Policy Context and Current Conditions

Transbay travel consists primarily of private vehicles and buses on the San Francisco-Oakland Bay Bridge and a heavy rail tube operated by BART. The Transbay Joint Powers Authority (TJPA) is overseeing the construction of a new, estimated $3.9 billion Transbay Transit Center to unify and improve transit service into San Francisco. The first phase is a new bus terminal, scheduled to open in late 2017, that will serve transbay AC Transit buses and other intercity bus operators.[31] The second phase is the Downtown Rail Extension (DTX), which will extend existing Caltrain service from the peninsula into the Transbay Transit Center, 1.3 miles from its current terminus at 4th Street and King Street.[32]

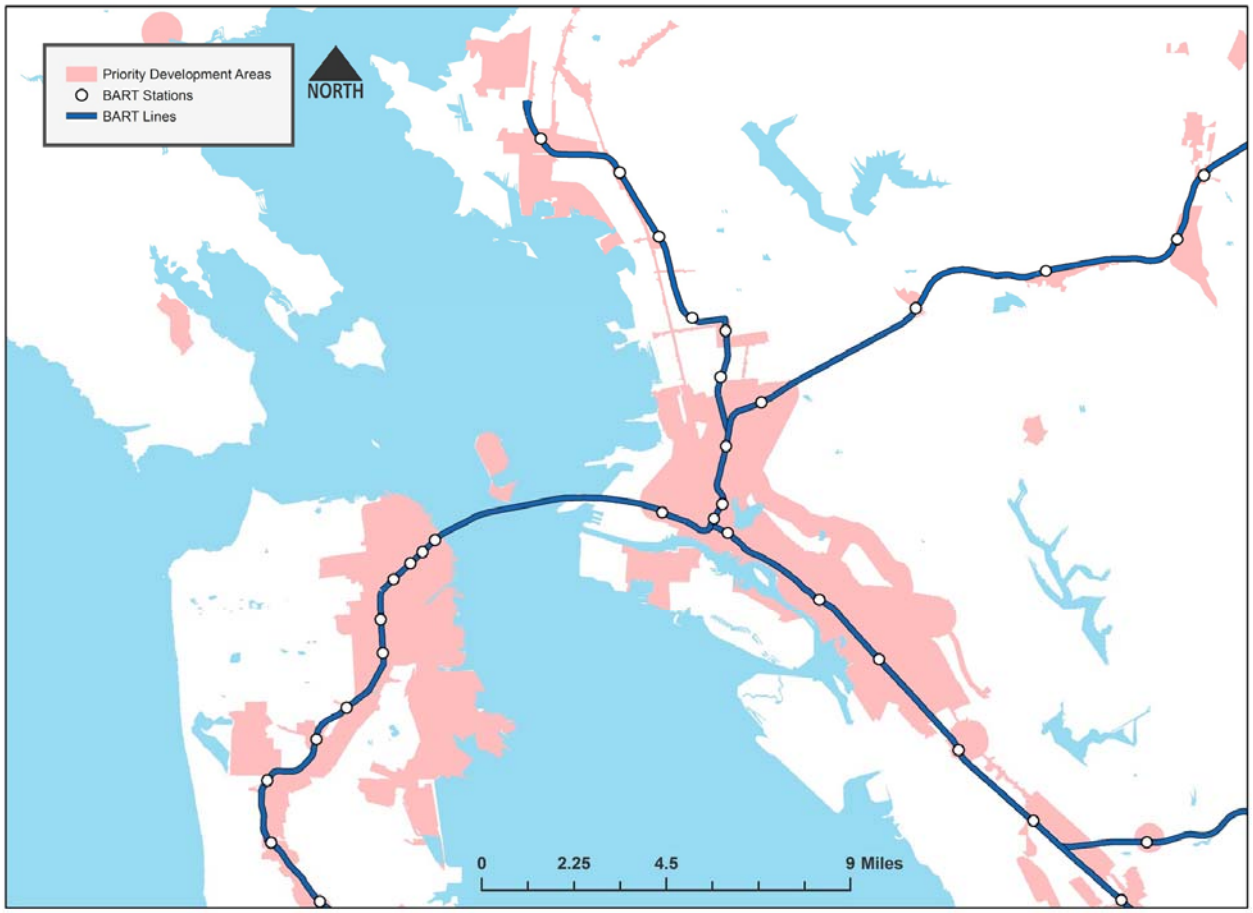
Policy Context

Transportation policy and provision in the Bay Area is situated within a complex policy context, featuring many actors with overlapping jurisdictions and responsibilities.[33] As the federally designated regional transportation planning agency, the Metropolitan Transportation Commission (MTC) coordinates with Bay Area municipalities, the nine county governments, transit operators, and a variety of other county, regional, and state agencies. MTC is responsible for allocating federal and state transportation funding and managing programs like freeway express lanes and the regional transit pass program.

