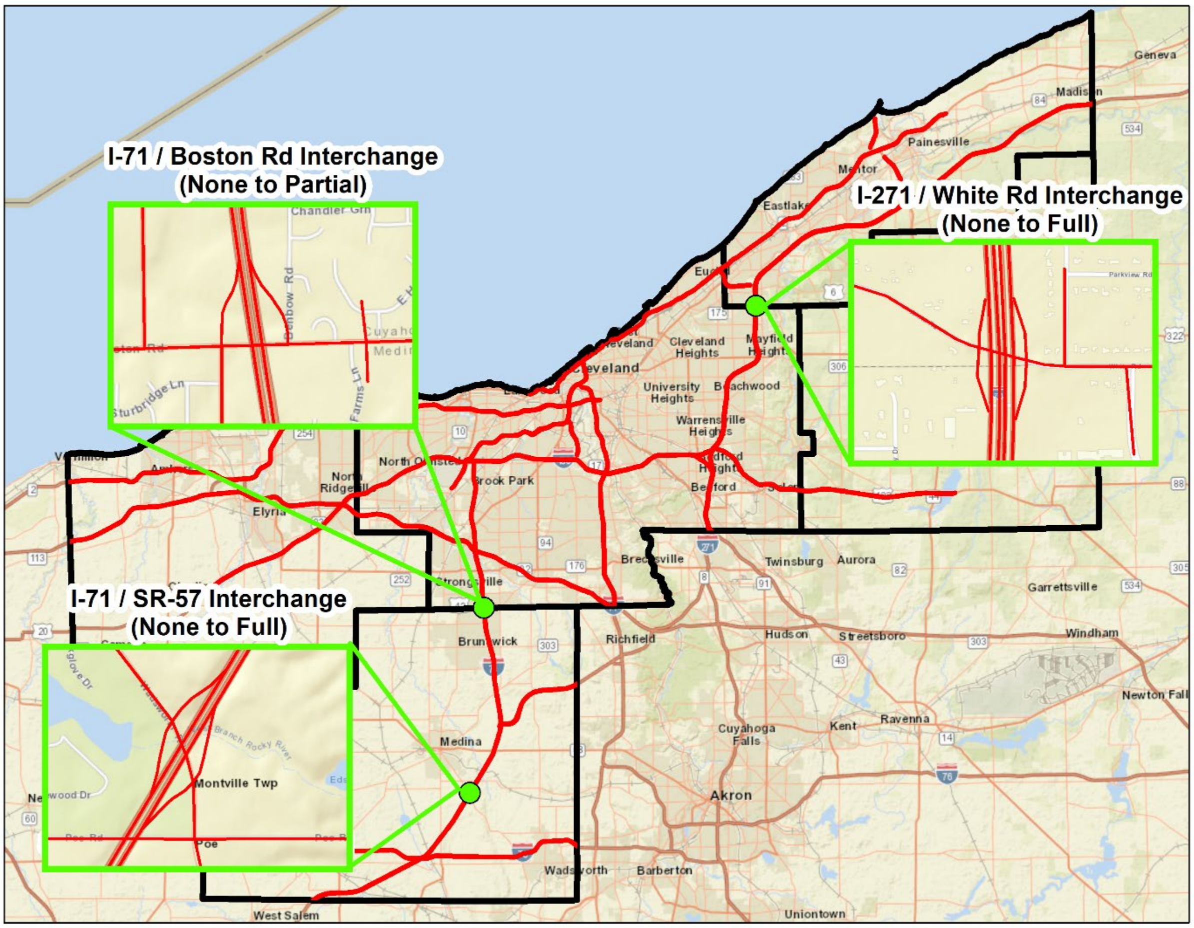


Figure 9-18. Locations of Proposed Interchanges

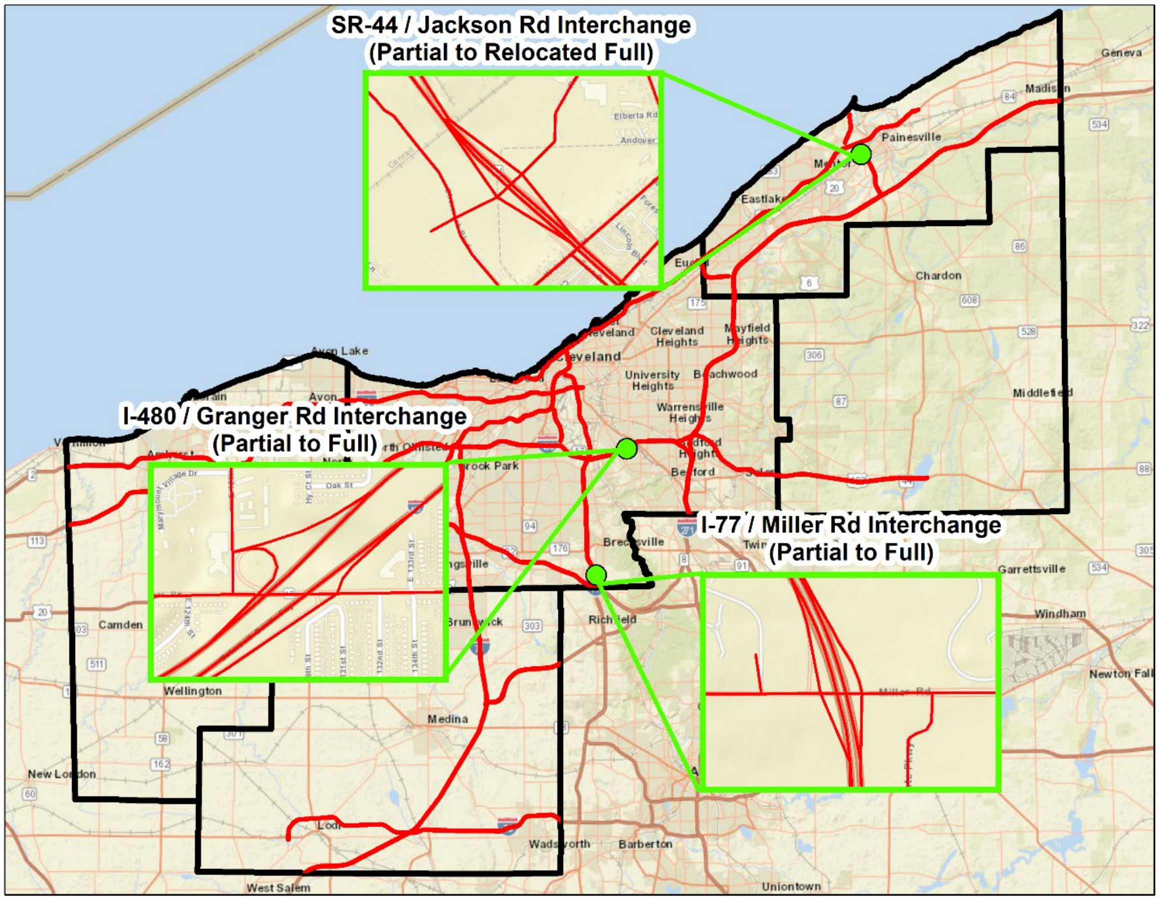
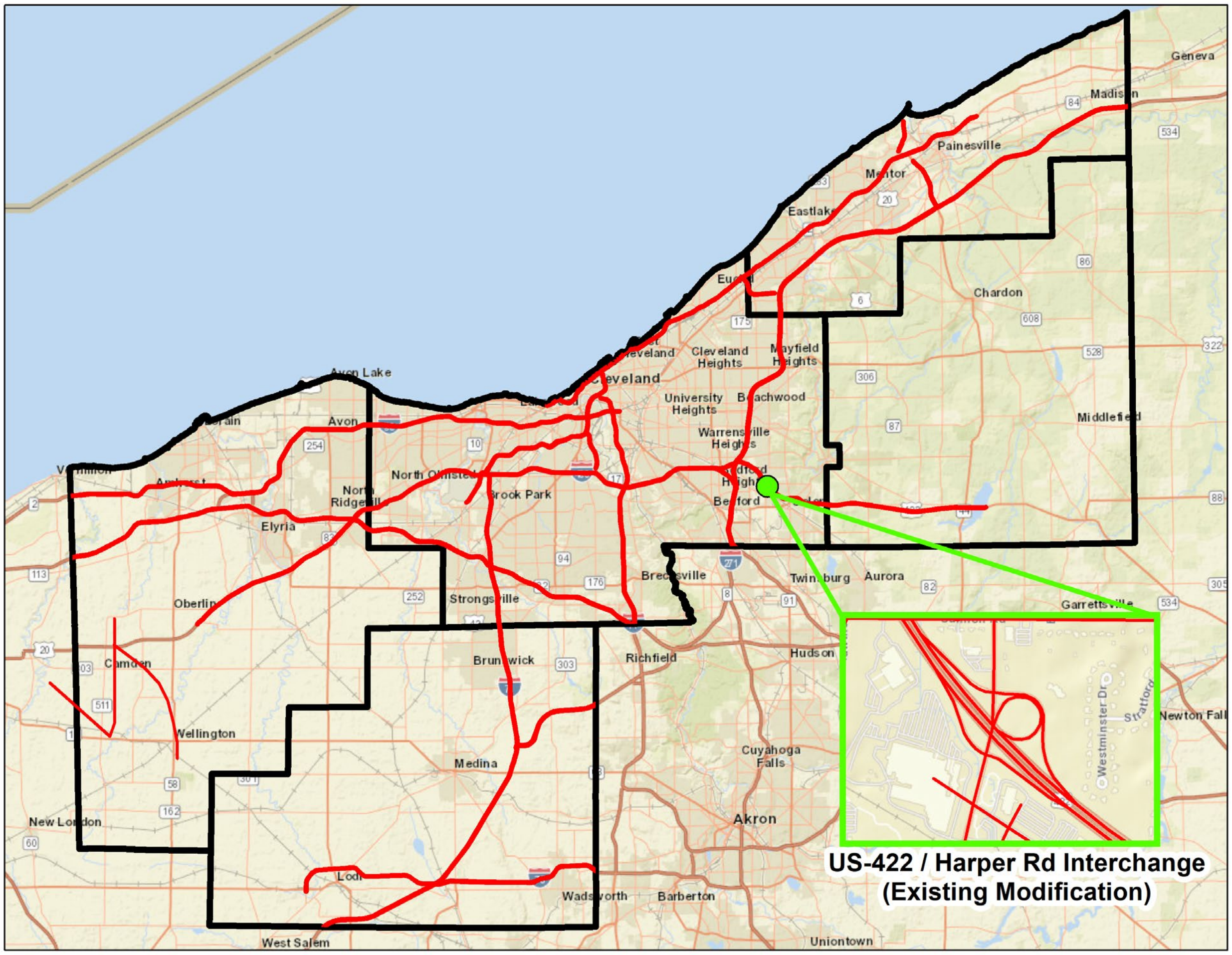


Figure 9-19. Locations of Proposed Interchanges

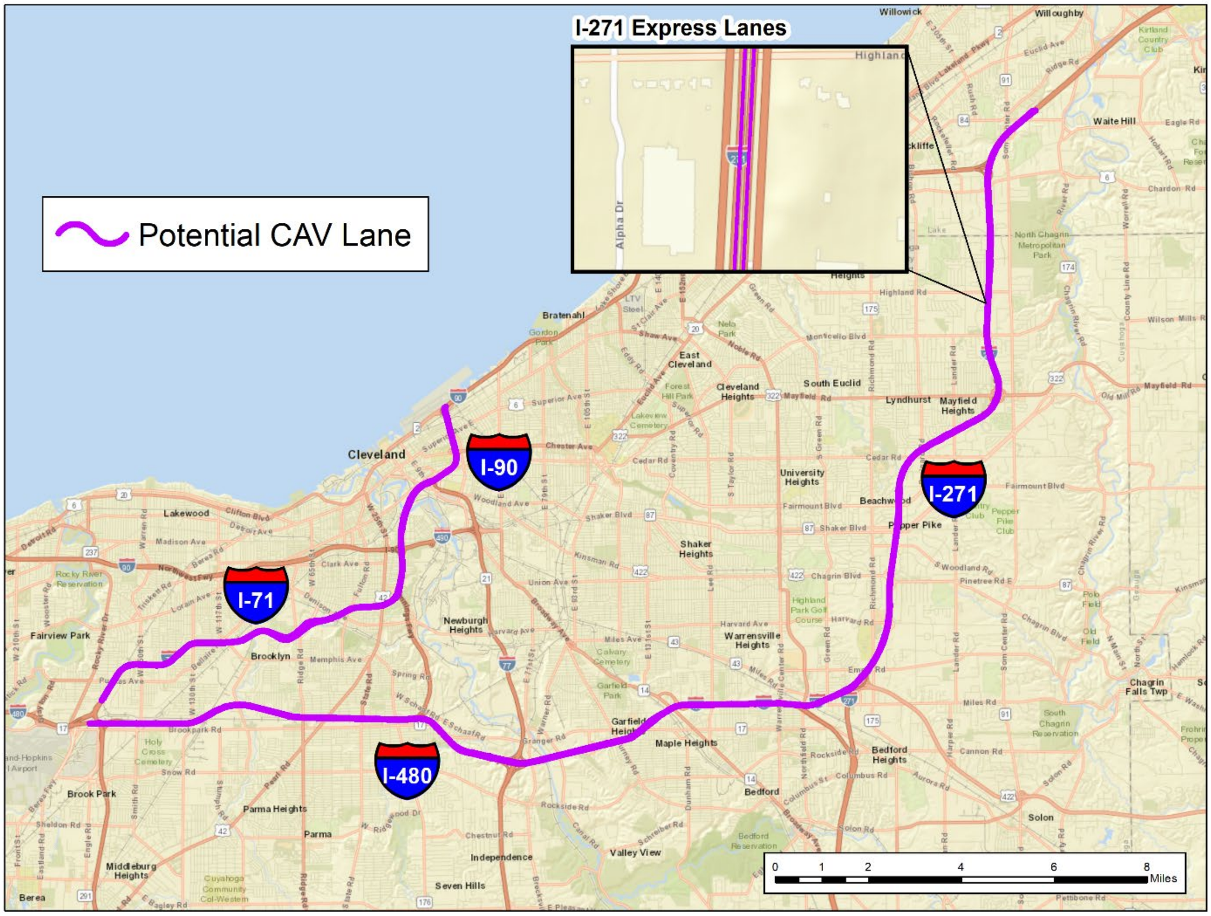


Proposed High Occupancy Vehicle (HOV) and Connected and Autonomous Vehicle (CAV) Lanes

High Occupancy Vehicle (HOV) lanes and High Occupancy Toll (HOT) lanes are normally created to increase average vehicle occupancy with the goal of reducing traffic congestion and air pollution. The technology associated with Connected and Autonomous Vehicles (CAV) is slowly being introduced to the consumer market in the form of autopilot vehicles. With such advancement, the infrastructure they will operate on also needs to be equally advanced. Just as CAVs are operating with artificial intelligence; the highways should as well. CAVs will communicate with other vehicles and roadway infrastructure. They will use real time traffic data to anticipate congestion, make better routes, and sync their speed. In addition to improving traffic management, establishing systems of communications between vehicles and the roads will also be necessary what is known as V2I (Vehicle to Infrastructure). CAVs are going to be equipped with multiple sensors which will be their eyes when it comes to travelling on a highway. An equipped highway can sharpen these sensors.

Figure 9-20 illustrates selected interstates where HOV or CAV lanes could be utilized. The exploded view depicts how the HOV or CAV could be implemented by designating two directional lanes on the existing interstates. Their applicability and effectiveness in future scenarios will be discussed in following sections.

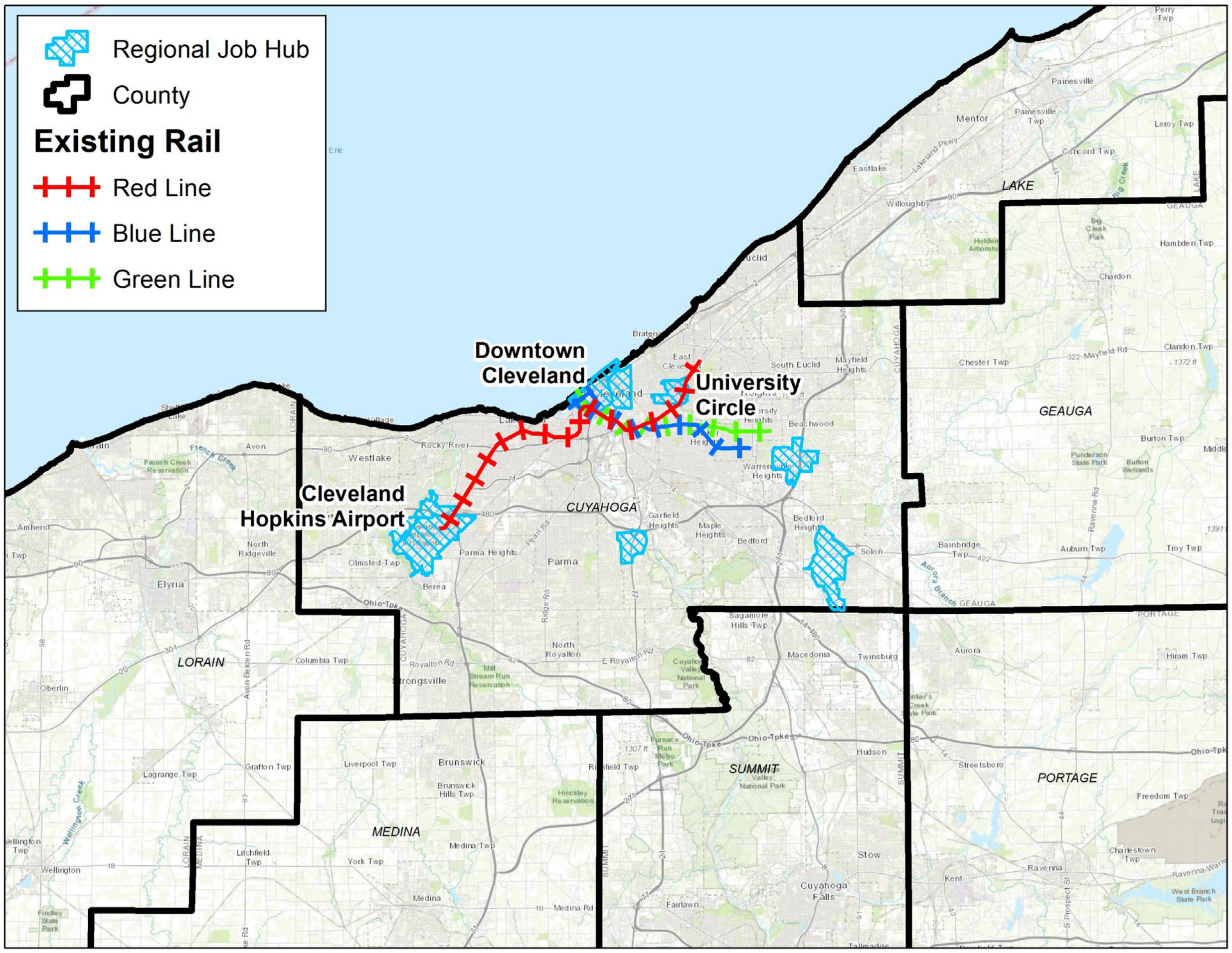
Figure 9-20. HOV or CAV Lanes of the Future Scenarios



Proposed Rail Line Extensions

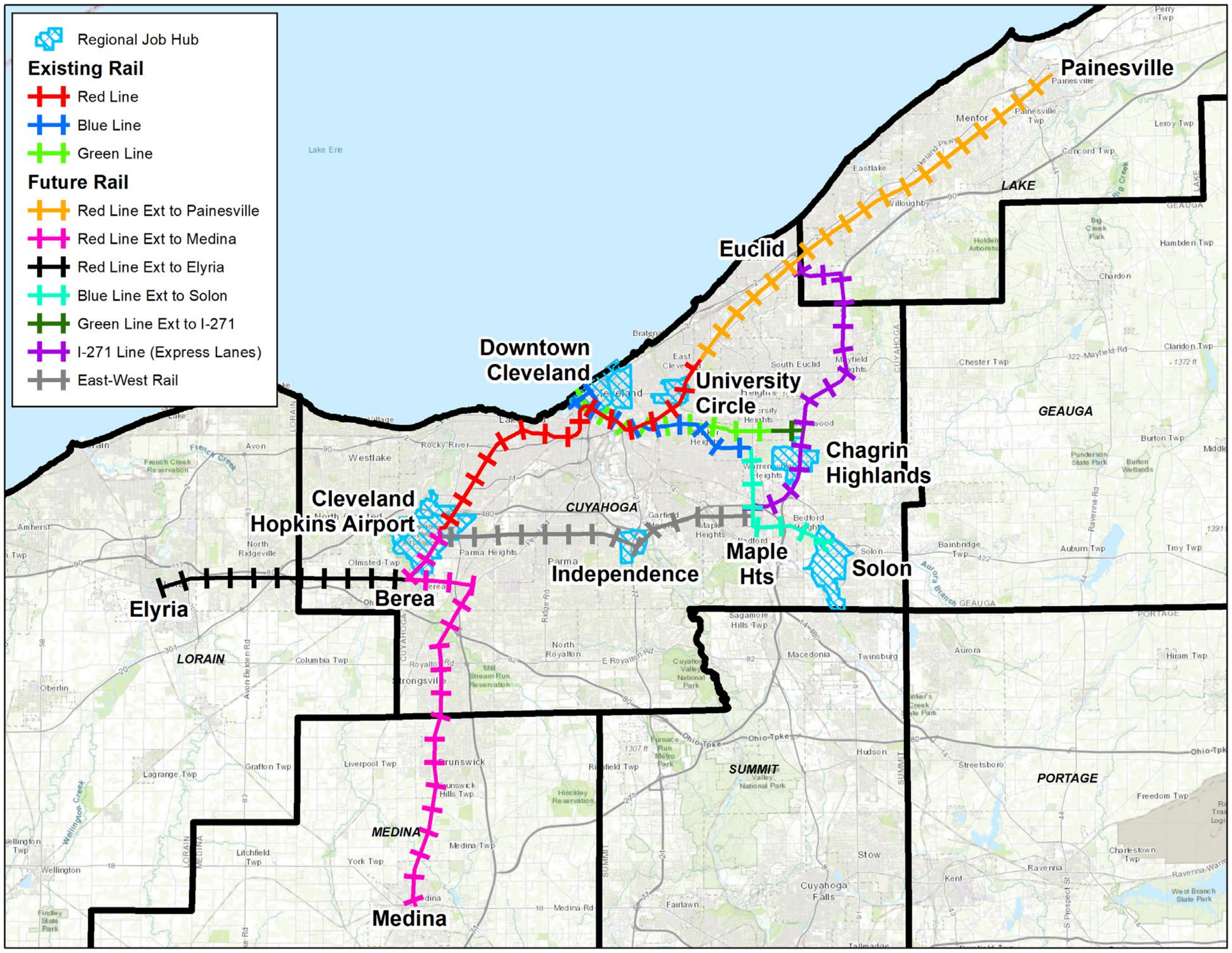
As previously discussed, the current transit network consists of various modes of transit, most notably local bus, premium/park-and-ride bus, bus rapid transit (BRT), and rail. Figure 9-21 shows the existing regional rail lines in the NOACA region.