MTC also coordinates with the Association of Bay Area Governments (ABAG) to lead the region's long range planning efforts. In 2013 the two agencies adopted Plan Bay Area, the most recent long range plan. The plan was developed in concordance 2008's California Senate Bill 375 (SB 375), which mandates coordinated transportation and land use planning to achieve 15% regional greenhouse gas emissions reductions by 2035. Plan Bay Area establishes Priority Development Areas (PDAs)—some of which touch the existing transbay crossings (see Figure 2)—that are intended to receive 80% of new housing and 60% of new jobs. A new transbay crossing would increase transit access and service in the PDA areas shown and would likely support sustainable development consistent with Plan Bay Area, due to be updated in 2017.

Figure 2: Priority Development Areas

[31] Transbay Joint Powers Authority. Current Activity web page. http://transbaycenter.org/construction-updates/updates-notices/current-activity. Accessed 8 December 2016.
[32] Sabatini, Joshua. "Funding blocked for transit center amid concerns of sinking Millennium Tower." San Francisco Examiner. 27 September 2016. http://www.sfexaminer.com/funding-blocked-transit-center-amid-concerns-sinking-millennium-tower/.
[33] Metropolitan Transportation Commission. "What We Do" web page. http://mtc.ca.gov/about-mtc/what-mtc/what-we-do. Accessed 9 December 2016.



Source: Map produced by students in the Fall 2016 Transportation Planning Studio.

Another policy with funding implications for a new crossing is California's cap-and-trade program, which has become a major source for transportation and housing projects around the state. It forces large polluters to buy emissions offsets, the proceeds from which must be spent to reduce greenhouse gas emissions. Senate Bill 535 (SB 535, 2006) codified requirements for program expenditures on disadvantaged communities, and 2016's Assembly Bill 1550 (AB 1550, 2016) increased this apportionment. At least 25% of program money must be spent to benefit Disadvantaged Communities, with another 10% to benefit low-income households or communities.[34] [35] [36] [37] [38]

[34] AB 1550 defines low-income as at or below 80% of statewide median income, or at or below the state low-income limits designated by the Department of Housing and Community Development.
[35] Gomez. AB 1550. Greenhouse gases: investment plan: disadvantaged communities., Pub. L. No. AB 1550 (2016). Retrieved from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB1550
[36] Official State Income Limits for the California Department of Housing and Community Development are provided at the following website: http://www.hcd.ca.gov/housing-policy-development/housing-resource-center/reports/state/incnote.html
[37] De León. SB 535. California Global Warming Solutions Act of 2006: Greenhouse Gas Reduction Fund (2012). Retrieved from http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120SB535
[38] The Greenlining Institute. (n.d.). Environmental Equity Senate Bill 535. Retrieved December 1, 2016, from http://greenlining.org/issues-impact/environmental-equity/cap-and-trade/senate-bill-535/

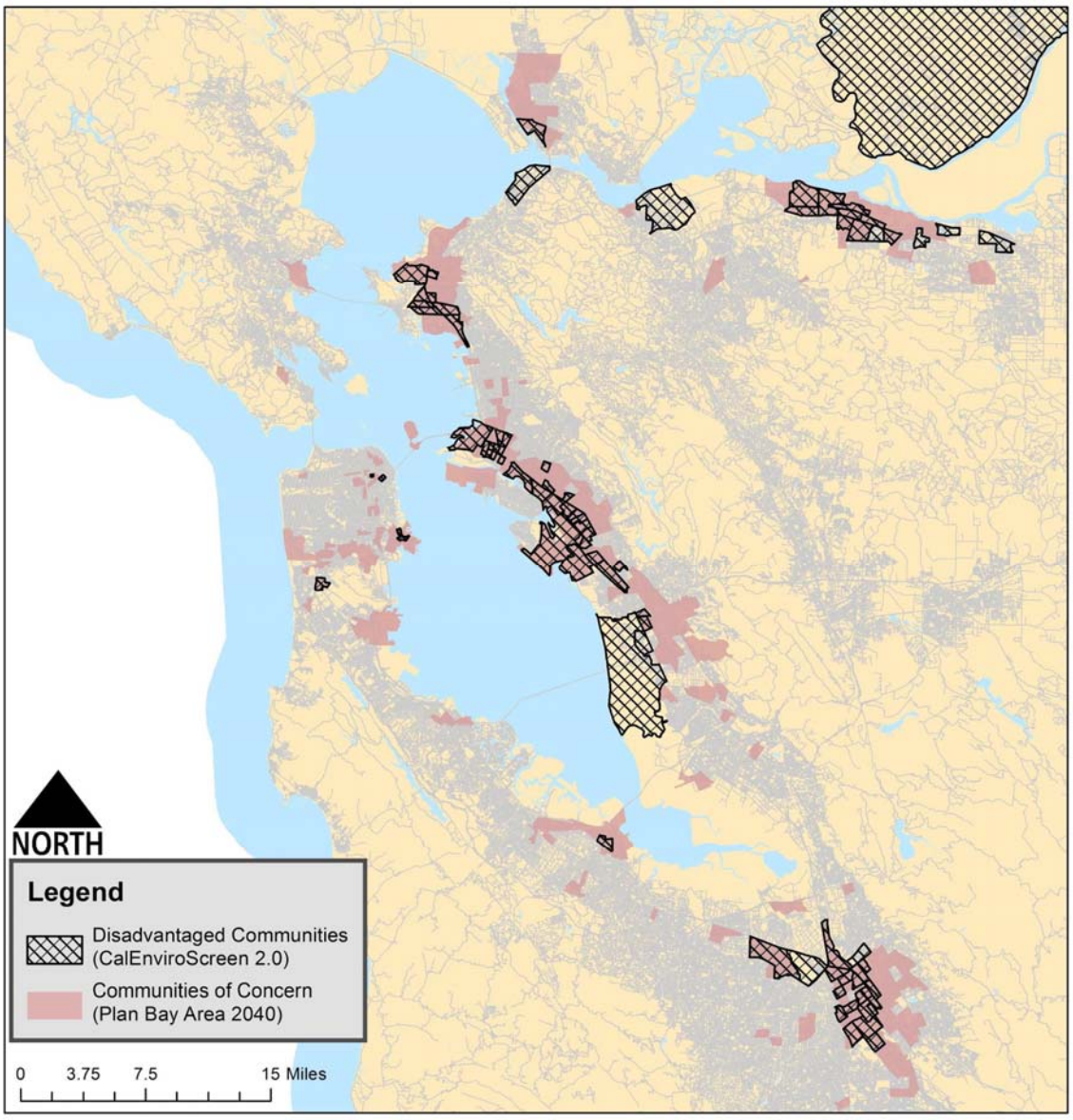
There is some debate about the program's definition of a disadvantaged community. Disadvantaged Communities are officially identified with an analysis tool called CalEnviroScreen 2.0, which makes a determination based on 19 environmental and social factors at the census tract level (Bridegam, 2014).[39] The tool is being revised, and MTC was one among many agencies that expressed concern that the revisions exclude many low-income communities from its *disadvantaged* classification. This reclassification could eliminate cap-and-trade funds that pay for transit and other programs in low-income communities, with negative outcomes for social equity.[40]

MTC and ABAG use a different set of criteria than the State of California and SB 535 to analyze the social equity impacts of Plan Bay Area. Their defined Communities of Concern differ from the cap-and-trade program's Disadvantaged Communities. Communities of Concern are census tracts with high concentrations of low-income households; people of color, the elderly, people with disabilities, zero-vehicle households, single-parent families, severely rent-burdened households, and households with limited English proficiency. A table further detailing these factors is in Appendix B. Figure 3 compares the boundaries of Disadvantaged Communities and Communities of Concern.

Figure 3: Comparison of Disadvantaged Communities and Communities of Concern

[39] Bridegam, M. (2014, September 12). Environmental justice and housing worlds seek meeting of minds on defining disadvantage | California Planning & Development Report. Retrieved May 9, 2015, from http://www.cp-dr.com/node/3570

[40] Metropolitan Transportation Commission. (2016, October 21). CalEnviroScreen 3.0 Draft: Public Comments. Retrieved from http://oehha.ca.gov/calenviroscreen/comment/calenviroscreen-30-draft-public-comments



Source: Map produced by students in the Fall 2016 Transportation Planning Studio.