Figure 9-21. Existing Regional Rail Network (2020)



The existing regional rail network only connects 3 of the 6 major regional job hubs. The existing rail network was completed in the late 1960s and the expansion of jobs into the suburbs since then has left a rail network that does not adequately connect residents to many of the major job centers of the region. Also of note is that the regional rail network only currently serves Cuyahoga County. Growth of population into the outer counties since the 1960s has also resulted in a rail network that does not connect to new population centers of the region. Figure 9-22 displays the improved 2017 visionary rail network as the proposed expanded rail network. Two future scenarios include this extended rail network which will be discussed in the next sections.

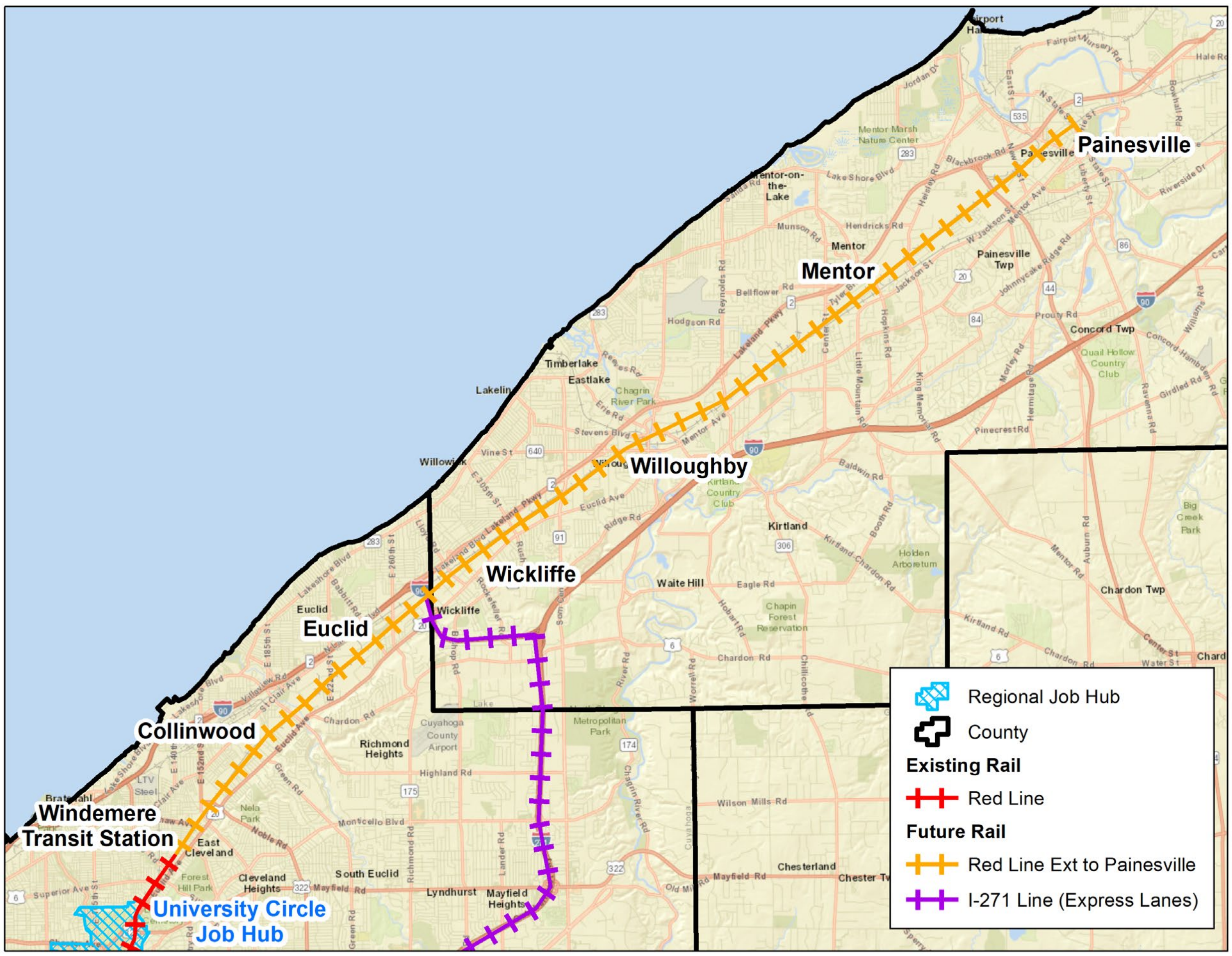
Figure 9-22. Expanded Regional Rail Network (2050)



An expanded rail network, as seen in Figure 9-22, would greatly increase transit ridership in the region and connect thousands more residents to a rail network that serves all six major regional job hubs, multiple minor and legacy job hubs and the growing suburban population centers of the NOACA region. This is especially important for residents of EJ areas because an expanded regional rail network would greatly increase the number of jobs accessible within a reasonable commute time. Currently, the rail network is confined to the urban core of Cuyahoga County and does not extend the connection to many of major regional job hubs or other growing job centers in the suburbs of Cuyahoga County or the four other counties of the region. Each specific extension to the rail network will be discussed in more detail in the next few sections.

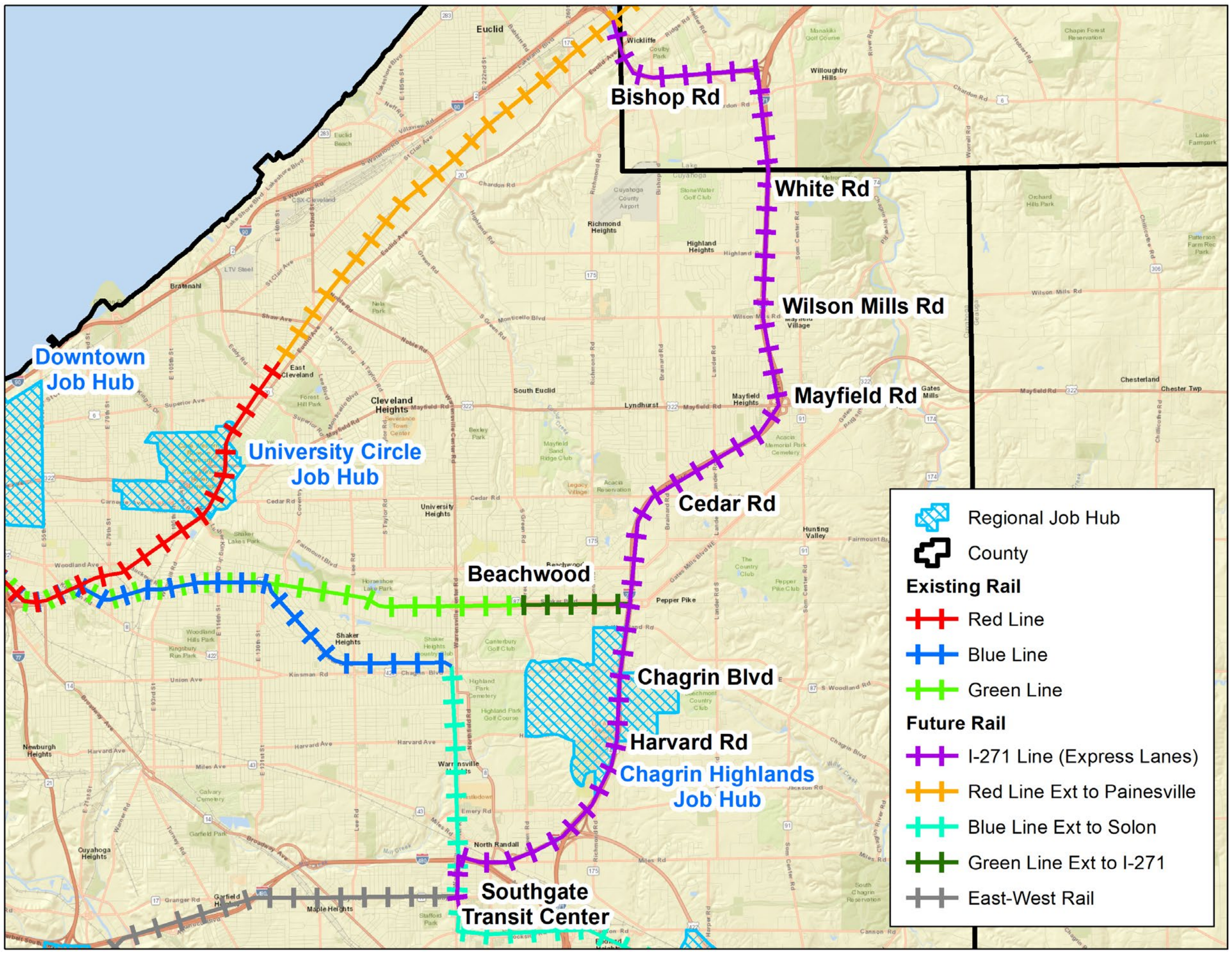
A northern extension to the existing red line would connect the Windermere Transit Station in East Cleveland to many job locations to the northeast, such as Painesville, Mentor, Willoughby, Wickliffe, Euclid, and the Collinwood neighborhood of Cleveland. Conversely, the residents of Lake County and northeastern Cuyahoga County, would have increased access to the University Circle regional job hub and additional points in west, such as the downtown Cleveland regional job hub. Also, in Euclid near the Lake County border, there would be a transfer location to the I-271 line that travels through many large employment centers, including the Chagrin Highlands regional job hub. Figure 9-23 displays the extension route of the existing red line to the City of Painesville in the northeast of the NOACA region.

Figure 9-23. Red Line Extension to Painesville (2050)



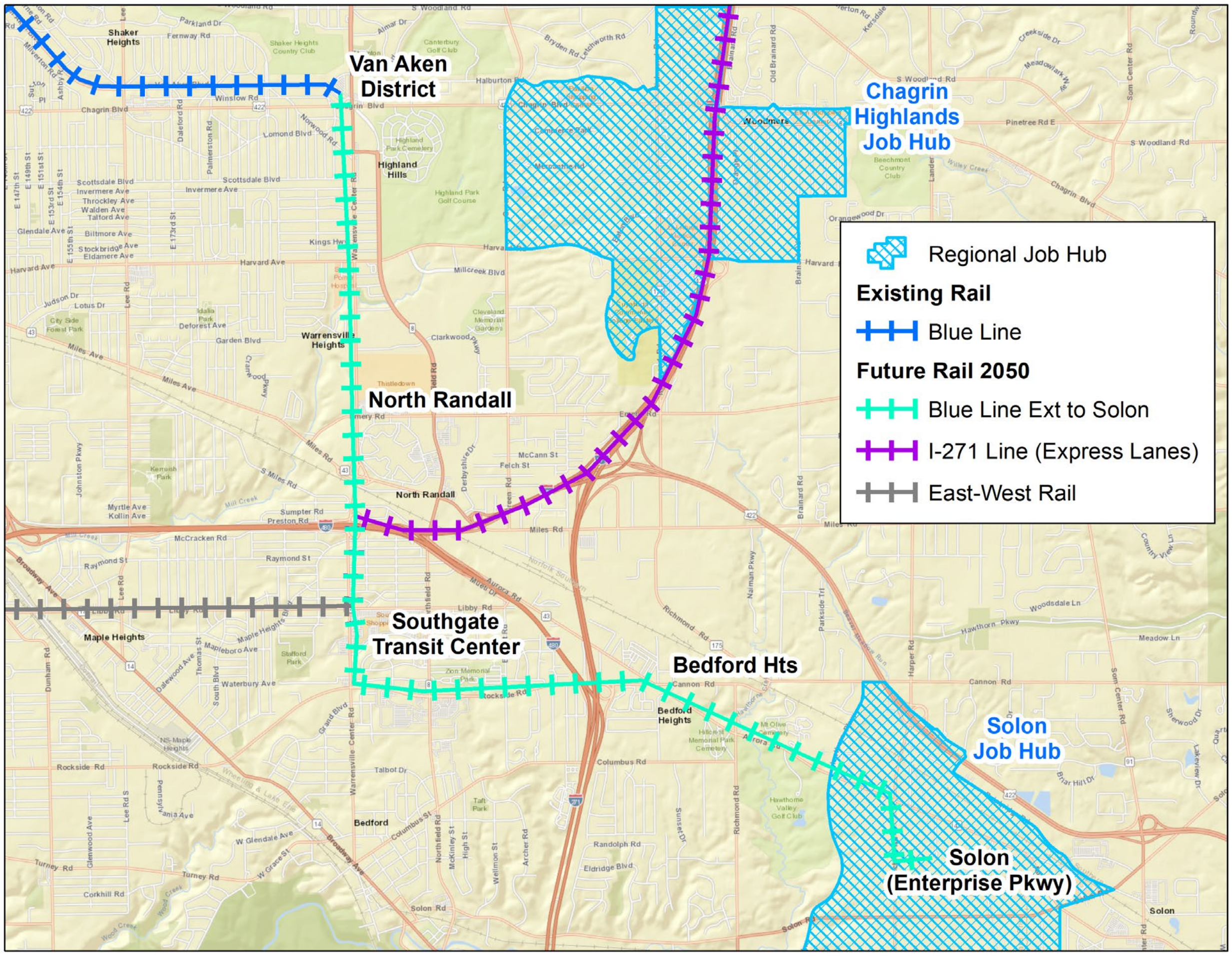
The I-271 rail line would connect Euclid to the Southgate Transit Center in Maple Heights, traveling through a dense corridor of suburban job locations, including the Chagrin Highlands regional job hub. This line could be built using the existing I-271 express lanes, either by replacing those lanes entirely or built using an elevated track. Most of the major stations would be close to I-271 interchanges and would create opportunities for park-and-ride stations at many of the retail or office parking lots that surround these interchanges. As part of this expansion would also be the extension of the existing Green line, which currently ends at Green Rd in Shaker Heights. The Green line could be extended through Beachwood to make a connection with the I-271 line near Shaker Blvd. Other transfer points would be in Euclid with the Red line extension to Painesville and at the Southgate Transit Center, which would provide transfers to the Blue line extension to Solon and the East-West line to Cleveland Hopkins Airport. Figure 9-24 dispicts the I-271 line from Euclid to Southgate Transit center.

Figure 9-24. I-271 Rail Line from Euclid to Southgate Transit Center (2050)



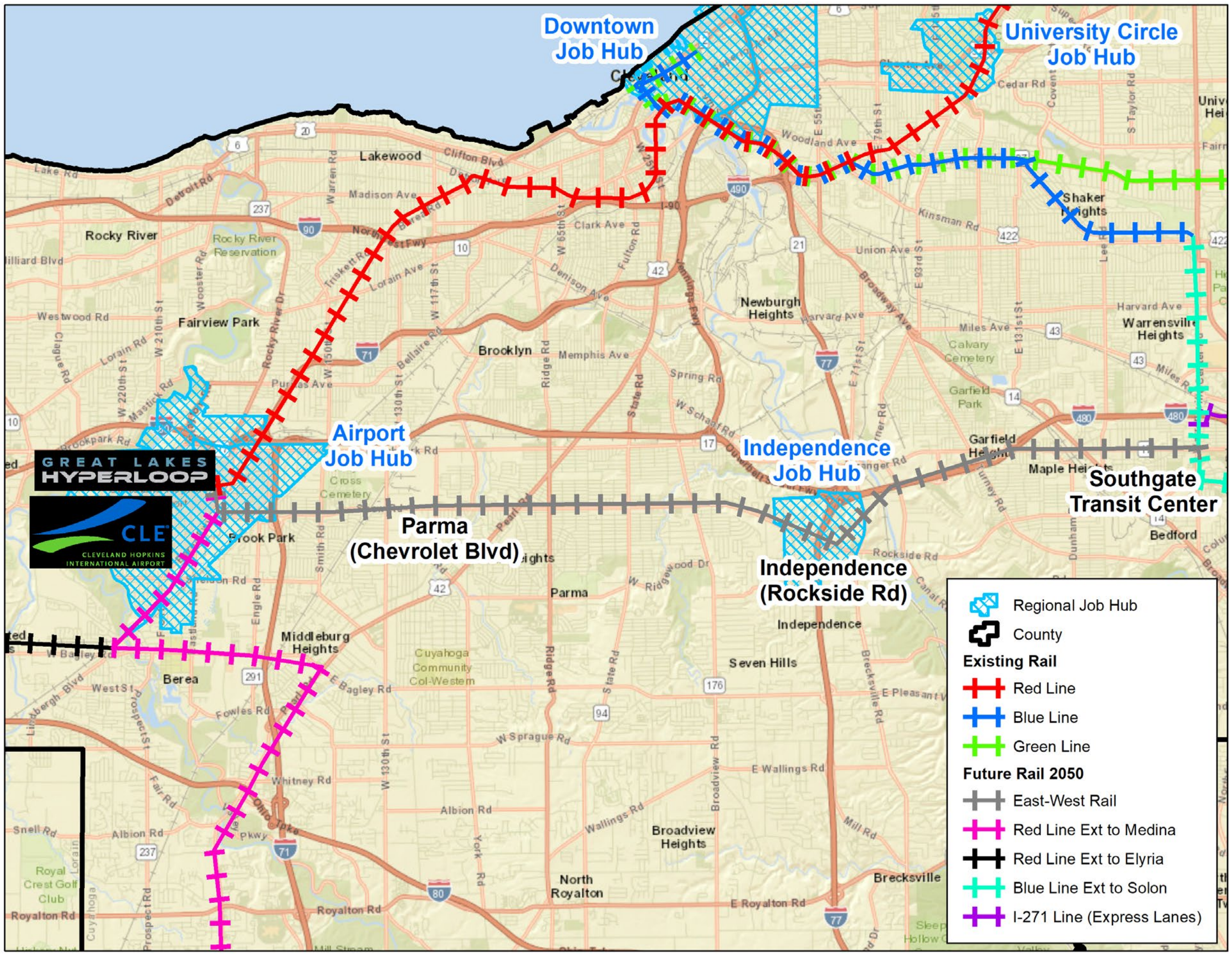
A southeastern extension of the Blue line would connect the Van Aken District in Shaker Heights, (where the Blue line currently terminates) to the Southgate Transit Center in Maple Heights and ultimately the Solon regional job hub. Other suburban locations included in this extension would be North Randall, Warrensville Hts and Bedford Hts. Much of this line directly serves EJ areas, and would provide a faster connection to the Solon job hub, which currently is only served by a small number of local buses. Transfers at the Van Aken District would take riders to Shaker Square and downtown Cleveland, while transfers at the Southgate Transit Center would allow riders to continue west on the East-West rail line to Independence and Cleveland Hopkins Airport or north on the I-271 line to the Chagrin Highlandsregional job hub. Figure 9-25 shows the Blue line extension from the Van Aken District to Solon.