Additional Agencies and Authorities

The San Francisco-Oakland Bay Bridge is managed by the Bay Area Toll Authority (BATA), which has operated under the oversight of the MTC since 1998. In 2010, BATA and MTC worked to implement a peak pricing toll scheme on the Bay Bridge to discourage drivers from crossing the bridge during the busiest time periods.[41]

[41] "A Closer Look at Congestion Pricing on the Bay Bridge." Berkeley Transportation Letter, ITS Berkeley. Winter 2012. http://its.berkeley.edu/btl/2012/winter/bridge%20toll.

The California State Transportation Agency (CalSTA) is the state office that oversees a number of transportation-related entities, including the Department of Transportation (Caltrans) and the High Speed Rail Authority (HSRA). Caltrans is responsible for managing much of the highway and freeway systems in the Bay Area and through the state, as well as providing inter-city rail services.[42] Since 1990 Caltrans has also entered into several agreements with private entities for the development, construction, and operation of toll roads.[43] HSRA is responsible for building the high-speed rail system that is planned to connect San Francisco to Los Angeles by 2029.[44] When completed, the high-speed rail service is planned to operate along the DTX route into the Transbay Transit Center in downtown San Francisco, with underground walkway connections to the existing rail systems.

CalSTA and Caltrans have been working on an update to the State Rail Plan that includes consideration of numerous rail links connecting to the Bay Area. The update to be released in 2017 is expected to set new strategic system goals, plan for more connections to existing local transportation infrastructure, and complement planned high speed rail development. This will mark a shift from past plans that have focused on more on the operations of individual systems and less on connections across the state and with local transit.[45]

The state has also established a number of entities that operate transit services within the Bay Area. BART was created by the state in 1957 to plan, construct, and operate a new heavy rail system for the region and was given the authority to levy voter-approved taxes for system finance.[46] The Peninsula Corridor Joint Powers Board was formed in 1987 to operate the commuter rail line from San Francisco to San Jose, and the Board purchased the track right of way in 1991.[47] The Capitol Corridor commuter rail service that operates between San Jose and Sacramento is governed by the Capitol Corridor Joint Powers Authority (CCJPA), which contracts with Amtrak for service operations. The 171-mile Capitol Corridor line runs almost entirely on privately owned railroad tracks held by the Union Pacific Railroad (UPRR).[48]

A new crossing project would also have potential environmental and ecological impacts on the San Francisco Bay itself. The state-established Bay Conservation and Development Commission (BCDC) is a coastal zone agency that has regional planning and regulatory authority across the Bay and its shoreline.[49] As a state agency, BCDC's mission is to protect the Bay from environmental or other harm, to enforce state law, and to ensure public access to the Bay within 100 feet of its shoreline. Any project

[42] About Caltrans web page. http://www.dot.ca.gov/aboutct.html. Accessed 9 December 2016.
[43] California Department of Transportation. Toll Road Fact Sheet web page. http://www.dot.ca.gov/hq/paffairs/about/toll/status.htm. Accessed 9 December 2016.
[44] About California High-Speed Rail Authority web page. http://www.hsr.ca.gov/About/index.html. Accessed 9 December 2016.
[45] Based on interviews and research conducted by students in the Fall 2016 Transportation Planning Studio, UC Berkeley Department of City and Regional Planning.
[46] "A History of BART: The Concept is born." https://www.bart.gov/about/history. Accessed 9 December 2016.
[47] Caltrain Historic Milestones web page. http://www.caltrain.com/about/Caltrain150/Milestones.html. Accessed 9 December 2016.
[48] Capitol Corridor 2014 Vision Plan Update Final Report. November 19, 2014. http://www.capitolcorridor.org/downloads/CCJPAVisionPlanFinal.pdf.
[49] San Francisco Bay Conservation & Development Commission website. http://www.bcdc.ca.gov/. Accessed 10 December 2016.

that would fill in or remove material from the Bay requires a BCDC permit, so a major infrastructure project like a new crossing would need to clear BCDC's approval.