Figure 9-25. Blue Line Extension from Van Aken District to Solon (2050)



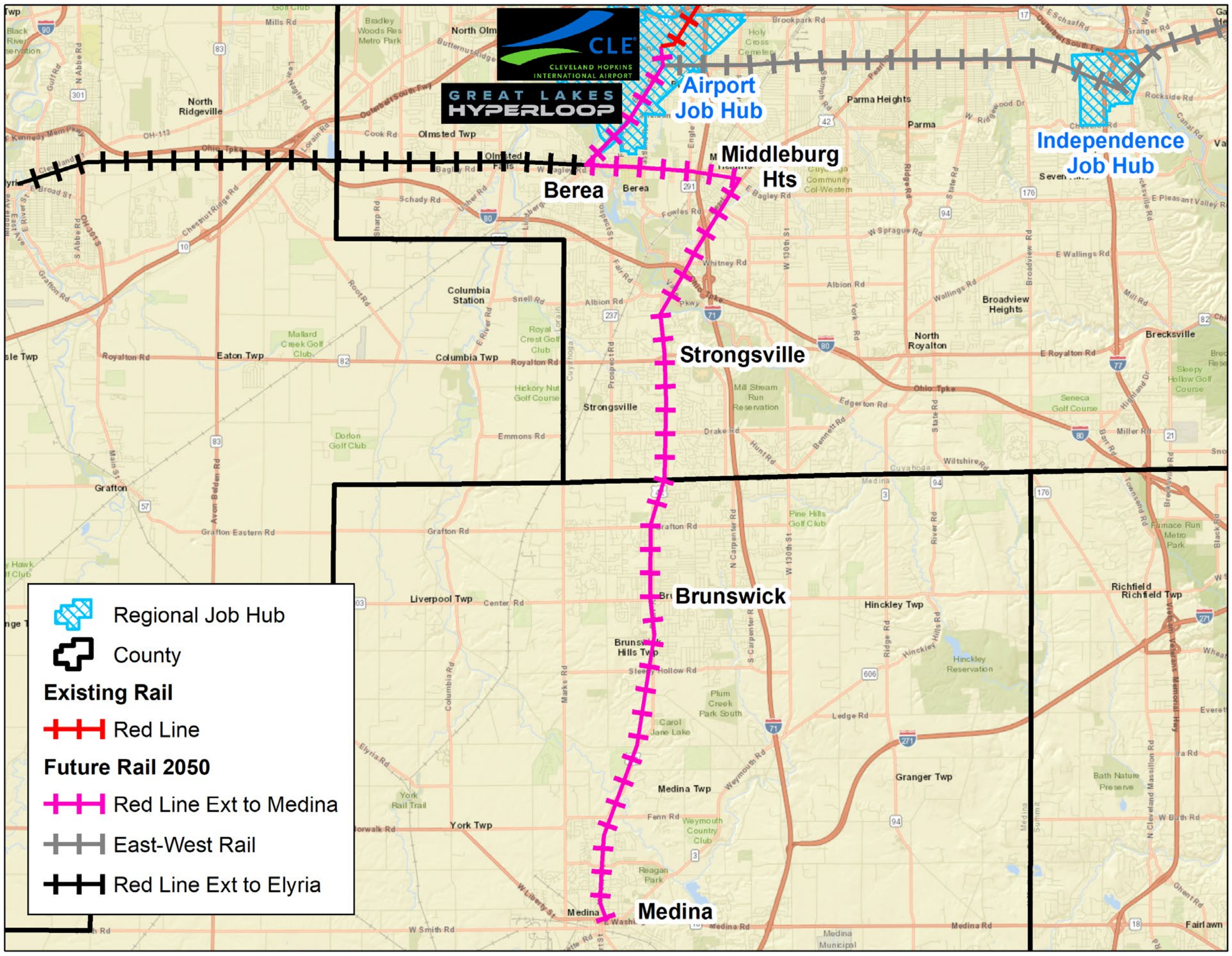
The East-West line would function as an express route with only four stops along its route. On either ends of the route would be the Southgate Transit Center and Airport regional job hub, and in between would be stations at the Independence regional job hub and in Parma. In the expanded rail network, both the Southgate Transit Center and Cleveland Hopkins Airport function as major transfer points to other lines. From Southgate, riders can transfer to the Blue line extension and the I-271 line to points north and east. From the airport, riders can transfer to the existing red line north to downtown Cleveland or head south towards Strongsville and Medina. The Airport regional job hub is also a possible location for the Great Lakes Hyperloop station, and the East-West line would serves as a feeder line for residents traveling from the east. Figure 9-26 displays the East-West rail line from the southgate transit center to ClevelandHopkins airport.

Figure 9-26. East-West Line from the Southgate Transit Center to Cleveland Hopkins Airport (2050)



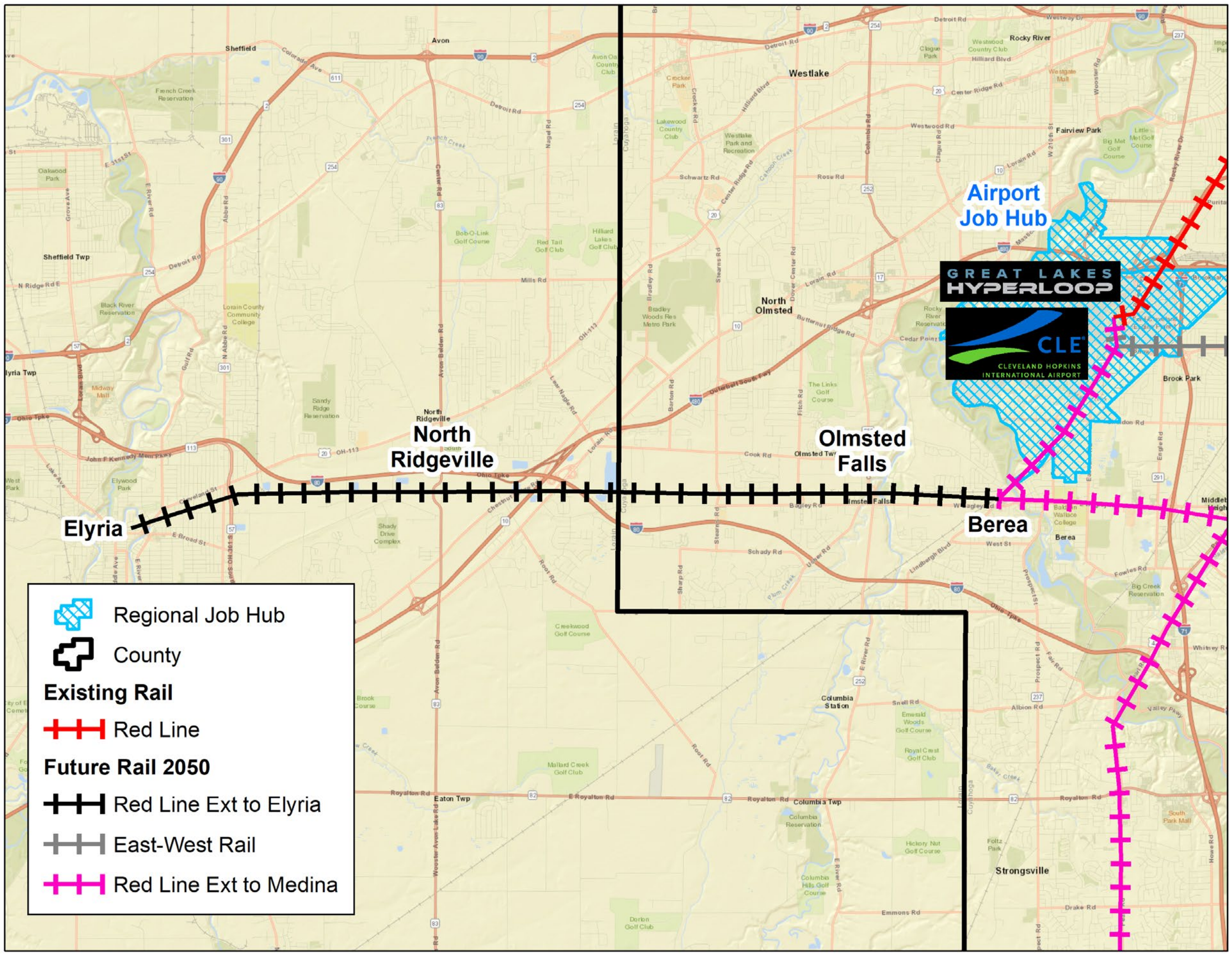
The southern extension of the Red line would begin at Cleveland Hopkins Airport, within the Airport regional job hub, and travel south, making stops in Berea, Middleburg Hts, Strongsville, Brunswick and terminating in Medina. This line traverses through many areas of the region that have experienced high amounts of population growth and forecasted to continue to grow, such as Medina County and southeastern Cuyahoga County. This growth could lead to high ridership along this route. Similar to the East-West line, the Red line extension to the south would provide a direct connection to a possible Great Lake Hyperloop station located within the Airport regional job hub. Other transfer points would include Berea, where a connection could be made to the Red line extension to Elyria, and Cleveland Hopkins Airport, where connections could be made to the Red line heading north towards downtown Cleveland or to the East-West line heading east towards the Southgate Transit Center. Figure 9-27 illustrates the Red line extension from Cleveland Hopkins Airport to Medina County.

Figure 9-27. Red Line Extension from Cleveland Hopkins Airport to Medina (2050)



The western extension of the Red line would branch off the southern Red line extension in Berea and travel west to Elyria. Similar to the southern Red line extension to Medina, this route also travels though communties that have experienced high population growth in the recent past and are forecasted to continue to grow, such as Olmsted Falls, Olmsted Township and North Ridgeville. This could result in a high level of ridership for this extension in 2050. At a transfer point in Berea, riders could head south on the Red line extension to Medina, or head north to the Airport regional job hub and the Great Lakes Hyperloop station. Figure 9-28 Displays the Redline extension from Berea to Elyria.

Figure 9-28. Red Line Extension from Berea to Elyria (2050)

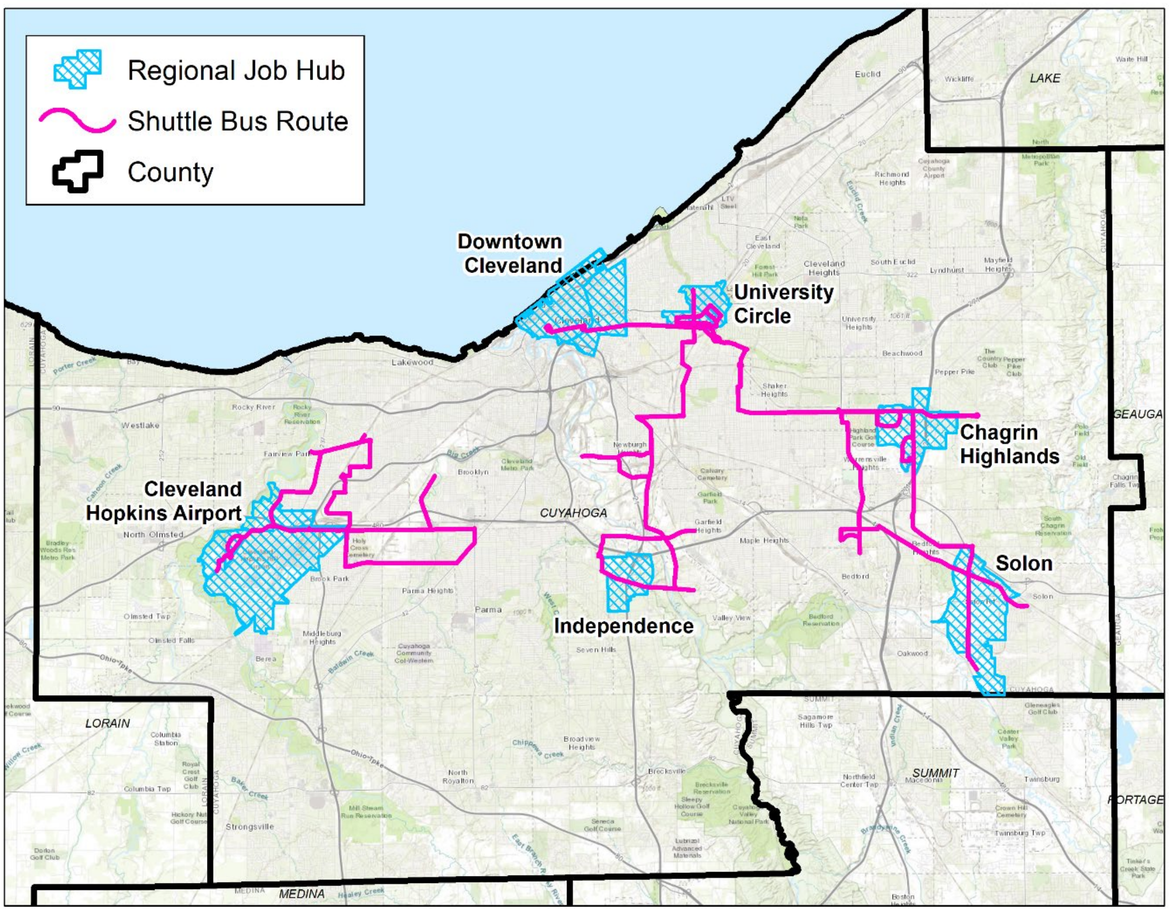


Proposed Autonomous Shuttle Feeder Buses

Autonomous shuttle feeder buses would assist with the last-mile connections of transit riders to jobs. Once a rider reaches a job hub via the expanded transit network, the final location of their work trip might not be within a reasonable walking distance. A series of autonomous shuttles would help circulate riders within the job hub or to other employment centers nearby. In addition, these shuttles would help feed riders into the expanded transit network from nearby residential areas with direct and frequent service to the job hub stations.

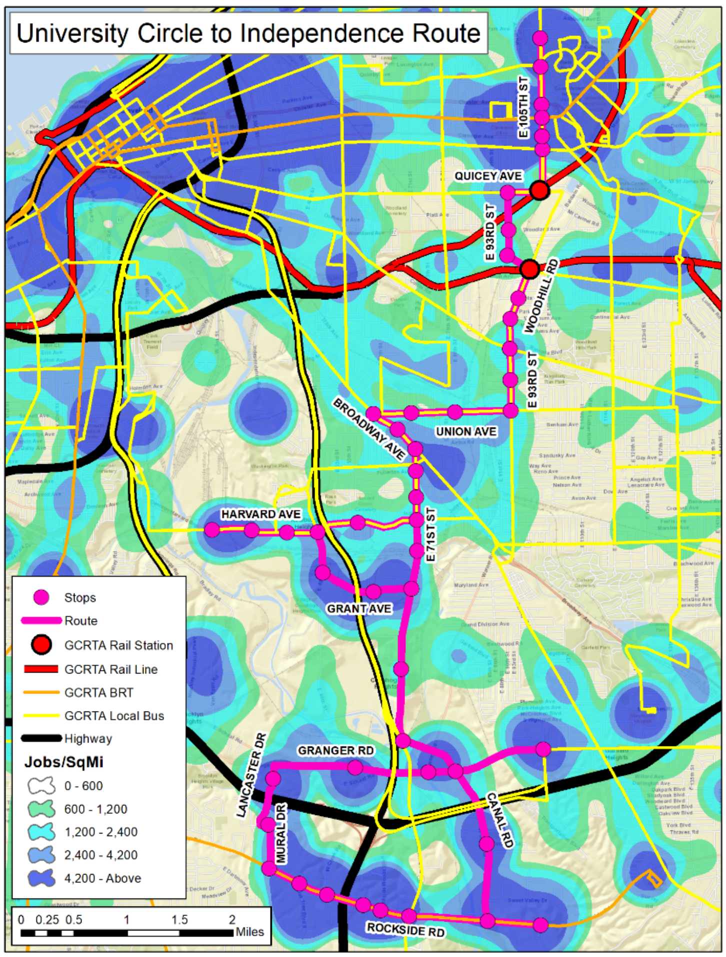
These shuttles would also provide connections to and from job hubs that might not have direct transit service between them, such as University Circle and Independence or Chagrin Highlands and Solon. Ultimately, these autonomous shuttles would serve two major purposes: helping transit riders make their last-mile connections and providing expanded access between residential areas and job hubs. Figure 9-29 illustrates the proposed future autonomous shuttle bus routes. As technologies emerge, shuttles may be able to operate not on fixed routes but rather on-demand similarly to a taxi service.

Figure 9-29. Autonomous Shuttle Feeder Buses and Connections to Regional Major Job Hubs



As a more detailed example, Figure 9-30 shows a potential route that an autonomous shuttle could take between the University Circle regional job hub and the Independence regional job hub. The shuttles would circulate riders to significant employment centers in and around the job hubs, as can be seen when examining the job density of the area. Transit riders living in between the two hubs would also have improved access to either hub, either by walking to a shuttle stop or transferring from a local bus onto the autonomous shuttle. The shuttle routes would also feed the expanded rail network by making stops at the various rail stations along the route, where riders could then travel to other job hubs and employment centers throughout the region.

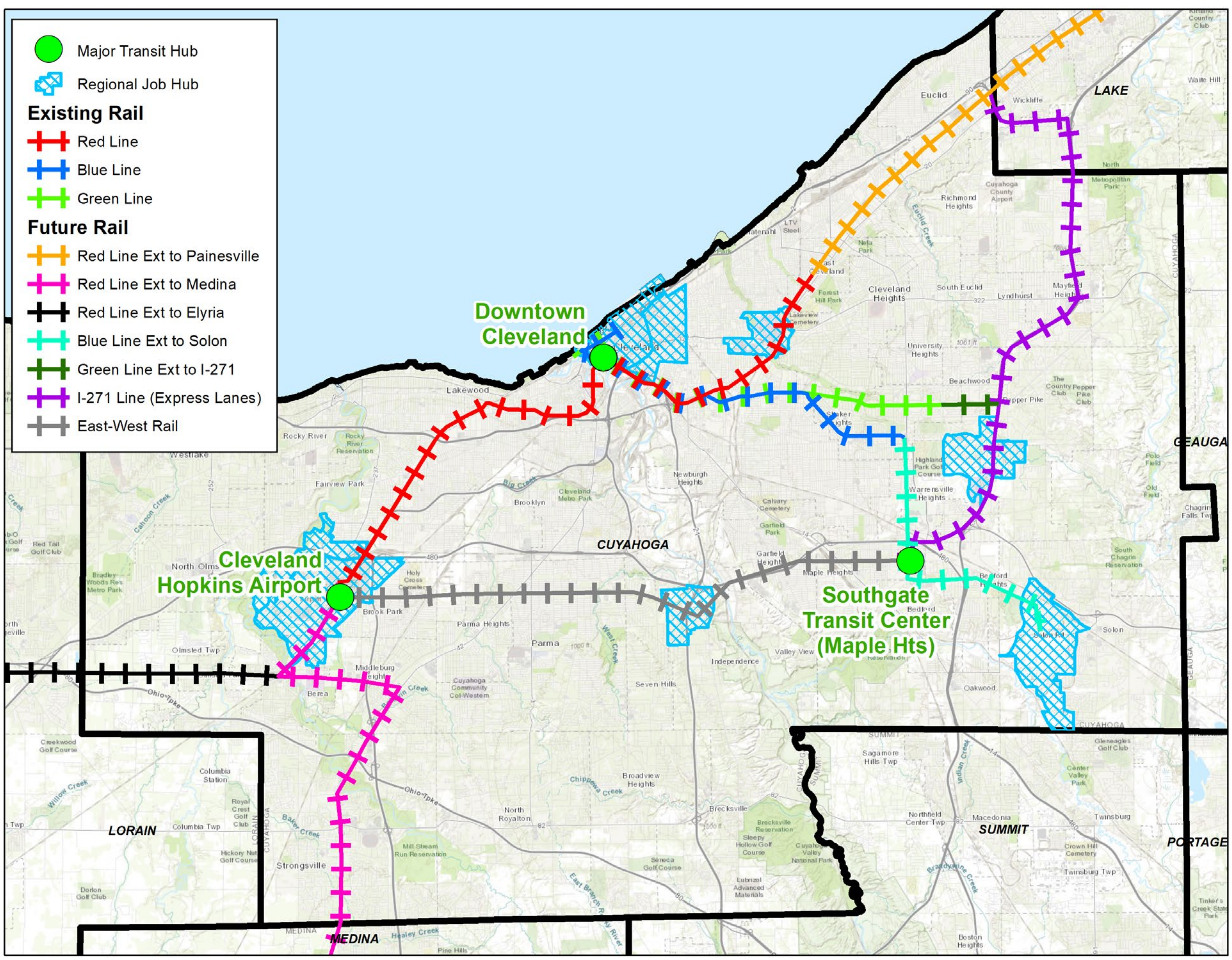
Figure 9-30. Autonomous Shuttle Feeder Bus Route from University Circle to Independence



Major Transit Hubs

With the expansion of the rail network into 2050, the transit system would need the establishment of new major transit hubs that would serve as transfer points between rail lines, as well as other transit modes. Tower City and Public Square in downtown Cleveland would continue to be the largest major transit hub of the regional transit system with three rail lines serving this location, and many other transit modes, such as BRT (Healthline and Cleveland State line), premium bus, local bus, and autonomous shuttles also connecting here. The Cleveland Hopkins Airport would also become a major transit hub, with the inclusion of new the Red line extension to Medina and the East-West line terminating here. Local buses and autonomous shuttles would also serve the Cleveland Hopkins Airport hub, and provide connections to the Great Lakes Hyperloop station. On the eastside of Cuyahoga County, a transit hub would be established at the Southgate Transit Center in Maple Heights. This location currently has local bus service and the addition of the I-271 rail line, the East-West rail line, and the Blue line extension to Solon to this location will create an even greater need to create a major transit hub here. Figure 9-31 displays locations of the major transit hubs in the NOACA region.

Figure 9-31. Major Transit Hubs in the NOACA Region (2050)



Plug-In Electric Vehicles (PEV)

The future of Plug-in Electric Vehicles (PEVs) is evolving rapidly. The number of PEVs is projected to reach 18.7 million in 2030 up from slightly more than one million at the end of 2018. This is about seven percent of the 259 million vehicles (cars and light trucks) expected to be on U.S. roads in 2030.

The National Renewable Energy Laboratory (NREL) spearheads transportation research, development and deployment to accelerate the widespread adoption of high-performance, low emission, energy-efficient passenger and freight vehicles. This section has used those reports and materials extensively.

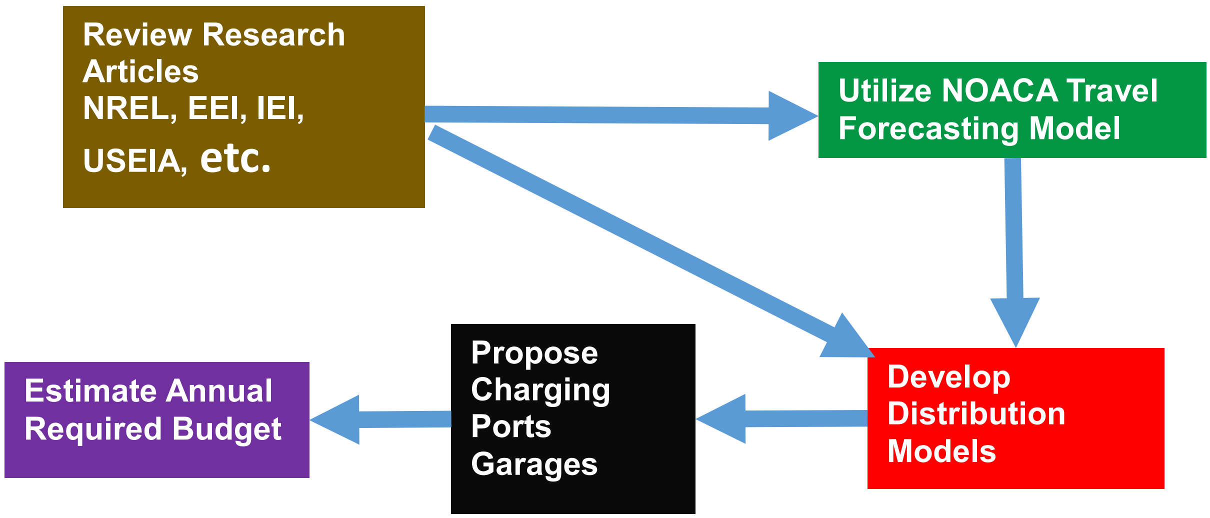
This section summarizes the recently developed NOACA plan; “PEV Charging Station Site Plan”. This plan discusses the current status and projected growth of PEVs over the next three decades in the NOACA region and also focuses on the required workplace charging stations and Direct Current Fast Charging (DCFC) stations. The plan also proposes parking garages and lots for locating these charging stations.

The required PEV charging station sites are a necessary part of the required Electric Vehicle Supply Equipment (EVSE). As expected, many PEV owners currently charge their vehicles overnight at home using residential charging ports, however, residential charging will not be adequate for the expected PEV growth in the next three decades. The NOACA site plan identifies the locations of the workplace charging stations and publically accessible DCFC stations as the required EVSE complement to residential charging. As the workplace station name indicates, these charging stations will be placed at the parking garages and lots close to major employment activities in the NOACA region. The main factor for selecting these parking garages is the walking distance of 0.5 miles to work places as the final destinations of workers. For the financial and practical purposes, each selected parking lot was deemed to have 20 or less charging ports.

According to the NOACA charging station site plan, the location of the DCFC charging stations would be located along highly travelled identified routes of PEVs and also along major highway routes for long distance travelers.

Figure 9-32 illustrates the study process of the NOACA implemented charging station sitting plan for identifying charging ports in the publicly and privately owned garages.

Figure 9-32. The Electric Vehicle Supply Equipment (EVSE) Study Process



Charging Station Type

Based on the NREL documents, there are currently three types of charging station for PEVs and Table 9-4 shows their general level, location and other characteristics.

Table 9-4. Charging Station Types

Charging Level	Charging Time	Vehicle Range Added (Mile)	Power Rate (kw)	Supply Power
AC Level 1	One Hour	4 6	1.4 1.9	120VAC/20A (12-16A continuous)
AC Level 2	One Hour	10 20 60	3.4 6.6 19.2	208/240VAC/20-100A (16-80A continuous)
DC Fast Charging (DCFC)	20 Minutes	24 50 90	24 50 90	240/480VAC 3-phase (input current proportional to output power; ~20-400A AC)

Plug-In Electric Vehicle (PEV) Forecast

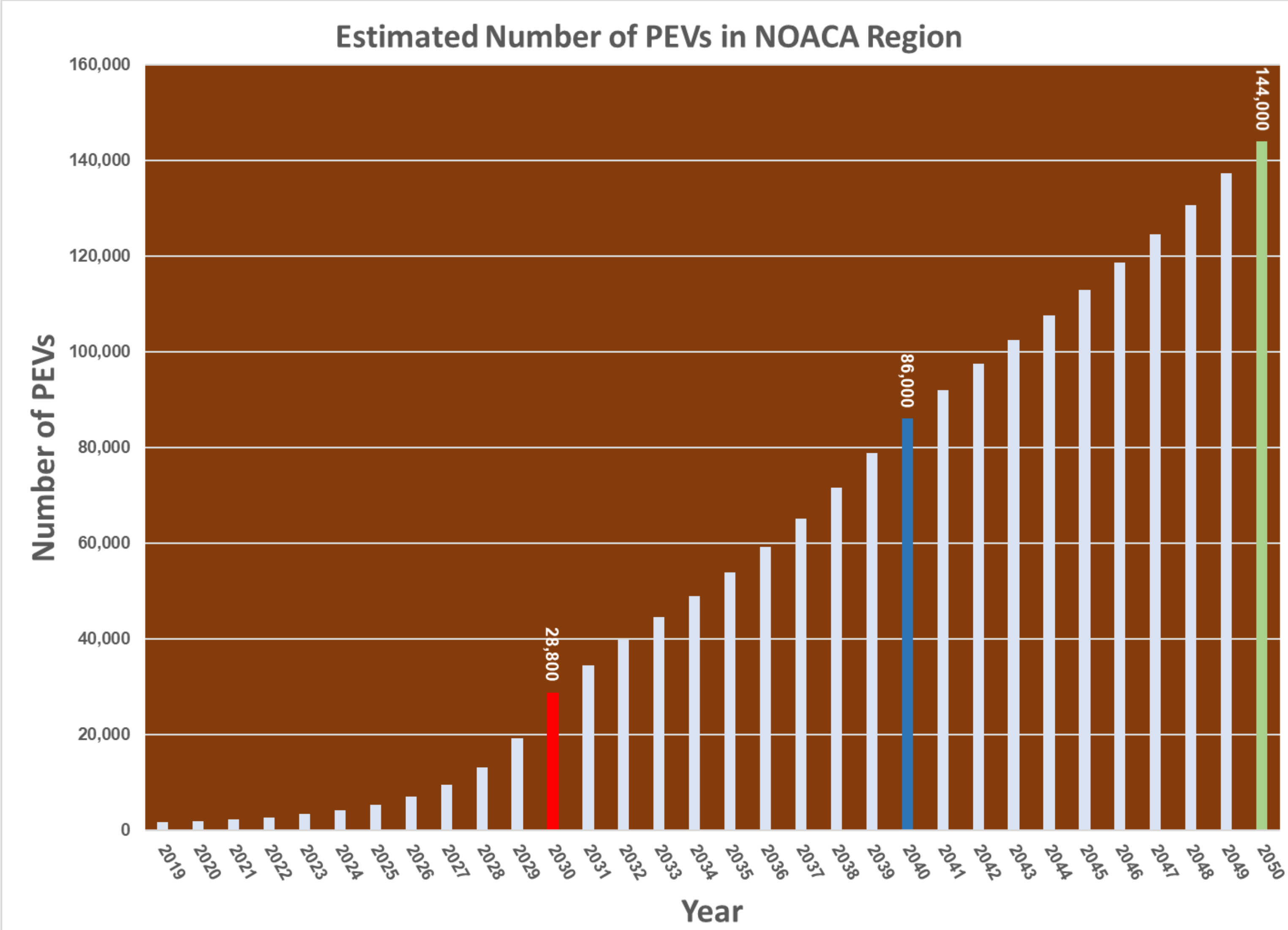
The recent NOACA "PEV Charging Station Site Plan" developed an estimated annual PEV forecasts based on several independent forecasts of PEV sales projections. These forecasts included three key factors in their projections:

- Customer preference models that determine interest in PEVs,
- Declining battery costs that influence PEV cost competitiveness with internal combustion engine vehicle and manufacturer profitability, and
- Fuel efficiency standard and environmental regulations.

Based on these independent forecasts and several NREL reports the NOACA Charging Station Site Plan projected that 28,800 PEVs will be on NOACA roads by 2030. This number of PEVs will be increased to 86,000 and 144,000 PEVs by 2040 and 2050 respectively.

Figure 9-33 shows the estimated annual PEVs forecasts in the NOACA region.

Figure 9-33. Estimated Number of PEVs in the NOACA Region



Plug-In Electric Vehicle (PEV) Charging Stations

The NOACA plan estimates annual number of required charging ports for supporting the projected annual PEVs. Table 9-5 summarizes the required charging ports by planning year and the accumulated required total budget for workplace and DCFC ports.

Table 9-5. Estimated Number of Required Charging Ports by Planning Year

Charging Level	Required Charging Ports by Planning Year		
	2030	**2040**	**2050**
Home Level 2	12,000	34,000	57,000
Public Level 2	800	2,300	3,900
Workplace Level 2	1300	3,800	6,300
Public DCFC	120	290	480
Total of Charging Ports	**14,220**	**40,390**	**67,680**
Accumulated Required Total Budget for Workplace and DCFC Ports	**$36 Million**	**$82 Million**	**$107 Million**

The plan emphasizes specific employment centers that have a high amount of work trip destinations, as well as high volume corridors that represent the traffic traveling through an area.

The DCFC charging ports will mainly be located on high volume corridors of PEV early adopters and regional through-traffic, and regionally significant intersections and interchanges in terms of traffic volumes. PEV early adopters were identified as those travelers living in high income neighborhoods and it was posited that they were the likeliest in the region to be owners of PEVs in the near future due to their high cost compared to traditional gas vehicles. Regional through-traffic was included in the analysis since these users are generally traveling far distances and thus would have an increased need to use a DCFC station compared to users traveling shorter distances. The typical daily routes of all the PEV early adopters and regional through-traffic were generated by the NOACA travel forecasting model, and areas where there was a high amount of cross traffic of these early adopters' routes were selected as the optimal locations for DCFC stations. All of these optimal locations are near busy highway interchanges, which makes sense since those are often locations where many current gas stations are found.

DCFC locations were also prioritized at locations along the major arterial network. The rational being that this would also provide access to DCFC ports to those residents not using the interstate system for longer trips. The intersections of the major arterial network were identified as possible locations that also represented a significant amount of cross traffic leading to a high usage rate of DCFC stations. Large parking locations, either privately or publically owned, were then identified near these optimal interchanges and intersections to allow for immediate access off of these high traveled corridors. Some locations, due to their proximity to both high traveled corridors and employment centers, made them ideal candidates for both workplace Level 2 and DCFC ports, and the co-locating of these port types is being explored.

Currently, locations of fuel stations for the conventional internal combustion engine vehicles are distributed in such a way that drivers can reach one of these locations by driving a few miles. The ultimate objective of the PEV charging port location distribution and consequently their coverage area is to mimic the current gas station distribution.

Figures 9-34 and 9-35, show the selected public-owned parking locations, the selected privately-owned parking locations most suitable for PEV charging stations. Also Figure 9-36 displays the ultimate coverage area of DCFC ports.

Figure 9-34. Proposed Government Owned Workplace (Level 2) and DCFC Port Locations

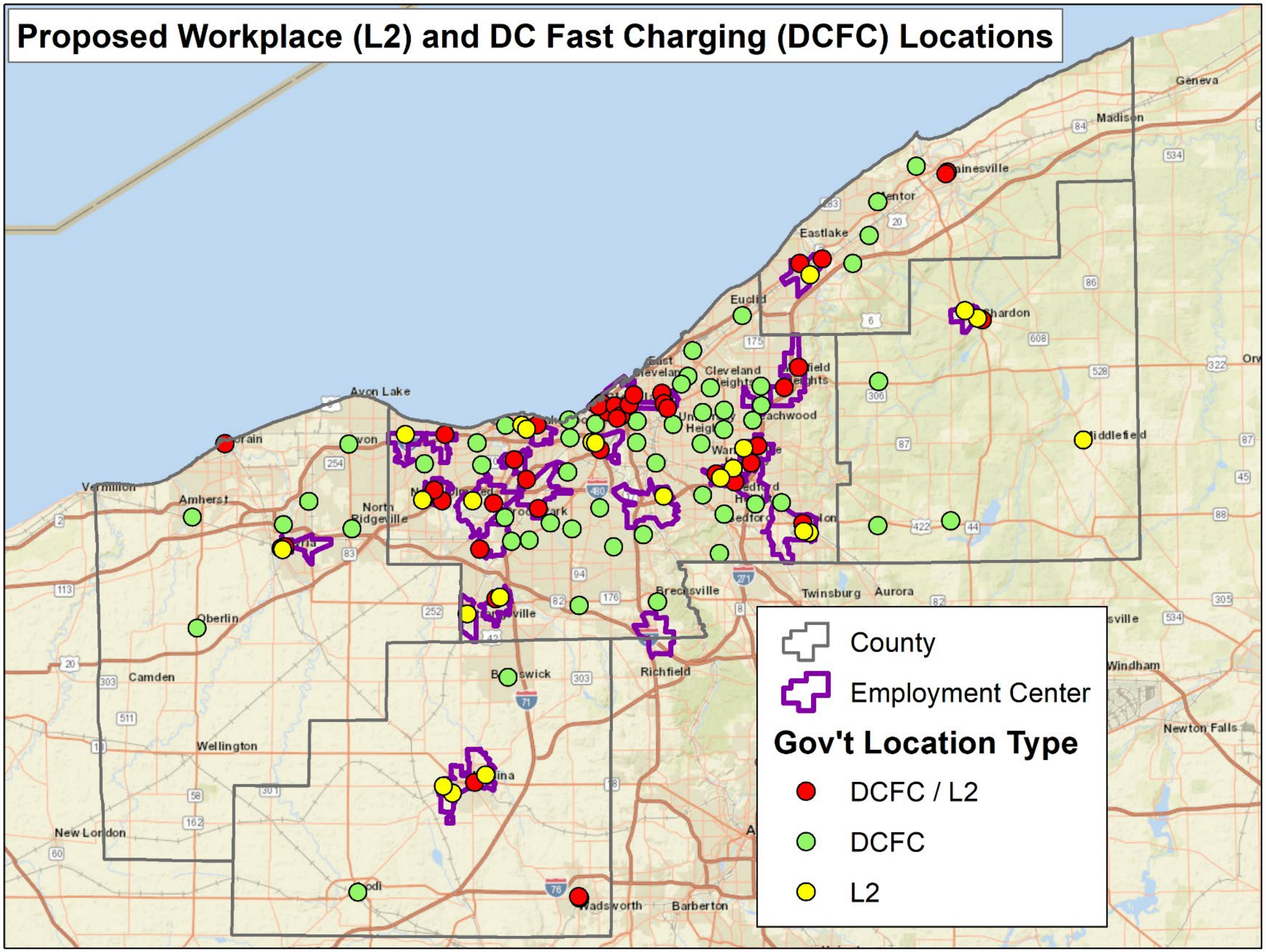


Figure 9-35. Proposed Private Owned Workplace (Level 2) and DCFC Port Locations

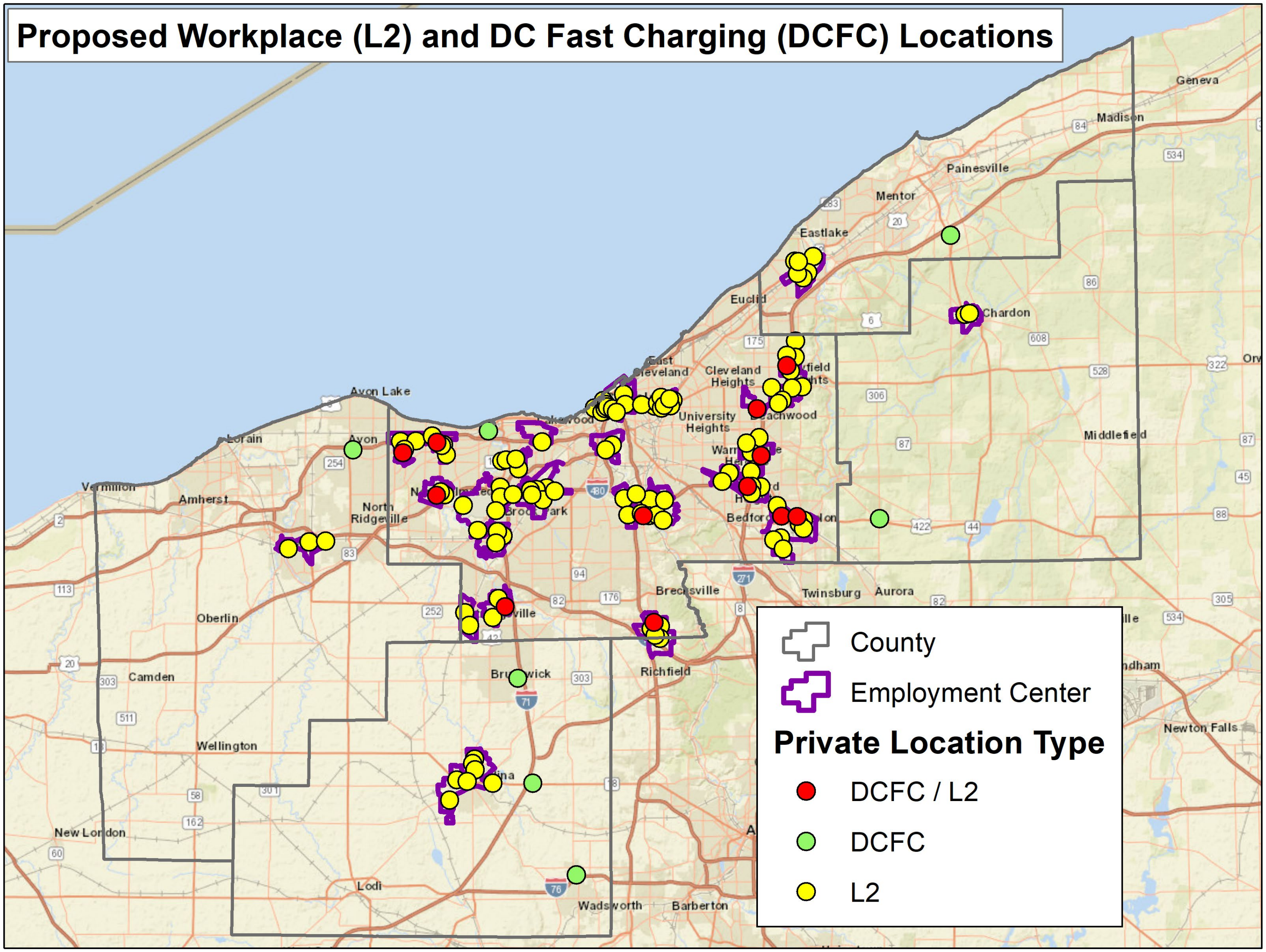


Figure 9-36. The Coverage Area for DCFC Locations (2030)