Land Use and Growth

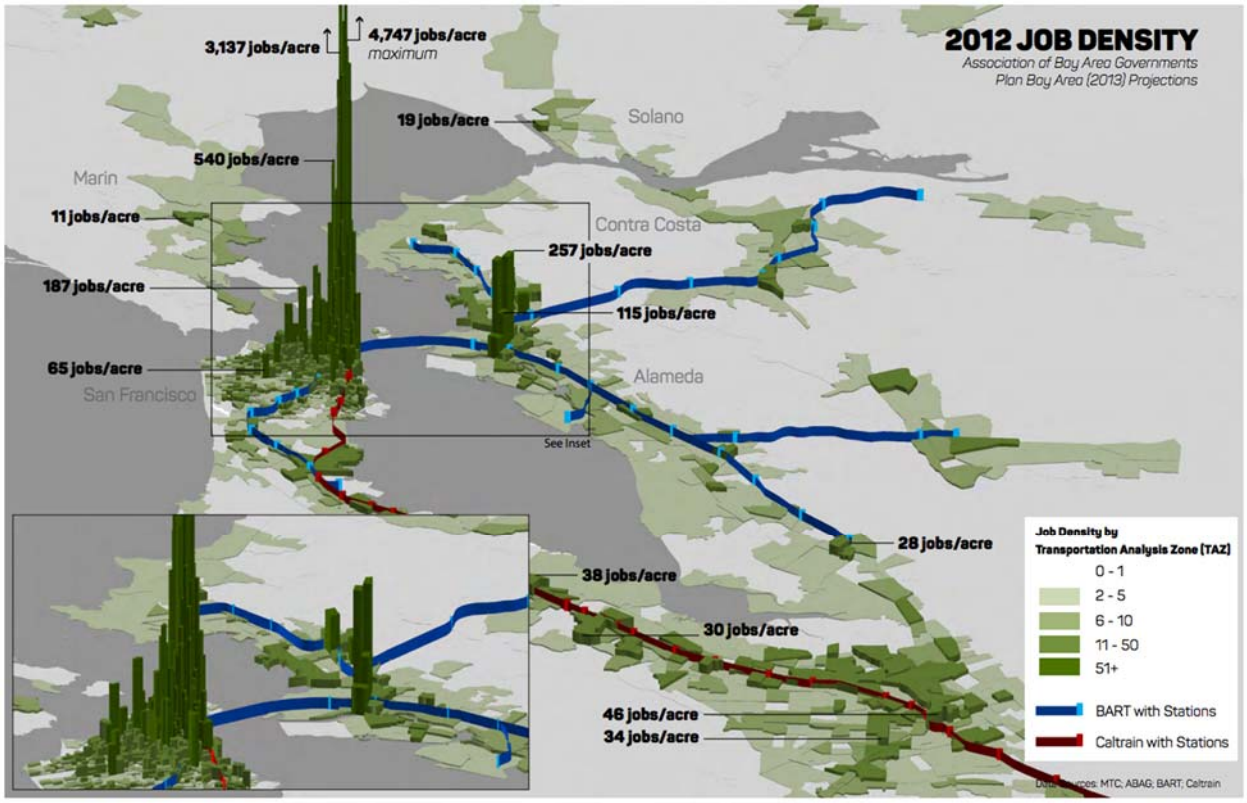
Land use and growth patterns in the Bay Area are intimately linked with the eventual benefit a new crossing could bring. Efficient transit investments have been linked to job location and housing density, and job density in particular has been shown to drive transit ridership.[50]

Employment in the Bay Area is growing faster than in any other metropolitan area in California.[51] As the region has grown, jobs have been spreading away from traditional downtowns. Job growth rates have been highest in the Sonoma, Napa, and Solano counties, and only 25% of job growth from 2002 and 2014 has occurred within half a of BART and Caltrain stations.[52] [53] One statewide study determined that there was virtually no new job growth around new transit stations between 1992 and 2006 and attributed this in part to a policy environment that favored residential uses over employment in transit station planning.[54]

Transportation and land use research has confirmed that employment density near stations is more important for driving transit use than residential density; the Public Policy Institute of California has estimated the relationship to be twice as strong.[55] Figure 4 illustrates where current job densities are highest and perhaps best suited for high-capacity transit infrastructure, especially around Downtown San Francisco and Oakland. San Jose and other parts of the South Bay stand in contrast where the large number of jobs are less spatially concentrated and potentially more difficult to serve with transit.

Figure 4: Existing job density in 2012.

[50] Kolko, Jed. "Making the Most of Transit: Density, Employment Growth, and Ridership around New Stations." Public Policy Institute of California. February 2011. http://www.ppic.org/content/pubs/report/R_211JKR.pdf
[51] Metropolitan Transportation Commission. Vital Signs: Jobs web page. http://www.vitalsigns.mtc.ca.gov/jobs. Accessed 10 December 2016.
[52] Based on geographic data analysis carried out by students in the Fall 2016 Transportation Planning Studio using LEHD data.
[53] SPUR. "The Urban Future of Work." January 2012. http://www.spur.org/publications/spur-report/2012-01-09/urban-future-work.
[54] SPUR. "The Urban Future of Work." January 2012. http://www.spur.org/publications/spur-report/2012-01-09/urban-future-work.
[55] Kolko, Jed. "Making the Most of Transit: Density, Employment Growth, and Ridership around New Stations." Public Policy Institute of California. February 2011. http://www.ppic.org/content/pubs/report/R_211JKR.pdf