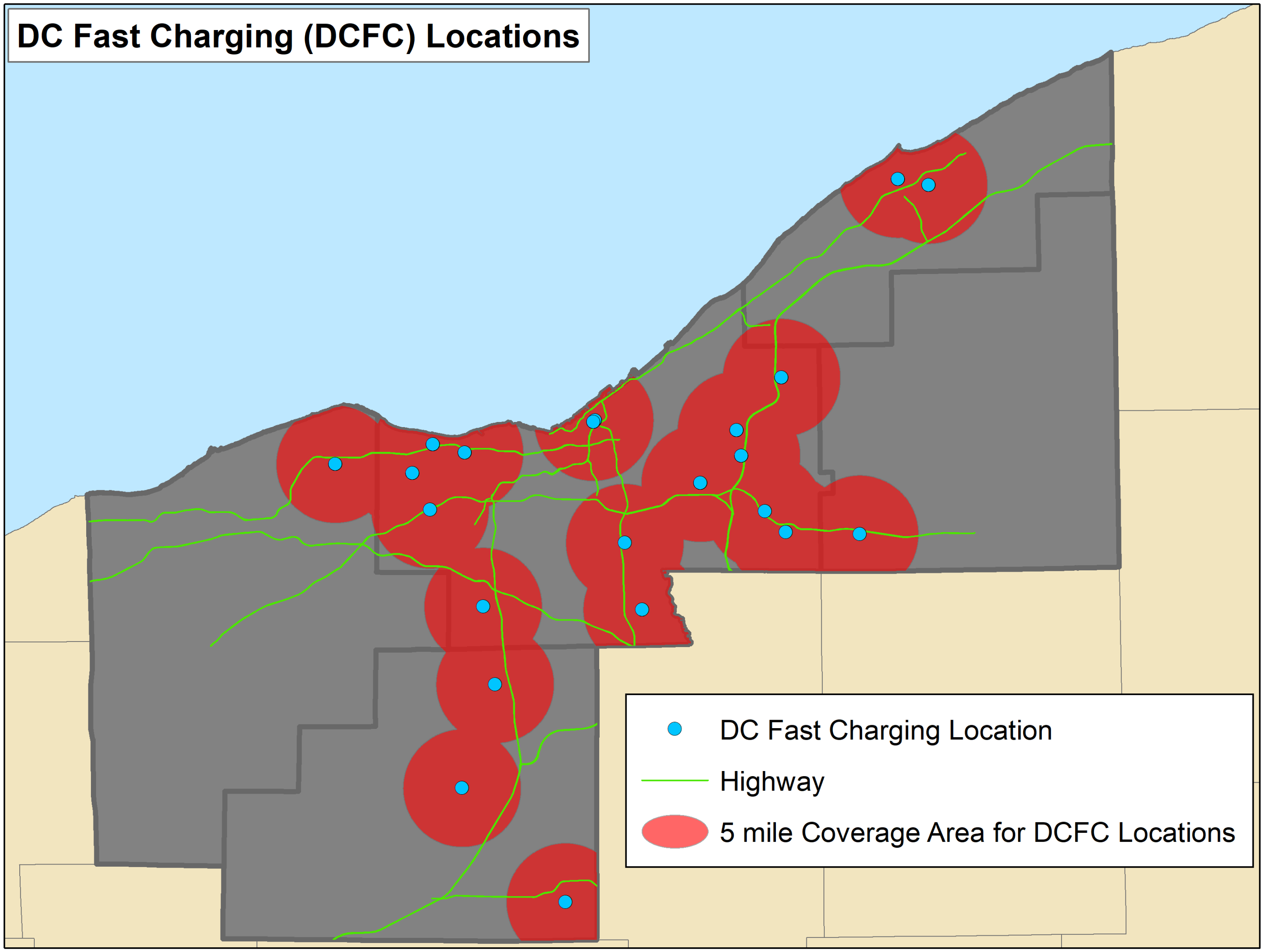
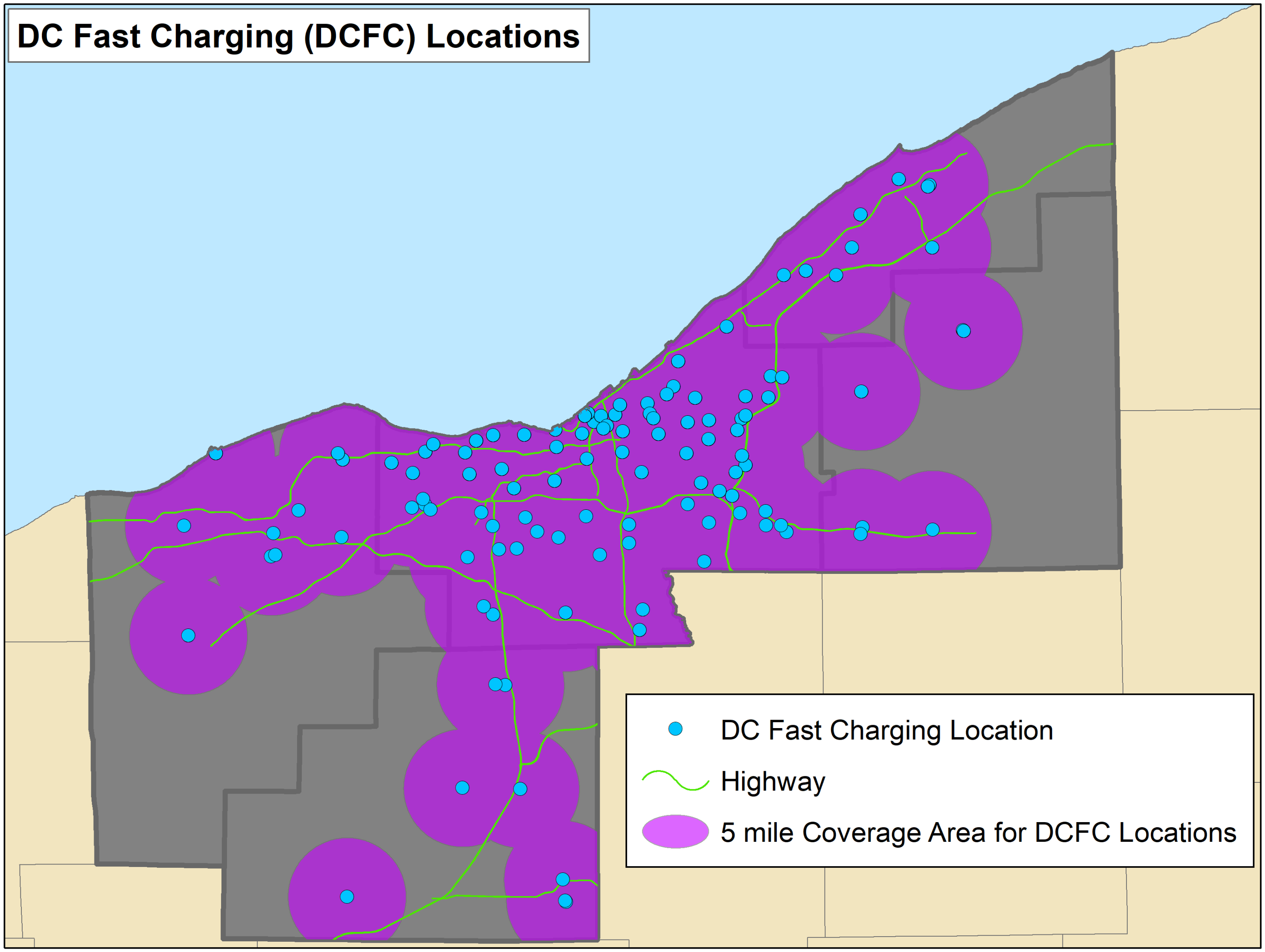
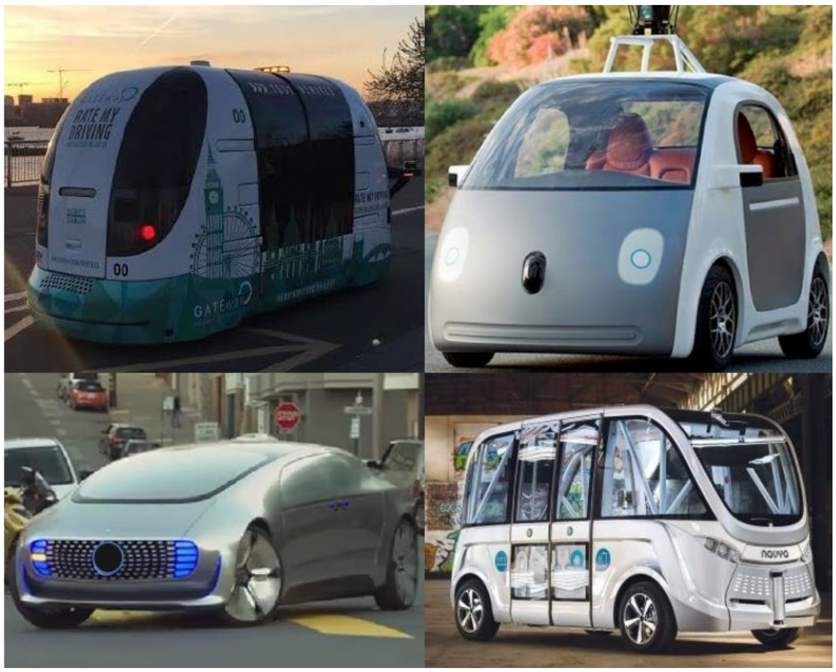


Figure 9-37. The Coverage Area for DCFC Locations (2050)



Connected and Autonomous Vehicles (CAVs)

Over a century ago, automobiles or horseless carriages were a revolutionary transportation option. Their deployment altered land use and travel patterns and drove the development of transportation infrastructure, policies, and regulations. Today it is Connected and Automated Vehicles (CAVs) that are poised to bring the next wave of changes to the transportation system in conjunction with related developments in vehicle electrification, shared mobility, and the emergence of new mode options such as electric scooters.



Connected vehicles are connected through interoperable wireless communications to other vehicles (V2V), transportation infrastructure (V2I), and to everything (V2X).

Automated vehicles use on-board and remote hardware and software to perform driving functions. The National Highway Traffic Safety Administration (NHTSA) has adopted the following Society of Automotive Engineers (SAE) Automation Levels:

- Level Zero: No Automation
- Level One: Driver Assistance
- Level Two: Partial Automation
- Level Three: Conditional Automation
- Level Four: High Automation
- Level Five: Full Automation

Table 9-6 displays these levels schematically.

Table 9-6. Society of Automotive Engineers (SAE) Automation Levels

Level Zero	Level One	Level Two	Level Three	Level Four	Level Five
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving function.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option of control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option of control the vehicle.

While there are vehicles in the current fleet with elements of connected and automated vehicle technology, there is still considerable uncertainty in how exactly full scale deployment will play out. Although this makes it difficult to predict its impacts with certainty, this chapter explores what it means for the transportation system and its users.

Potential opportunities of CAVs are:

- Currently user error is the main factor in accidents. CAVs will improve safety by reducing user error.
- Increased capacity, reduced congestion, and fewer high capacity improvements due to the potential to operate with fewer incidents, decreased following distances, and narrower lane widths.
- Improved first and last mile connections with transit.
- With appropriate design, moderated or decreased growth in vehicle miles traveled and increased growth in ridesharing, public transportation use, bicycling, and walking
- New funding and financing mechanisms and the potential to leverage private sector funds
- Expanded mobility for those currently unable to drive
- Increased efficiency for freight movement through improved efficiency and applications such as freight platooning
- Additional data source
- Potential to retrofit the built environment and provide more complete streets—for example to repurpose parking

Challenges of CAVs are:

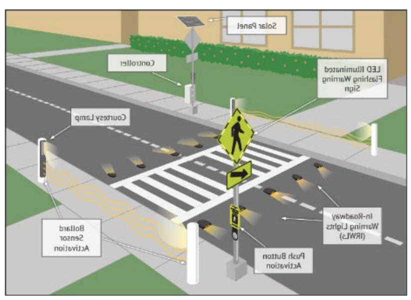
- Safety in a mixed fleet environment during early deployment
- Security from vulnerabilities and intrusions to connected elements
- Increased vehicle miles traveled due to improved traffic flow, additional mobility options, and zero occupancy vehicles
- Decrease in public transportation use due to the alternative mode options
- Impacts to current funding and financing mechanisms as individual ownership could transition to shared fleets or on demand services
- Cost of infrastructure required to support the new technology
- Need for better maintenance of the roads as vehicles rely on sensors and technology
- Potential for deployment to disadvantage some transportation system users or impact vulnerable road users
- Induce sprawl or encouraging “super-commutes”
- Certain transportation investments may become obsolete

Active Transportation Facilities

Scenarios 3 and 4 include potential future bicycle networks and pedestrian improvements. To determine the addition of new bicycle and pedestrian facilities, NOACA first identified active transportation projects, many that have been proposed in existing planning documents. After identifying the proposed projects, NOACA evaluated them along multiple criteria to determine likely implementation decades. This section briefly outlines both steps to provide context to the discussion of the scenarios.

Identification of Potential Active Transportation Initiatives

Active transportation facility projects are derived from various sources, both within and external to the organization. NOACA's existing "Regional Bicycle Plan" is the foundation for the mapped facilities featuring its "Regional Priority Bikeway Network". Furthermore, NOACA is currently in the process of preparing a new plan called ACTIVATE, which focuses on biking and walking as active transportation. Although ACTIVATE is not complete, some components were integrated into *eNEO2050*. Another resource for the LRP is NOACA's Transportation for Livable Communities Initiative (TLCI) program that has completed more than 100 studies, many of which include recommendations for active transportation facilities. These studies were initiated in partnership with local communities and their insight is invaluable. Furthermore, other collaborations, such as the Cuyahoga Greenways, provided additional project ideas, as did NOACA's Bicycle and Pedestrian Council. Lastly, needs were identified as part of the *eNEO2050* planning efforts, which included research, analysis and modeling as well as significant public outreach.



Bike and pedestrian facility projects are categorized according to the sources from which they were derived:

NOACA Bicycle and Pedestrian Plans helped to identify the following projects:

- Pedestrian infrastructure crossing improvements at intersections,
- Pedestrian infrastructure crossing improvements at midblock crossings, and
- Regional Priority Bike Network (RPBN) routes

eNEO2050 identifies specific needs of the transportation network that can be supported through investments in active transportation:

- Connections from major transit hubs to major job hubs,
- Access connection from EJ neighborhoods to transit network stations (first-/last-mile),

- Access from major residential areas to transit network stations (first-/last-mile),
- Major transit hub bike storage improvements
- Smart crossings at midblock locations along major arterials

TLCI studies and plans by other organizations have identified active transportation projects for particular corridors and routes across the region:

- State and US bike routes along high stress corridors according to ODOT plans,
- Bike facility and pedestrian streetscape projects ,
- Cuyahoga Greenways Plan network,
- Bike project recommended by other studies or plans tracked in NOACA's bike network inventory file,
- Projects submitted by local agencies.

While there is some attention to the improved utilization of major arterials for motorized vehicles, the conclusion does not preclude bicycle facilities on major arterials. Many factors will be evaluated to ensure safe travel for all modes, such as traffic volumes, destinations, geography, redundancy and local access. To that end, he following bike lanes along major arterials are included:

- An on-road facility type was specifically recommended along a potential road diet candidate.
- The recommended facility is an off-road all-purpose trail,
- The project is already in active status,
- A lane reduction was already implemented,

For modelling purposes, however, bicycle facilities were excluded as non-motorized facility projects if an on-road facility type required lane reductions, but it was deemed not feasible due to roadway characteristics of the major arterial.

Prioritization Based on Implementation Decade

The considered bike and pedestrian projects have been divided into three Priority Tiers: HIGH, MID, and LOW, with each representing a different implementation decade of:

- 2021-2030,
- 2031-2040, and
- 2041-2050.

The project priority tier is determined based on the following criteria:

- Immediate readiness,
- Fill critical gaps or connectivity needs in regional trail network,
- Location in highest need or demand areas,
- Intersection and midblock pedestrian crossing improvements identified in the NOACA ACTIVATE plan which connect EJ neighborhoods and major residential areas to the regional transit network,
- Projects with potential funding,

- Cuyahoga Greenways Plan prioritization level,
- Local sponsor importance,
- Presence along US or State bike route network,
- Projects along high stress routes where no nearby alternative alignment exist,
- Bike projects in outer counties that are in high need or demand areas,
- Connections between major transit hubs and major regional job hubs, and
- Prioritized smart midblock pedestrian crossings based on safety issues.

Figures 9-38 and 9-39 illustrate the locations of the discussed active transportation projects.

Figure 9-38. Pedestrian Improvement Projects (2050)

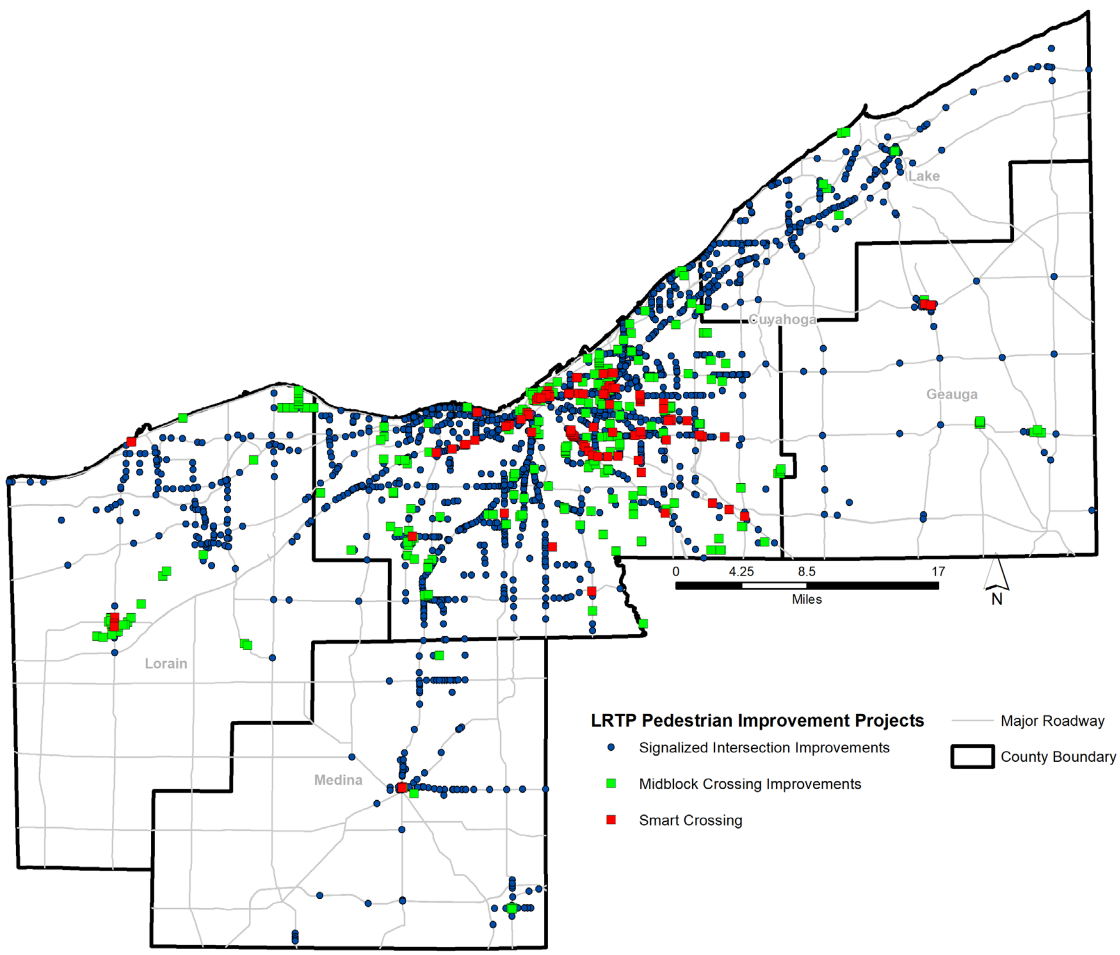
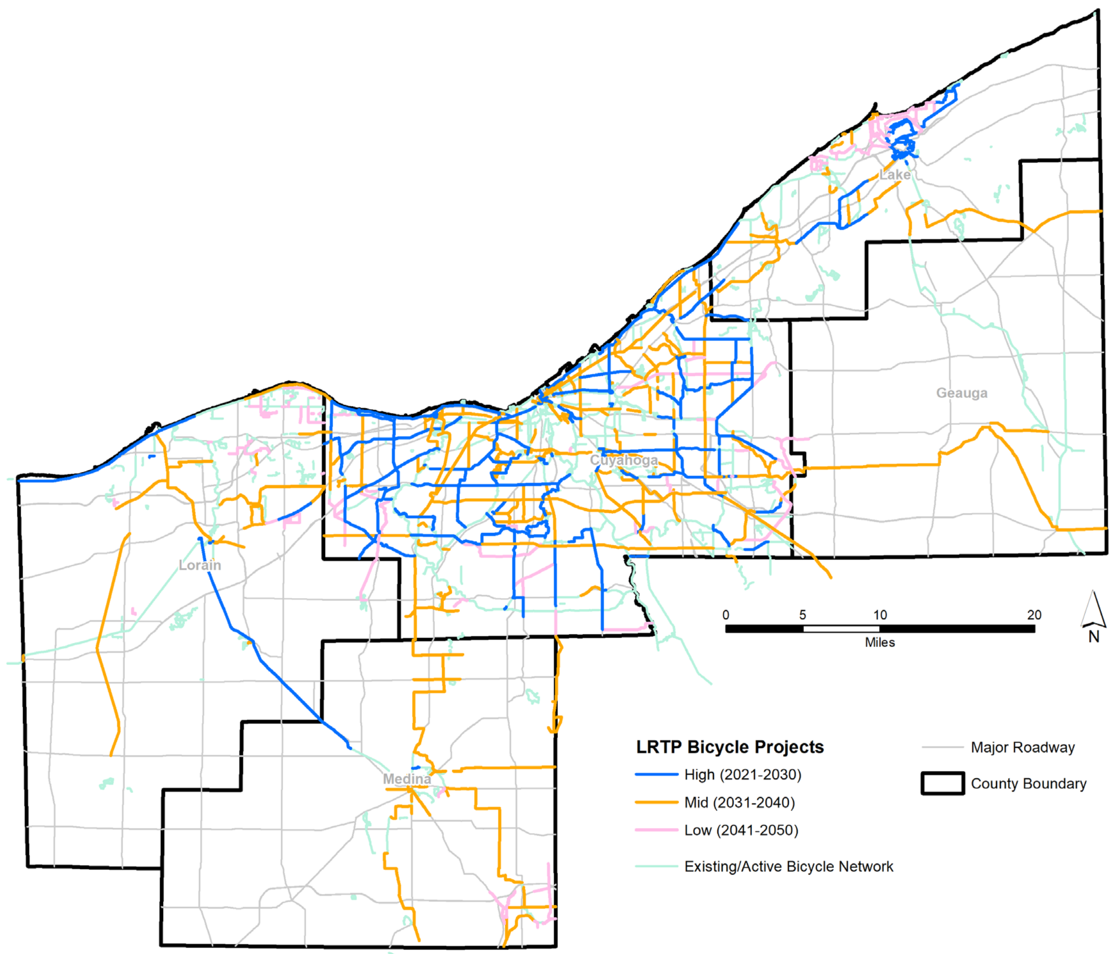


Figure 9-39. Bicycle Projects (2050)



Scenario Planning

Recent planning practices have demonstrated that the traditional approach of first generating predictions as a continuation of current or historical trends and then planning accordingly does not accommodate the uncertainty of events that may occur. To mitigate this uncertainty, the second level of planning adds an investment scenario analysis. A scenario analysis essentially accounts for the risks and preferences associated with various transportation investment decisions.

Scenario planning is a technique used to better prepare for the future by developing multiple plausible situations, or scenarios, representing alternative futures rather than committing to prepare for a single expected future. Scenario planning may consider situations which are not reachable by the current trend. For example, a traditional trend-based planning approach is unlikely to forecast a high investment in extending the current trail network in the NOACA region. Scenario planning approach shifts from predicting the future to preparing for potential futures.