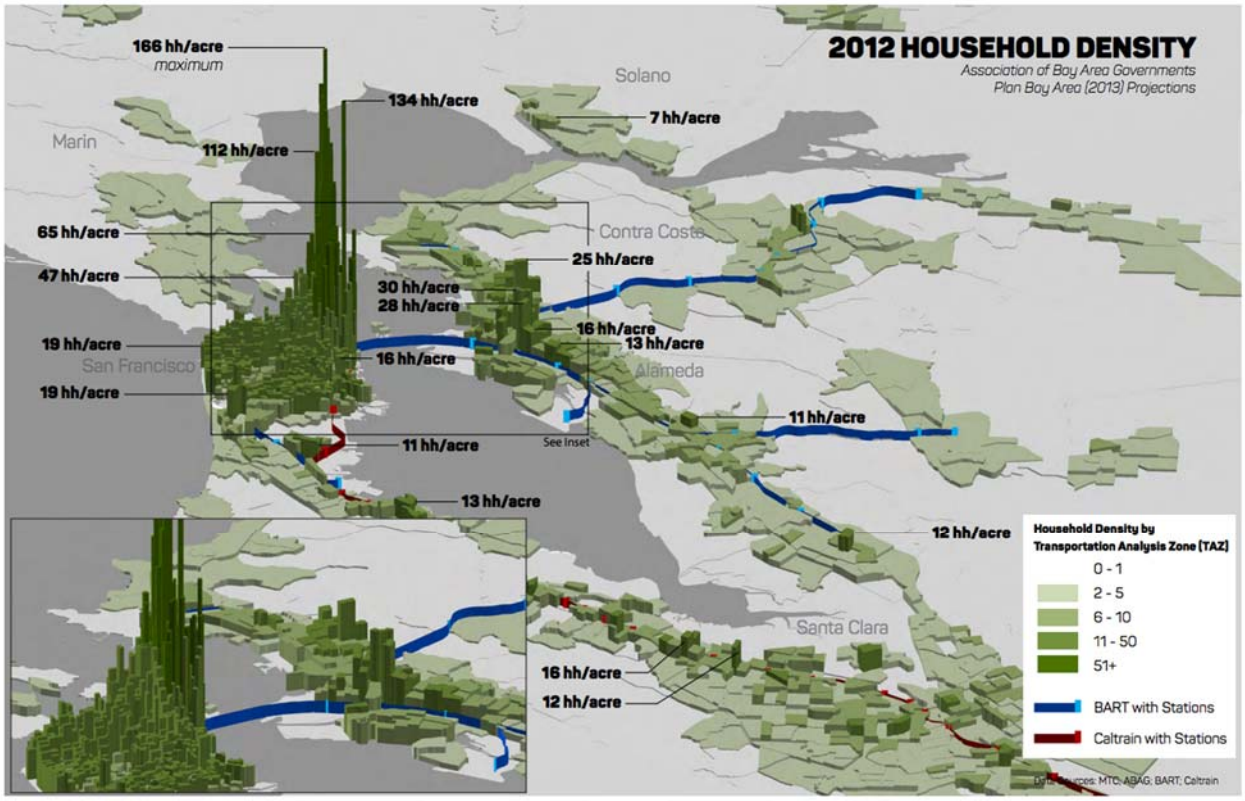


Source: MTC Core Capacity Study Briefing Book.

Although less decisive than employment density, residential density also impacts and relates to transit usage. Population in the Bay Area is growing at about 1%, which is slower than major sunbelt metropolitan areas like Houston, Dallas, Atlanta, and Miami.[56] The South Bay has changed and grown the most since 1960, with Santa Clara County now accounting for 25% of the Bay Area population.[57] Yet Figure 5 shows that the population is much less concentrated compared to San Francisco and the inner East Bay, indicating land use patterns in the latter locations may be better support high-capacity transit investment.

Figure 5: Existing household density in 2012

[56] Metropolitan Transportation Commission. Vital Signs: Population. http://www.vitalsigns.mtc.ca.gov/population#chart-3. Accessed 10 December 2016.
[57] Metropolitan Transportation Commission. Vital Signs: Population. http://www.vitalsigns.mtc.ca.gov/population#chart-3. Accessed 10 December 2016.