Similar to the traditional trend-based planning, the starting point of the scenario analysis is the current year rather than a future year.

Figure 9-40. Traditional and Risk Analysis Planning Approaches

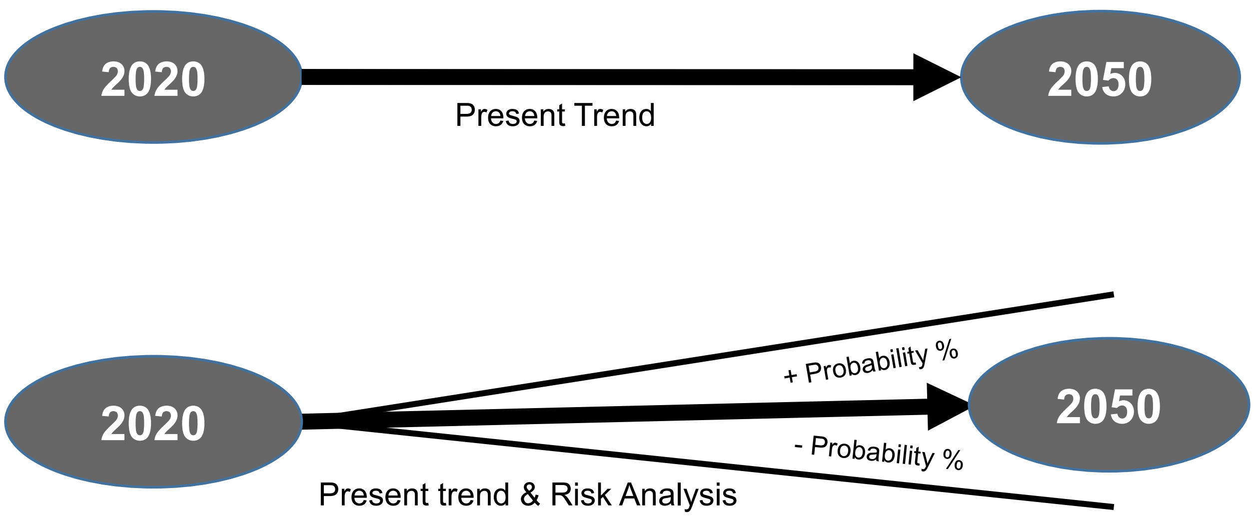
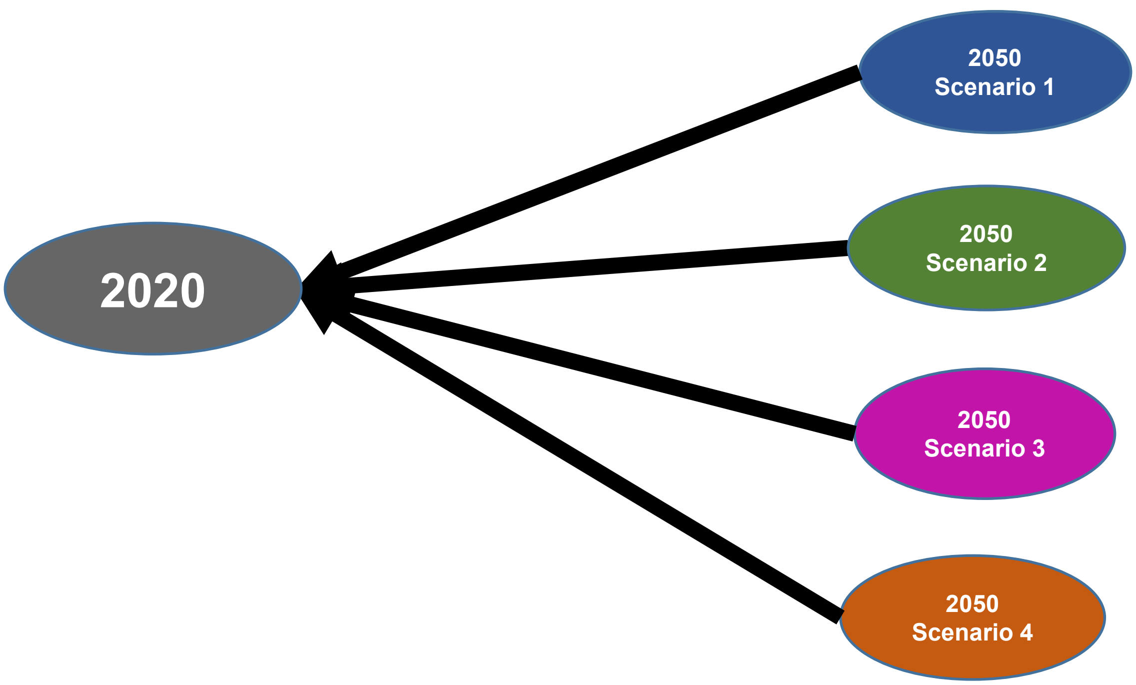


Figure 9-41. Scenario Planning Approach



Description of Four Investment Scenarios

The Long Range Transportation Plan (LRTP) scenarios are based on the projects discussed in previous sections. Each scenario includes a set of proposed projects, their implementation decades and applied technology levels. Each scenario uses assumptions about the regional growth/development patterns (see section 9.3.2 for details). The scenarios reflect that transportation investments on the one hand accommodate existing growth patterns while also perpetuating or changing them. Growth patterns and transportation investment taken together have implications for the quality of life in the region in 2050. The four scenarios are subsequently described. It needs to be noted that the scenarios make simplified assumptions about the transportation investments to establish reference points to explore a future mix of investments as part of the visioning. In other words, the scenarios are models that can aid a regional conversation about desirable transportation investments when developing the Transportation Improvement Program.

Table 9-7 displays the title and theme of the proposed scenarios.

Table 9-7. LRTP Scenarios: Name, Title and Theme

Scenario Name	Title	Theme
1: MAINTAIN	**Maintain** Infrastructure System	State of Good Repair
2: CAR	**C**aptivating **A**uto **R**egion	Single Occupancy Vehicle
3: TRANSIT	**TRAN**sportation **S**ystem with **I**mproved **T**ransit	Multimodal Transportation System
4:TOTAL	**T**ransportation with **O**ptimal **T**echnology and **A**ccess for AL**L**	Advanced Multimodal Transportation System

A short description of scenarios are:

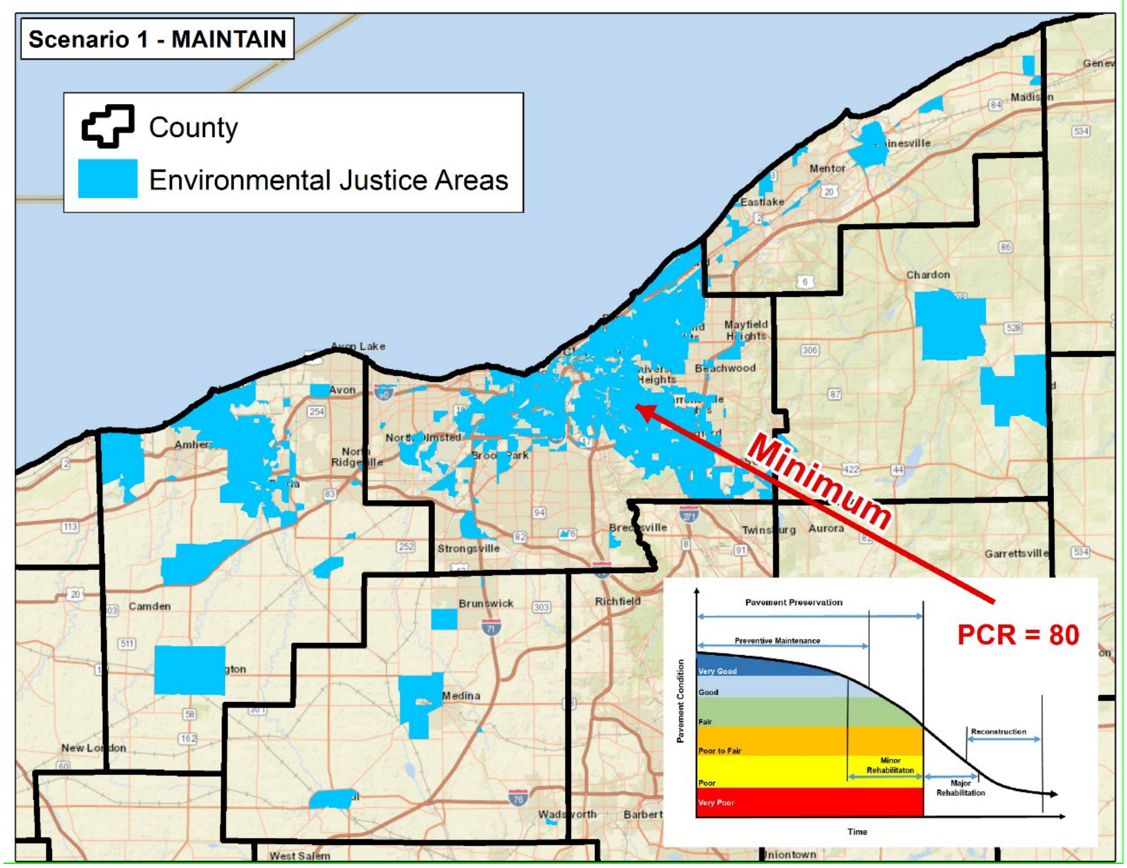
Scenario 1: MAINTAIN; Preservation of the existing infrastructure is the theme of Scenario 1 - MAINTAIN. This scenario invests 100 percent on maintaining the existing transportation system and zero dollars in expansion.

Majority of daily trips are vehicular and the highway and street network accommodates those trips. Therefore maintenance of this important asset is a crucial investment for the transportation infrastructure. In addition, maintaining and replacing transit vehicles and rolling stocks are another part of this scenario.

The focus of the eNEO2050 is Equity. While the maintenance of the entire road and transit system is a priority, special attention is paid to streets and transit services in the Environmental Justice (EJ) areas. Scenario 1 attempts to keep pavements and bridges in the EJ areas and transit vehicles serving the EJ areas in a good condition all the time. It should be noted that the Pavement Condition Ratings (PCR) measure is a qualitative description of the structural state of the pavement. The PCR values span a spectrum of descriptive narrative ranging from "Very Good" to "Very Poor". Each roadway segment is scored from 0 to 100 with 0 representing completely distressed pavement and 100 indicating perfect pavement condition.

The transit network of the Scenario 1 is the current bus / BRT and rail networks with no extensions.

Figure 9-42. Scenario 1: MAINTAIN



Scenario 2: CAR; in the past decades, the regional investment in the transportation field was focused on supporting automobile movement. Continuation of investing in capacity adding projects is the theme of Scenario 2 – CAR.

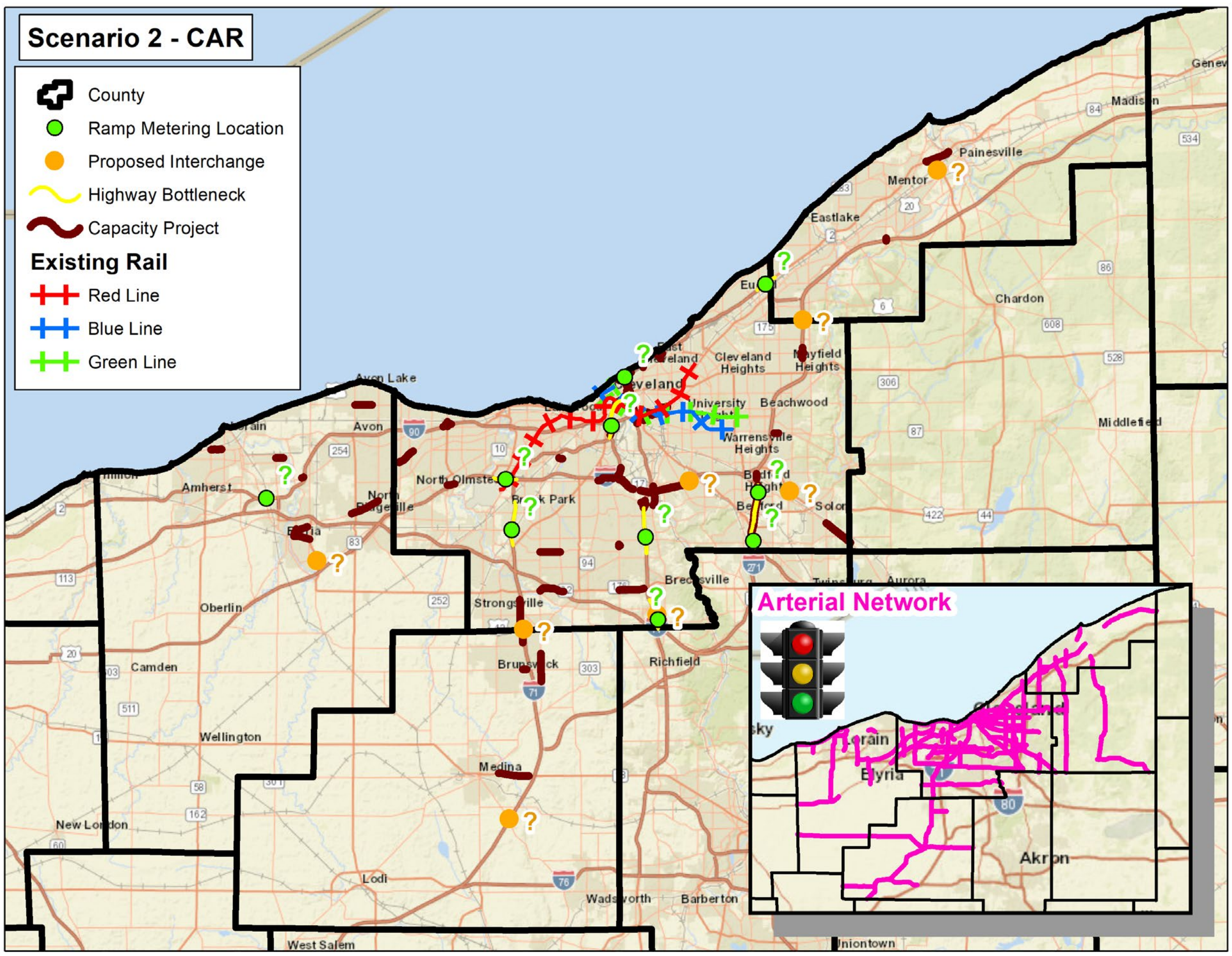
Investing in future highway network capacity projects and adding viable freeway interchanges are two major highway items in this scenario. Regulating the traffic flow entering freeways by installing ramp metering and reducing highway bottlenecks are traffic management investments in this scenario. Also, banning truck movement in the Commercial Business Districts (CBD) during the AM peak period is the other traffic management policy in this scenario.

In addition, optimizing the timing of traffic signals and other similar arterial projects will restore mobility function of arterials as an alternative network to the freeway network.

Scenario 2 attempts to achieve the average auto work commute times to the regional major hubs to 30 minutes during the AM peak period.

The transit network of the Scenario 2 is the current bus / BRT and rail networks with no extensions.

Figure 9-43. Scenario 2: CAR



Scenario 3: TRANSIT; developing a multimodal transportation system is the theme of Scenario 3 – Transit. The 2017 visionary rail network is the backbone of the transit network of this scenario with some modifications for improved connections. The transit network also includes the transit agencies' future Bus / BRT plans.

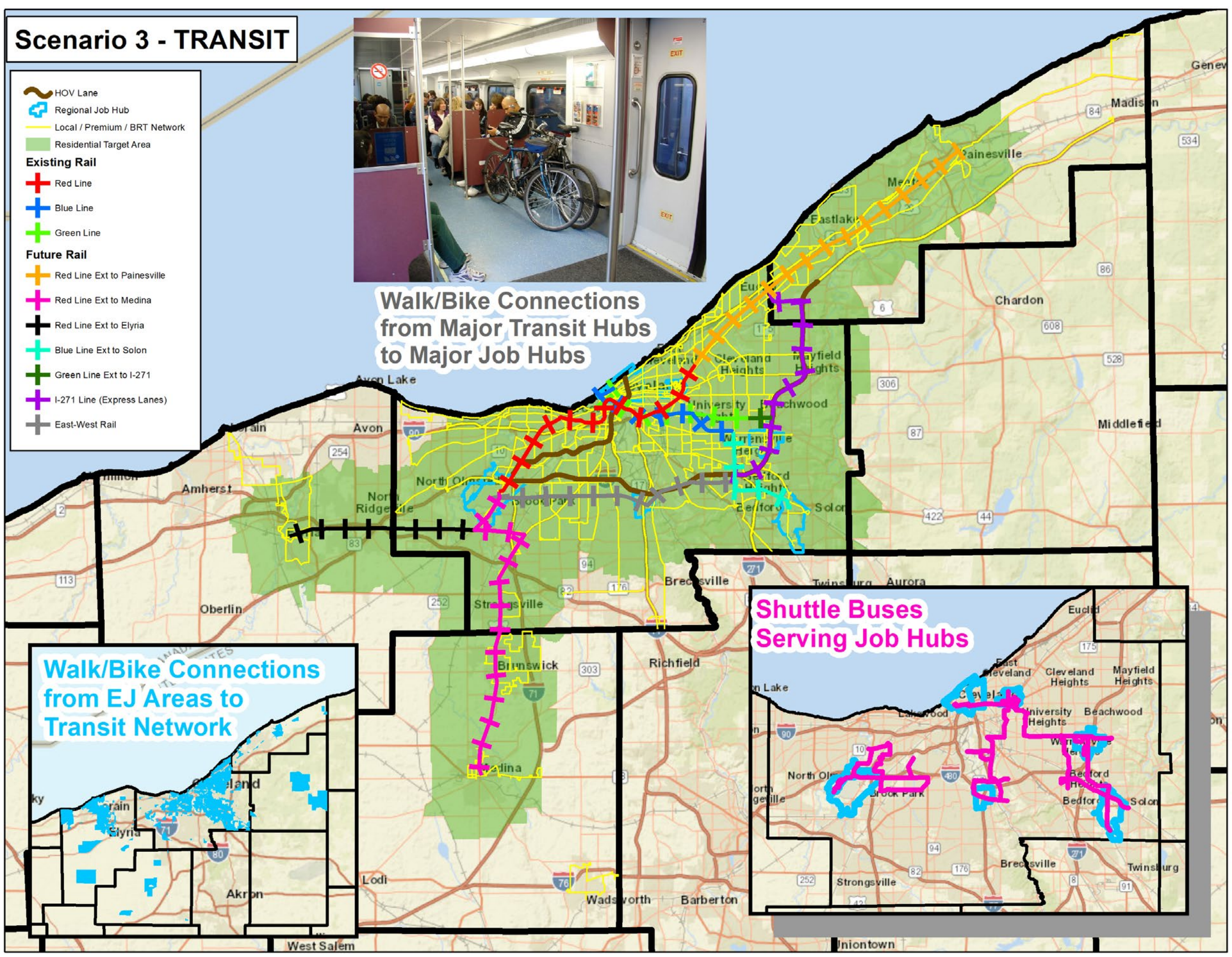
The technology advancement will add autonomous shuttle buses to the scenario 3 transit network for the improved workers' accessibility to the regional job hubs and transit hubs.
Since the focus of the eNEO2050 is equity, this scenario pays special attention to reducing transit service headways to Environmental Justice (EJ) areas. The objective of this scenario is to reduce the average transit work commute time to the regional job hubs to 45 minutes.

Scenario 3 does not include any extensions to the highway network, however, it allocates some freeway lanes only to High Occupancy Vehicles (HOV) which can also be used as express bus lanes.

The investments in this scenario will also support significant bike and pedestrian improvements to ensure a multimodal system that supports access to job from EJ areas.

This scenario considers housing developments around transit stations and major job hubs so more workers live closer to where they work.