Source: MTC Core Capacity Study Briefing Book.

While residential density around transit stations can improve ridership and environmental outcomes, targeting station areas for infill development can also affect the lives of existing residents, particularly low-income communities and communities of color. Researchers at UC Berkeley have estimated that about 10% of Bay Area neighborhoods have already been transformed due to the influx of capital and higher-income, higher-educated residents into working-class neighborhoods.[58] They have identified that SB 375 and other initiatives to create transit-oriented development may create significant displacement among disadvantaged populations. As can be seen in Figure 6, many residents living near transit in and around the transbay corridor are renters and therefore vulnerable to displacement.

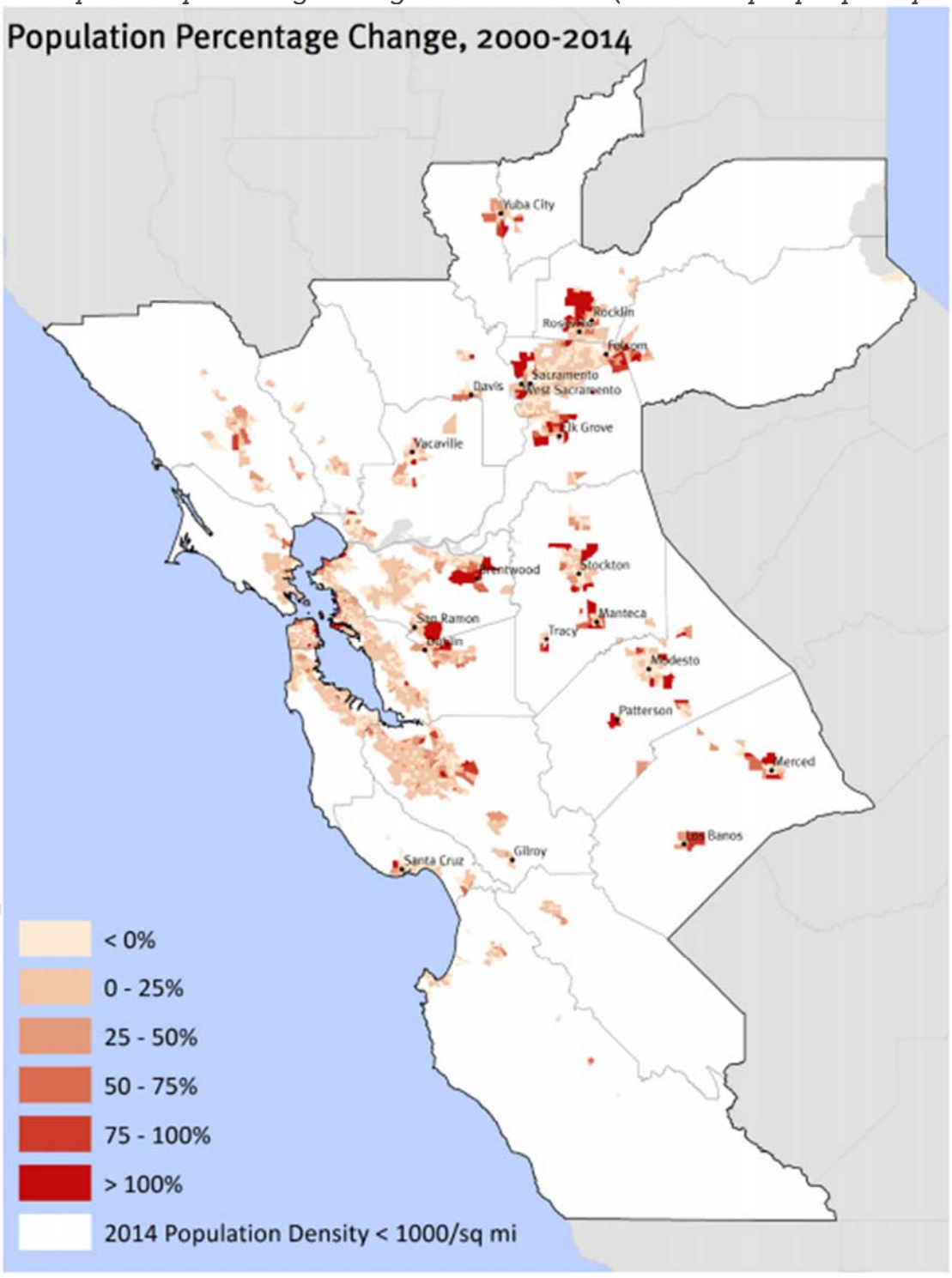
[58] Urban Displacement Project. "Executive Summary." UC Berkeley. December 2015. http://www.urbandisplacement.org/sites/default/files/images/urban_displacement_project_-_executive_summary.pdf.