Figure 9-44. Scenario 3: TRANSIT



Scenario 4: TOTAL; an advanced multimodal transportation system using emerging transportation technology is the theme of Scenario 4 – Total. This scenario invests in all modes of travel:

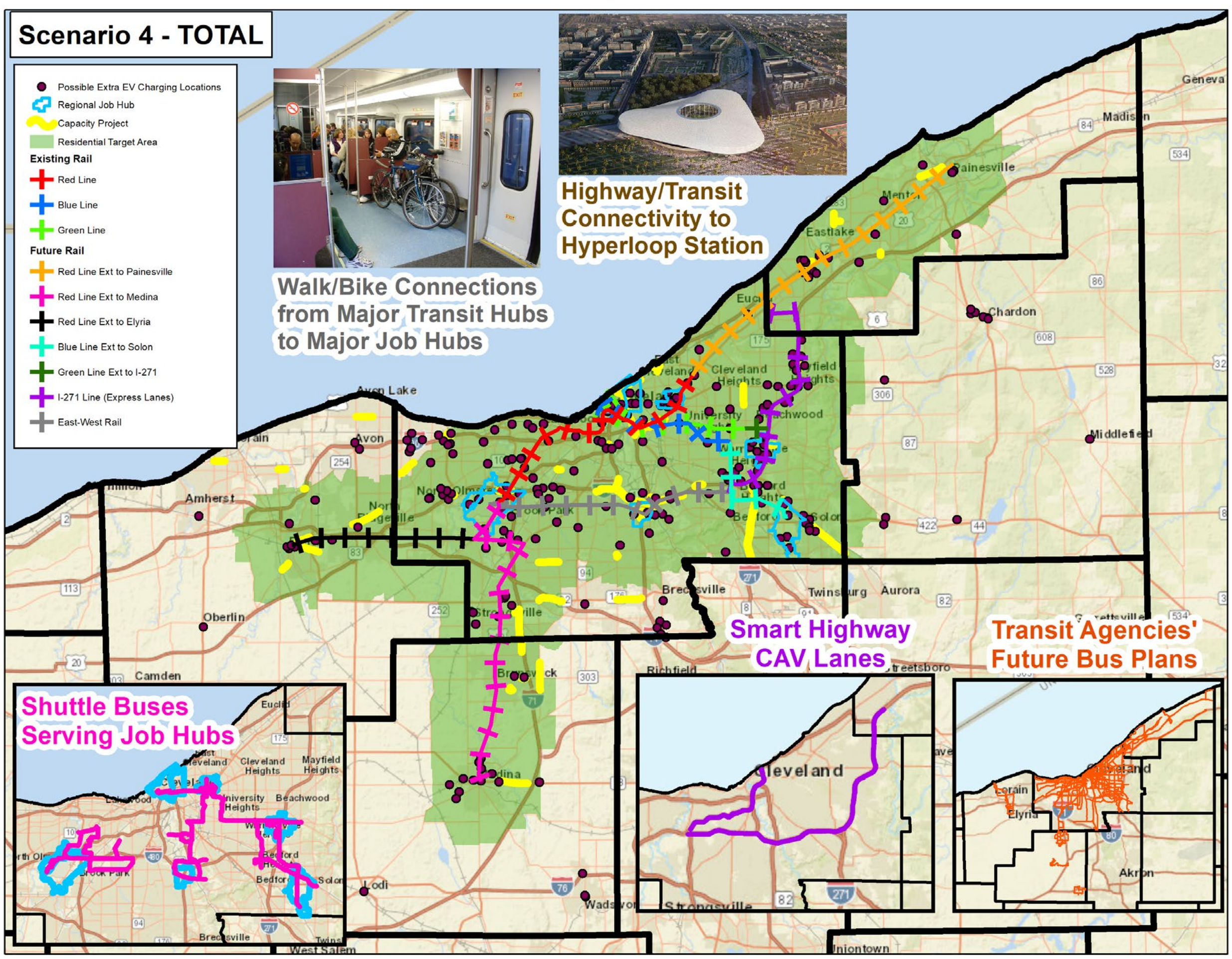
- The highway network will include major capacity projects.
- The improved 2017 visionary rail network is the major transit investment of this scenario. The transit network also includes the transit agencies' future Bus / BRT plans.
- Walk and bike access from major residential neighbors to transit network and from major transit hubs to the regional major job hubs.

The emerging transportation technology will add:

- Selected smart freeway lanes to autonomous cars and trucks.
- Extra electric vehicle charging ports.
- Autonomous shuttle buses to improve workers' accessibility to the regional major job hubs and transit hubs.
- The Hyperloop station.

Since the focus of the eNEO2050 is equity, this scenario attempts to reduce the average transit work commute time to regional job hubs to 30 minutes and auto commute time to 20 -30 minutes.

Figure 9-45. Scenario 4: TOTAL



Scenario Development: Population and Employment Forecasts

Scenarios 1 and 2 follow the population and employment trends detailed in the previous sections. In summary, these scenarios assume that the population and employment of the NOACA region will continue along the same trend lines as they have in the past. Population loss in the urban core of Cuyahoga County and other legacy cities of the region will continue in these scenarios. Also, this continued outward migration will bring some growth to suburban and exurban communities, mostly in the outer counties of the region. However, the region as a whole will not grow leaving fewer residents to pay for the same or more infrastructure.

Scenarios 3 and 4 assume that growth will occur in the NOACA region, due to implementation of the Hyperloop, the establishment of an expanded rail network and local government supported land use changes, and as a result of climate change, with more people seeking residence in regions with abundant fresh water. Scenario 3 assumes 5% growth from 2020 for both population and employment, which is a modest level of growth. Scenario 4 assumes a 10% growth from 2020 for both population and employment, which is a moderately high level of growth.

Since the Scenarios 3 and 4 both establish an expanded rail network that connects regional job hubs of the NOACA region, the population growth apparent in these scenarios is targeted for residential areas with easy and convenient access to these new transportation options and major job locations. The assumption is that the region would be able to attract and retain residents that currently chose to locate on the East or West Coast due to the lifestyle preferences for denser, mixed-use and transit connected neighborhoods. How and if these denser, mixed-use transit connected neighborhoods materialize is certainly primary within the decision-making realm of local governments. Potentially, all five counties can benefit from this population growth as depicted in Map 9.29 if transit investment and land use changes are pursued.

By having more workers taking public transit and having shorter commutes due to workers living closer to jobs and major transit stations, the stress on the transportation network will be alleviated. Scenarios 3 and 4 assume that the additional population growth will occur in areas within 5 miles of the major regional job hubs and park-and-ride locations of the expanded rail network. A distance of 5 miles encompasses both persons who would access the major regional job hubs and rail system via car, as well as those who might be accessing these same locations by non-motorized modes, such as bicycling or walking, which would occur at distances shorter than 5 miles.

The population growth was distributed based on the 2020 distribution of population within the target area. The TAZs with the most population with respect to the target area's total population received more of the population growth, and those with less population received less. This type of approach increased the density of locations with the most population in 2020. With regards to the type of housing that was inputted into Scenarios 3 and 4, multi-family housing was prioritized over single-family housing, with 80% of the new housing units in the residential target area being multi-family. This was implemented to offer more equitable housing choices for areas with increased transit and job access. Table 9-8 details the increases in population, households and workers in Scenarios 3 and 4.

Table 9-8. Regional Population Growth (2020-2050) – Scenarios 3 and 4

	Regional Population Growth 2020 – 2050 %		
	Population	**Workers**	**Households**
Scenario 3	5	5	5
Scenario 4	10	10	10

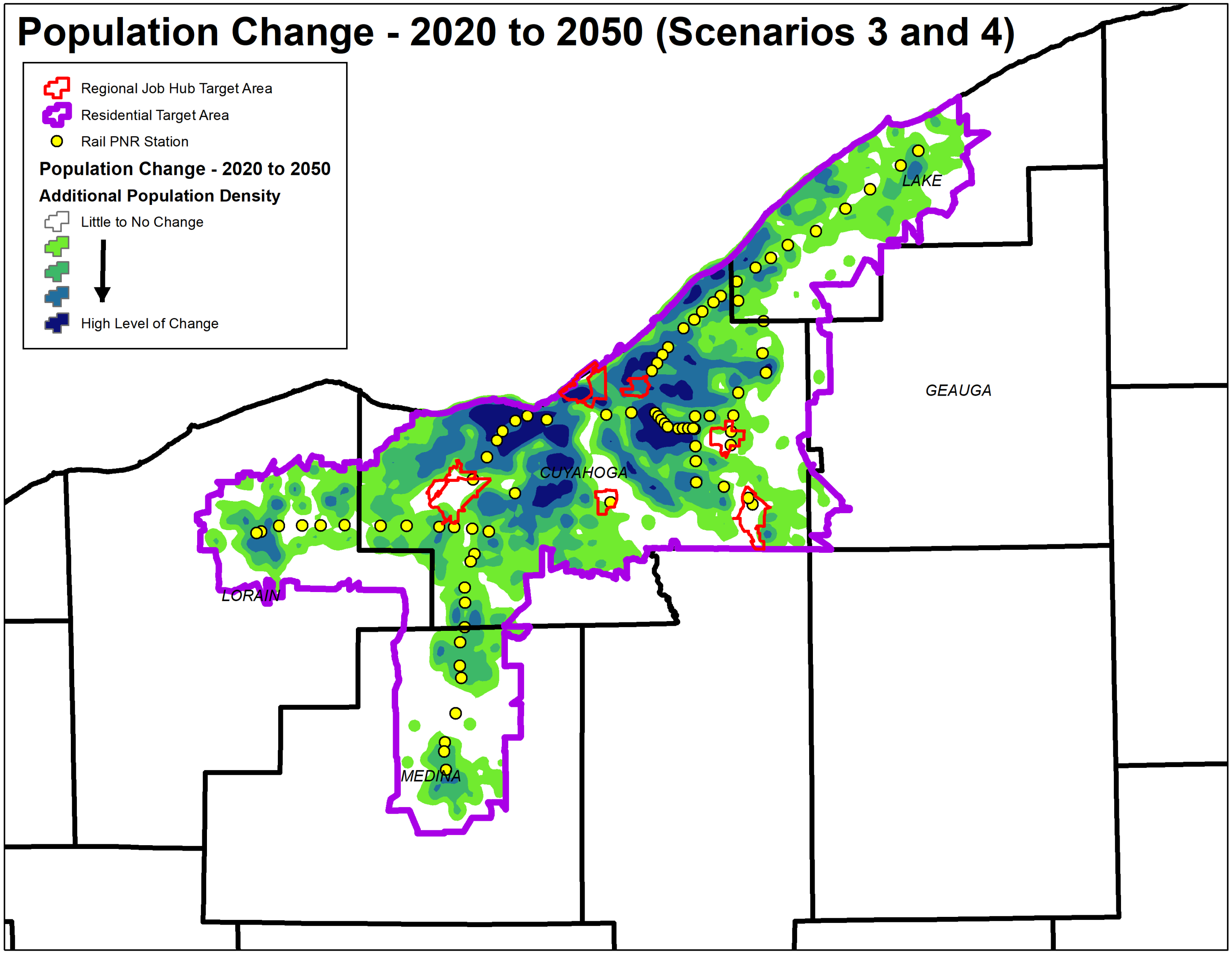
Table 9-8: Regional Population Growth (2020-2050) – Scenarios 3 and 4 (Continued)

	Regional Population Growth 2020 – 2050				
	Population	**Workers**	**Households**	**Single Family**	**Multi Family**
Scenario 3	101,343	52.451	42,860	8,572	34,288
Scenario 4	202.687	104,901	85,720	17,144	68,576

Source: NOACA Travel Forecasting Model (February 2021)

Map 9.30 displays the residential target area and where the population, households and worker density increases occurred in both Scenarios 3 and 4.

Figure 9-46. Population Density Increases within Residential Target Area – Scenarios 3 and 4



Source: NOACA Analysis of TAZ forecasts from the NOACA Travel Forecasting Model (February 2021)

Along with population and housing considerations, the industries in which workers are employed was also a variable in Scenarios 3 and 4. The 5-mile buffer zones around the major job hubs and expanded transit rail corridors were analyzed for their 2020 employment industry sector breakdowns. Then workers employed in the particular employment sectors that are highly concentrated in these areas were then selected to make up the growth of residents living near the regional job hubs and rail corridors.

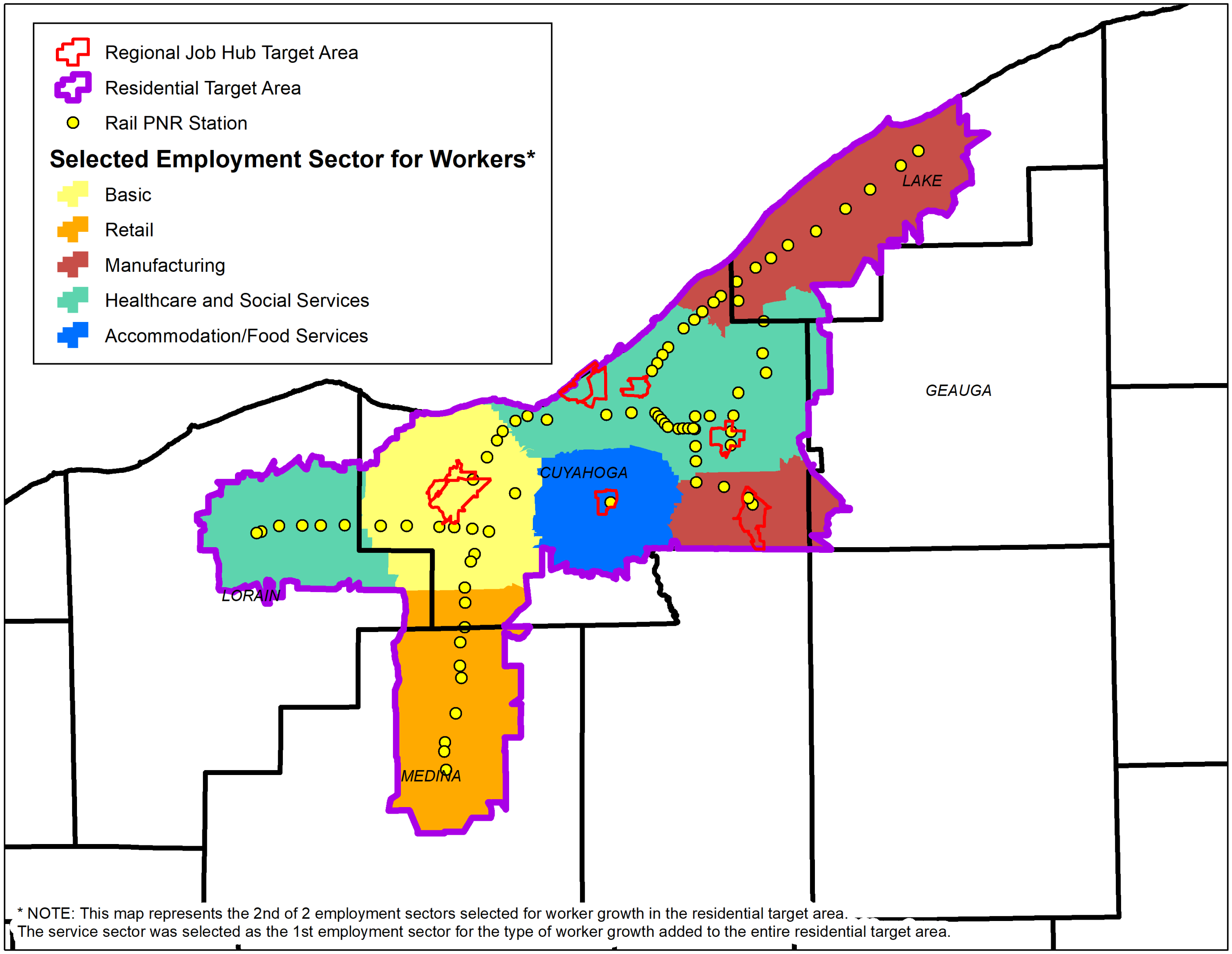
Then two of the NOACA model employment categories that had the highest concentrations were selected for each 5-mile buffer zone around the major job hubs and expanded rail corridors. Workers employed in these two industries were then directed in the NOACA travel forecasting model to these buffered areas. This process was utilized to have workers who work in certain industries live in areas with a high concentration of those types of jobs. This was designed to shorten the work commute of many residents in the region with the intent of reducing the region's overall VMT.

The NOACA travel forecasting model divides employment into seven broad industry sector classifications:

- Basic (agriculture, construction, utilities, transportation, etc.)
- Retail
- Service (finance, insurance, real estate, information, government, management of companies, etc.)
- Manufacturing
- Education
- Healthcare and Social Services
- Accommodations and Food Services

The service sector is the largest employment sector for all the buffer zones. This may sound counterintuitive to the reader. The data provided in Chapters 5 clearly showed that Healthcare and Social Assistance had become the largest sector in Northeast Ohio by total employment. However, the combination of all the other industries within the broader service sector still exceeds the health care component that NOACA staff separated for this particular analysis. Since the service sector is the largest across all the buffer zones of the major regional job hubs, service workers were selected for a portion of the employment increase in all TAZs throughout the targeted area. The second largest employment sectors varied throughout the buffer zones according to hub (see Figure 9-47).

Figure 9-47. Selected Employment Sectors for Growth of Workers in Targeted Residential Area in Scenarios 3 and 4



Source: NOACA Travel Forecasting Model (February 2021)

For the employment growth in both Scenarios 3 (5%) and 4 (10%), NOACA staff targeted jobs for the six existing major regional job hubs. This occurred in a similar process as the population growth. TAZs with the most employment relative to all of the TAZs within all of the job hubs received the most employment growth; the others received less. This ensured TAZs with high job density in 2020 would experience the highest job density growth by 2050. Map 9-32 shows the target areas and their associated job density increases under this distribution method.

The types of jobs destined for the job hubs were handled in a similar way. For the growth allocated to these major job hubs, the employment sectors with the highest concentrations in 2020 were selected for these targeted job areas. Service jobs were the highest category for each of the hubs, and thus jobs in this employment sector were selected for placement in all of the job hubs. The second highest grouping of job types varied throughout the hubs. Since employment sector types were not evenly distributed across the job hubs, all of the employment types were not increased by the same 10% growth rate. To account for the differences in the breakdown of employment types, varying growth percentages were assigned to the selected employment sector types. In the end, these percentages balanced out regionally to the predetermined growth rate in total jobs for Scenarios 3 and 4 (5% and 10%, respectably). Tables 9-9 and 9-10 show the details of the employment changes for both Scenarios 3 and 4.

Table 9-9. Regional Employment Change by Percentage (2020-2050) – Scenarios 3 and 4

	Regional Employment Change (%): 2020-2050					
	Total	**Basic**	**Service**	**Manufacturing**	**Healthcare**	**Accommodation/ Food Services**
Scenario 3	5	3	7	3	8	3
Scenario 4	10	6	16	6	16	6

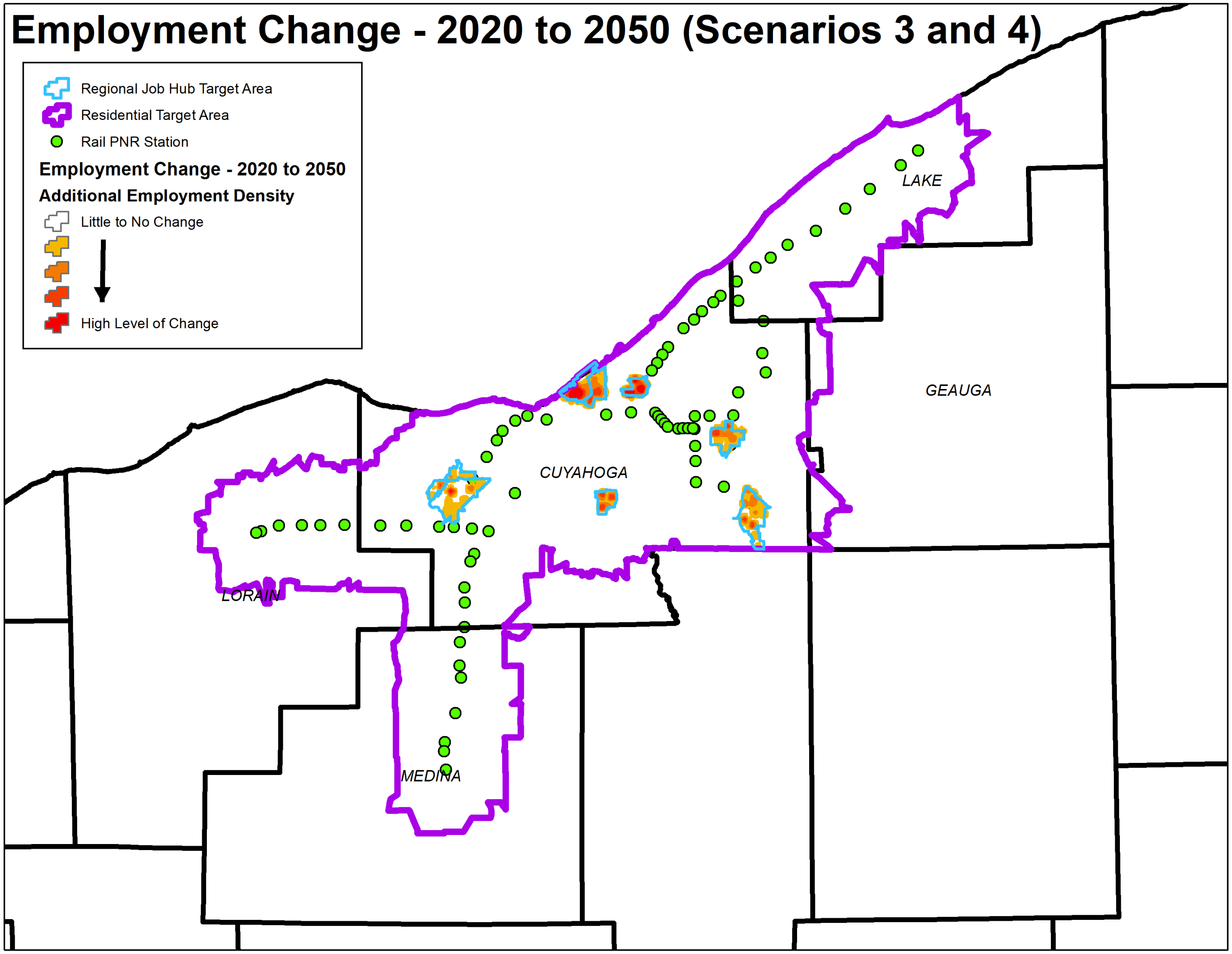
Source: NOACA Travel Forecasting Model (February 2021)

Table 9-10. Regional Employment Change by Number (2020-2050) – Scenarios 3 and 4

	Regional Employment Change (#): 2020-2050					
	Total	**Basic**	**Service**	**Manufacturing**	**Healthcare**	**Accommodation/ Food Services**
Scenario 3	70,245	6,213	32,274	6,172	21,558	4,028
Scenario 4	140,875	11,554	68,482	11,477	42,871	7,491

Source: NOACA Travel Forecasting Model (February 2021)

Figure 9-48. Employment Density Increases within Job Hub Employment Target Areas – Scenarios 3 and 4



Source: NOACA Analysis of TAZ forecasts from the NOACA Travel Demand Forecasting Model (February 202

Scenario Development and Project Lists

Each LRTP scenario comprises three types of projects;

- Common projects,
- Shared projects between two scenarios (**Shown in bold**)
- Scenario specific projects.

Common Projects: The following common projects are included in all the scenarios:

- Addressing location-Specific Safety issues
- Reducing Traffic Fatalities & Major Injuries
- Installing EV charging Ports
- Pavement & Bridge Conditions with Average Pavement Condition Rating (PCR) of 75
- Smart Pedestrian Crossings.
- **Congestion Management Plan**
    - Work Zones Management
    - Implementing TDM
    - Special Events Traffic Management
    - Faster Traffic Incidents Responses
    - Encouraging Telecommute

Scenario 1: MAINTAIN: This Scenario includes the following projects:

- Allocating 100% of the annual budgets to Maintenance,
- Maintaining Pavement & Bridge Conditions at the Average Network PCR of 80,
- Maintaining Pavement Conditions at Minimum PCR of 80 in the EJ areas,
- Maintaining Transit Vehicles in the Good State in the end of each Decade,
- Maintaining Transit Vehicles Serving the EJ Areas in the Good State all the time.

Scenario 2: CAR: This Scenario includes the following projects:

- **Future Highway Network including Major Capacity Projects**
- Adding Viable Interchanges
- Reinvigorating Arterial Network
- Traffic Signal Timing Optimization
- Reducing highway Bottlenecks
- Reducing Average Auto Commute Times to Major Job Hubs to 30 Minutes
- Regulating the Flow of traffic Entering Freeways (Ramp Metering)

Scenario 3: TRANSIT: This Scenario includes the following projects:

- **Improved 2017 Visionary Rail Network**
- **Adding Autonomous Shuttle and POD Routes from Major Transit Hubs to Major Job Hubs**
- **Creating Walk & Bike Connections from Major Transit Hubs to Major Job Hubs**
- Implementing Transit Agencies' Future Bus / BRT Plans

- Reducing Transit Service Headways to EJ Neighborhoods
- Reducing Transit Commute Time to Major Job Hubs to 45 Minutes
- Adding HOV Lanes
- Creating Walk & Bike Access from EJ Areas to Transit Network.

Scenario 4: TOTAL: This Scenario includes the following projects:

- **Future Highway Network including Major Capacity Projects**
- **Improved 2017 Visionary Rail Network**
- **Adding Autonomous Shuttle and POD Routes from Major Transit Hubs to Major Job Hubs**
- **Creating Walk & Bike Connections from Major Transit Hubs to Major Job Hubs**
- Reducing Transit Commute Times to Major Job Hubs to 30 Minutes
- Reducing Auto Commute Times to Major Job Hubs to 20 to 30 Minutes
- Allocating Selected Smart Freeway & Arterial Lanes to Autonomous Cars and Trucks
- Installing Extra PEV Charging Ports
- Constructing the Hyperloop Station
- Creating Walk & Bike Access from Major Residential to Transit Network

Infrastructure Scenario Development and Technology Adaptation

The previous section introduced the emerging new technology in transportation and in the sections that followed, these electric and driverless vehicles were embedded in scenarios 3 and 4 more than other two scenarios.

As discussed, there are high uncertainties regarding how these technologies will develop, when their acceptance in the marketplace will occur and what additional investments may be needed to facilitate their adoption. Considering all these uncertainties, predicting the modal share of these advanced vehicles would generally be difficult. As with many new technologies, the opinions and forecasts among industry experts wildly vary, but all experts agree that the development of these vehicles will be incremental in the next decades advancing through the automation levels shown in Table 9.6. Some experts believe that by 2050 cars will be fully autonomous and electric, with advanced customization technology. Others predicts that by 2050 there will be about three billion light-duty vehicles on the road worldwide, up from one billion now. At least half of them will be powered by internal combustion engines using petroleum–based fuel.

This plan considers a conservative prediction for replacing convention car and trucks by fully automated and electric vehicles and Table 9-11 shows the predicted percent of vehicle shares of daily vehicular trips for the four developed scenarios.

Table 9-11. Vehicle Shares of Daily Vehicular Trips

Scenario	Conventional Car & Truck	PEV and Autonomous, Car &Truck	Autonomous Shuttle Bus, POD and Hyperloop
Scenario 1: MAINTAIN	81%	18%	1%
Scenario 2: CAR	81%	18%	1%
Scenario 3: TRANSIT	80%	18%	2%
Scenario 4: TOTAL	68%	28%	4%

It should be noted that assuming higher share percent for autonomous vehicles in scenario 4 is due to allocating smart highway lanes to these types of vehicle in the modeling process and installing extra PEV charging ports.

Scenario Evaluation : Performance Measures

As discussed in the previous section, four differentiable scenarios were developed based on:

- Moving forward to achieve the established NOACA five goals,
- Developing an equitable transportation system for improving the entire NOACA region socially and economically,
- Improving access to the transportation system for providing more modal options to all residents,
- Attracting commercial entities to the NOACA region in order to make it more globally competitive,
- Preparing the region for adaptation of emerging transportation technology,
- Reducing the potential negative impacts of transportation on society and the environment, and
- The results of the recent public engagement efforts.

The 2050 developed scenarios were modeled using the NOACA travel forecasting model and the modeling results illustrate performance of scenarios from many various prospects. This section provides a framework based on a set of performance measures for evaluating scenarios and consequently prioritizing their projects and determining their implementation decades. The selected scenario will be one of the four scenarios or combination of them as an optimal scenario with a list of highway, transit, active transportation and technology adaptation projects.

Some scenarios include several future projects with significant investments. In the following sections, annual cost or required budget of scenarios will be estimated based on their project lists. In the next Chapter, the scenario required budget will be compared with the estimated annual available budgets as a set of constraints.

The final Chapter will include a practically applicable scenario which satisfy not only the transportation operation aspects, but the annual available budgets. Obviously, the budget constraint will impact the priority and implementation decades and years of the included projects.

Performance Measure Categories

This section discusses a set of performance measures for scenario evaluation and comparative analysis. Table 9-12 displays the performance measure categories and the selected measures.

Table 9-12. Performance Measure Categories and Selected Performance Measures

Performance Measure Category	Performance Measures
Multimodal Transportation System	• Percent of Non-Single Occupancy Vehicles • Annual Transit Ridership
Access to Transportation System	• Access to all Transit Stops • Egress from All Transit Stops • Access to Highway System
Mobility & Delay	• Total Annual Total VMT per Capita • Total Annual Freeway Delay per Capita • Annual Total Annual Principal Arterial Delay Per Capita • Annual Person Hours of Excessive Delay per Capita (PHED)
Transportation Cost	• Annual Congestion Cost Per Capita
Travel Time	• Average Auto Work Commute Time to All Major Job hubs • Average Transit Work Commute Time from EJ Neighborhoods to All Major Job Hubs • Average Work Commute Time From Households with Zero Cars • Maximum Level of Travel Time Reliability (LOTTR) • Maximum Truck Travel Time Reliability (TTTR)
Traffic Safety	• Fatalities, Serious Injuries and Non-motorized Fatalities and Serious Injuries
Emission	• Daily Volatile Organic Compound(VOCs) and Nitrogen Oxides (NO_x) • Annual Direct PM
Pavement & Bridge	• Average Highway Network Pavement Condition Rating (PCR) • Percent Structurally Deficient Deck Areas of All Bridges and NHS Bridges
Technology Adaption	• Daily Vehicular Trip Share of Autonomous, Electric Cars & Trucks

Evaluation Method

Effectiveness of the developed scenarios is correspond to the accomplishment of the LRTP goals and objectives. The general effectiveness of each scenario is assessed based on its performance in regard with a set of selected transportation planning and traffic engineering measures.

The Scenario 1 (MAINTAIN) does not include any specific expansion or enhancement projects apart from the common projects. Therefore, this scenario is considered as the "Do Nothing" case in similar planning processes and its performance measures are assumed as the benchmark values for evaluating other scenarios and implementing a comparative analysis.

The evaluation process comprises of four steps:

1. The scenario performance measure values of all the selected performance measures are estimated.
2. The estimated scenario performance measures is compared with those of scenario 1 to determine the percent of differences.
3. A weighting value is assumed for each performance measure. The public feedback had some impacts on determining the weighting values.
4. All the weighted difference percent values are summed to a single Scenario Measure of Effectiveness (SMOE) value.

$$\boldsymbol{SMOE_i} = \sum \alpha_j \times PM_{ij}$$

Where;

$\boldsymbol{SMOE_i}$: *Total of the weighted performance measure values for scenario i*

PM_{ij}: *Difference value percent of performance measure j for scenario i compared with the same performance measure value of scenario 1*

$\boldsymbol{\alpha_j}$: *Weighting value of Performance measure j.*

Table 9-13 shows the weighting values and scenario performance measure values. In this Table, the performance measures that highlighted in green should have higher values in order to be more effective. In contrast, the performance measures that highlighted in brown should have lower values in order to be more effective.

Table 9-13. Estimated Scenario Performance Values

Performance Measure	Weighting Value	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Population in 15 Minutes Walk to any Transit Stop	0.34	65%	65%	70%	70%
EJ Workers in 15 Minutes Walk to any Transit Stop	0.33	88%	88%	90%	90%
Number of Jobs within 15 Minutes Walk egress from any Transit Stop	0.33	77%	77%	81%	82%
Population in 5-Mile Drive Access to Freeway System	1	91%	92%	92%	92%
Annual Transit Ridership (Including Transfer Trips) – Million Person Trips	2	38	38	91	110
Non-Single Occupancy Vehicle Work Commute during a Typical Morning Peak Period	1	16%	16%	21%	22%
Average Highway Network Pavement Condition Rating (PCR)	1	80	87.1	87.1	87.1
Daily Vehicular Trip Share of Autonomous, Electric Cars and Trucks	2	19.00%	19.00%	20.00%	32.00%
Total Annual Vehicle Miles Traveled per Capita	1	7,946	7,967	7,433	7,243
Total Annual Freeway Delay per Capita (in Hours)	2	7.11	7.34	7.98	5.89
Total Annual Principal Arterial Delay per Capita (in Hours)	1	7.2	6.7	7.4	8.1
Annual Person Hours of Excessive Delay per Capita (in Hours)	2	24.89	24.38	25.1	25.64
Average Auto Work Commute Time to All Major Job Hubs (in Minutes)	1	37.7	37.5	39	40.4
Average Transit Work Commute Time from EJ neighborhoods to All Major Job Hubs (in Minutes)	1	60.4	60.3	58.6	54.3

Table 9-13. Estimated Scenario Performance Values (Continued)

Performance Measure	Weighting Value	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Average Work Commute Time for Households with Zero Cars (in Minutes)	1	42.88	42.85	41.77	41
Maximum Level of Travel Time Reliability (LOTTR)*	1	1.52	1.5	1.51	1.49
Maximum Truck Travel Time Reliability (TTTR)*	1	1.83	1.86	1.88	1.86
Annual Congestion Cost per Capita (2050$)	3	821	807	854	804
Estimated Fatalities (Based on 2019 Crash Data and Annual 2% Reduction)	1	75	75	75	75
Estimated Serious Injuries (Based on 2019 Crash Data and Annual 2% Reduction)	1	713	713	713	713
Estimated Non-Motorized Fatalities and Serious Injuries (Based on 2019 Crash Data and Annual 2% Reduction)	1	91	91	91	91
Daily Volatile Organic Compounds (VOCs) (in Tons)	1	9.25	9.28	9.28	9.48
Daily Nitrogen Oxides (NO_x) (in Tons)	1	8.34	8.36	8.36	8.54
Annual Direct PM (in Tons)	1	209.65	210.21	210.32	214.66
Structurally Deficient Deck Areas of NHS Bridges	1	1.77%	1.77%	1.77%	1.77%
Structurally Deficient Deck Areas of All Bridges	1	6.57%	6.57%	6.57%	6.57%

Note: LOTTR values are estimated as the ratio of 80th percentile and 50th percentile of all the inter-zonal travel times.

Note: TTTR values are estimated as the ratio of 95th percentile and 50th percentile of all the inter-zonal travel times.

Table 9-14 exhibits the general effectiveness of all the scenarios in achieving the goals and objectives of the LRTP compared with that of that of scenario 1 as “DO nothing” case. For instance, the total weighted MOE of scenario 4 is about six times than that of the scenario 1.

Table 9-14. Estimated Total Measures of Effectiveness

Scenario	Ratio of Estimated Scenario SMOE to the SOME of Scenario 1
1: MAINTAIN	1
2: CAR	0.19
3: TRANSIT	3.00
4: TOTAL	6.00

In the following sections, the total capital cost and the annual required budgets of scenarios will be estimated and synthesize with the SMOE ratios.

Scenario Costs

Transportation projects are the building blocks of the developed scenarios and their categories are; highway, transit, non-motorized, and emerging technology. It is envisaged that these projects will progressively be implemented during the next three decades.

As discussed in section 9.3.3, each scenario comprises of common projects, shared projects with another scenario and scenario specific projects. Table 9-15 displays the list of scenario projects and their planned implementation decades.

Table 9-15. Scenario Projects and their Planned Implementation Decades

Scenario Projects	Decades		
	2020 - 2030	2030 - 2040	2040 - 2050
Highway			
Regulating Flow of Traffic Entering Freeways by Adding Ramp Meters	Scenario 2		
Reinvigorating Arterial Network and Optimizing Traffic Signals			
Reducing Highway Bottlenecks			
Adding Viable Interchanges			
Maintain Pavement conditions in EJ neighborhoods with average of PCR = 80	Scenario 1		
Adding High Occupancy Vehicle Lanes		Scenario 3	
Implementing Major Highway capacity Projects	Scenarios 2 and 4		
Implementing 2024 TIP Highway and Transit Projects	All Scenarios		
Maintain Pavement Conditions with average of PCR = 75	All Scenarios		
Addressing Location-specific Safety issues in order to Reduce Traffic Fatalities			
Maintain Bridges in Good or Fair Conditions			

Table 9-15. Scenario Projects and their Planned Implementation Decades (Continued)

Scenario Projects	Decades		
	2020 - 2030	2030 - 2040	2040 - 2050
Transit			
Implementing Future Transit Agencies' Bus/BRT Routes		Scenarios 3 and 4	
Adding Improved 2017 Visionary Rail Network		Scenarios 3 and 4	Scenarios 3 and 4
Maintain Transit Vehicles in the Good State in the end of each Decades	Scenario 2	Scenario 2	Scenario 2
Maintain Transit Vehicles Serving the EJ Areas in the Good State all the times	Scenario 2	Scenario 2	Scenario 2
Reducing Transit Service headways to EJ Areas		Scenario 3	
Workforce Accessibility and Mobility			
Improve Average Auto and Transit Commute Times to Major Job Hubs	Scenario 1		
Reducing Average Auto Commute time to Major Job Hubs to 30 minutes		Scenario 2	
Reducing Average Transit Commute Time to Major Job Hubs to 45 minutes		Scenario 3	
Reducing Average Auto Commute Time to Major Job Hubs to 20 - 30 minutes			Scenario 4
Reduce Average Transit Commute Time to Major Job Hubs to 30 minutes			Scenario 4
Non-Motorized Facility			
Creating Walk and Bike Access from EJ Areas to Transit Network	Scenario 3	Scenario 3	Scenario 3
Creating Walk and Bike Connections from Major Transit Hubs to Major Job Hubs	Scenarios 3 and 4	Scenarios 3 and 4	Scenarios 3 and 4

Creating Walk and Bike Access from Major Residential Areas to Transit Network	Scenario 4
Implement Smart Pedestrian Crossings	All Scenarios

Table 9-15. Scenario Projects and their Planned Implementation Decades (Continued)

Scenario Projects	Decades		
	2020 - 2030	2030 - 2040	2040 - 2050
Emerging Technologies in Transportation			
Installing EV Charging Ports	All Scenarios		
Adding POD and Shuttle CAV Services from Major Transit Hubs to Major Job Hubs			Scenarios 3 and 4
Installing Extra EV Charging Ports			Scenario 4
Constructing the Hyperloop Station			
Allocating Selected Smart Freeway and Arterial Lanes to Autonomous Vehicles			

The plan year for the LRTP is 2050 and therefore the analysis period comprises of the next three decades of 2020-2030, 2030-2040 and 2040-2050. Considering the general budget and revenue annual basis, the project costs were estimated based of the dollar values of the project implementation years.

Table 9-16 displays the Net Present Value (NPV) of the total capital costs of projects by their categories.

Table 9-16. NPV (2020$) of Estimated Total Annual Budget Requirements by Project Category

Project Category	Net Present Value of Aggregated Annual Budget Requirements (2020$) Billions	Percent of the Total NPV (2020$)
Highway	10.432	52%
Transit	8.379	42%
Non-Motorized Facility	0.540	3%
Emerging Technology	0.782	4%
Total	**20.133**	**100%**

Table 9-17 shows the NPV of the total capital costs of the common projects which included in all the scenarios and also the scenario specific costs. It should be noted that there are projects shared with only two projects and their costs are included in both scenarios. This table also includes the NPV percent of the total costs for scenario specific projects compared with the grand total. It should be noted that the total NPV in Table 9-17 is higher than that of Table 9-16. This is due to the fact that there are a few projects, such as the visionary rail network project, which is shared between scenarios 3 and 4 and therefore their annual project costs are accounted for in both scenarios.

Table 9-17. NPV (2020$) of Estimated Total Specific Project Costs of Scenarios

Scenario	Net Present Value of Total Project Costs (2020$) Billions	Percent of the Total NPV (2020$)
Common Projects	9.280	32.49%
Scenario 1: MAINTAIN	1.298	4.54%
Scenario 2: CAR	1.845	6.46%
Scenario 3: TRANSIT	7.004	24.52%
Scenario 4: TOTAL	9.134	31.99%
Total	**28.561**	**100%**

Table 9-18 illustrates the percent of the NPV of the total project costs of the common projects and the scenario specific projects by project categories.

Table 9-18. Percent of NPV (2020$) of Estimated Total Specific Project Costs of Scenarios by Project Category

Scenario	Roadway	Transit	Non-Motorized Facility	Emerging Technology	**Total**
Common Projects	27.19%	4.74%	0.01%	0.55%	**32.49%**
Scenario 1: MAINTAIN	2.77%	1.77%	0.0%	0.0%	**4.54%**
Scenario 2: CAR	6.46%	0.0%	0.0%	0.0%	**6.46%**
Scenario 3: TRANSIT	0.1%	22.83%	1.13%	0.46%	**24.52%**
Scenario 4: TOTAL	6.04%	22.82%	0.93%	2.2%	**31.99%**
Total	**42.56%**	**52.16%**	**2.07%**	**3.21%**	**100%**

As shown in Tables 9-17 and 9-18, the share of the common project costs is approximately one third of the NPV of the total project costs. As mentioned before, the scenario 1 maintains the system only and does not include any enhancement or expansion projects. The Specific project cost for this scenario is the lowest value and the specific project cost of the scenario 4 is the highest.

The scenario specific projects determine the difference between scenario costs. Similar to the relative scenario effectiveness discussed in the previous section, the quotients of the additional scenario capital costs divided by the lowest scenario additional cost (that of the "Do Nothing" case) shown in Table 9-19, provide a set of comparison values.

Table 9-19. NPV Cost Percent of Scenarios and Comparison Ratios

Scenario	NPV Cost Percent of Scenario Specific Projects	Ratio of Scenario Specific Cost Percent to Scenario 1 Specific Cost Percent
Scenario 1: MAINTAIN	4.54%	1
Scenario 2: CAR	6.46%	1.42
Scenario 3: TRANSIT	24.52%	5.40
Scenario 4: TOTAL	31.99%	7.04

Combining the SMOE values with the estimated scenario specific project cost ratios in Table 9.19 results in an indication for the economic return of scenarios. Table 9-20 shows the ratio of SMOE and the total costs.

Table 9-20. Ratio of SMOE and Scenario Cost Ratios

Scenario	SMOE Value Relative to Scenario 1 SMOE	Specific Project Cost Quotient Values	Ratio of SMOE Values and Corresponding Cost Values
Scenario 1: MAINTAIN	1.00	1.00	1.00
Scenario 2: CAR	0.19	1.42	0.13
Scenario 3: TRANSIT	3.00	5.40	0.56
Scenario 4: TOTAL	6.00	7.04	0.85

Considering the ratio of SMOE and corresponding costs as an indication of economic return, then as illustrated in Table 9-20, the economic returns of all the scenarios are less than that of the scenario 1, “Do Nothing” case, as the benchmark. Therefore, these comparison results indicate that the hybrid scenario may have a higher level of economic return. In the next chapter the scenario costs will also be compared with the predicted available annual budgets to identify a hybrid and fiscally constraint scenario with the economic return greater than 1.

Scenario Evaluation Summary

This section summarizes the comparative analysis results based on the scenario performance measures.

- **Scenario 1: MAINTAIN**
  - Transit ridership is the lowest.
  - The lowest number of people with 5-mile drive access to freeway system.
  - Higher VMT compared with the current VMT.
  - Requires the least capital investment.

- **Scenario 2: CAR**
  - The percent of the drive alone choice is same as today.
  - Access to highway system is slightly improved.
  - The lowest arterial delay.

- **Scenario 3: TRANSIT**
  - Doubles the transit ridership.
  - More people and workers have walk access to buses and rails.
  - Number of EJ workers living inside the 30 minutes transit commute time shed is higher than today.

- **Scenario 4: TOTAL**
  - Transit ridership is almost tripled.
  - Access to transit and freeway systems are simultaneously improved.
  - Technology adaptation rate is the highest.
  - Higher budget and efficient distribution are required.