Figure 6: Homeownership rate as percentage of population

Source: Map produced by students in the Fall 2016 Transportation Planning Studio.

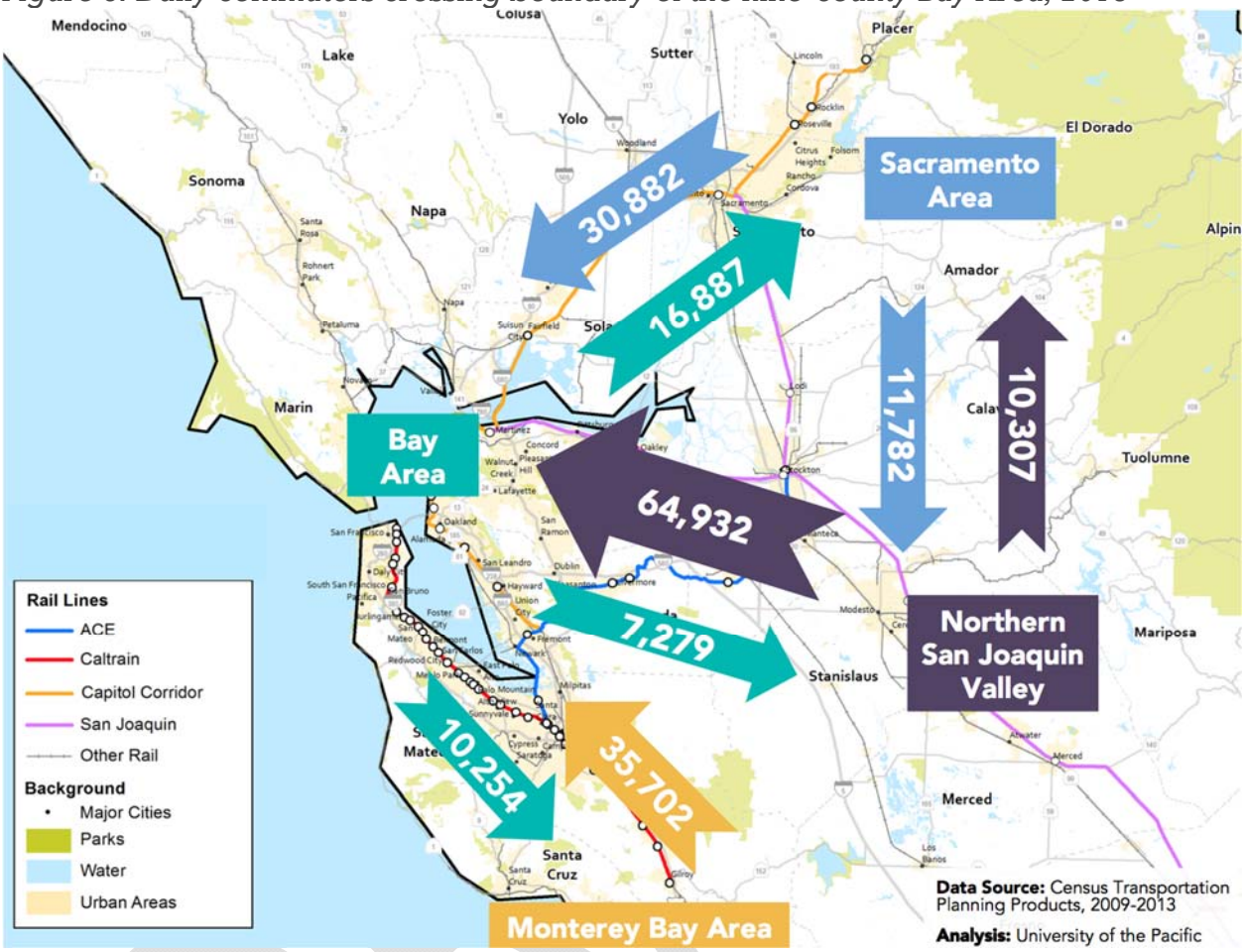
A large-scale transportation investment like a new crossing must be planned to serve future growth. Figure 7 shows the fastest growth is occurring at the edge of the region in the far East Bay into the Central Valley and Sacramento. This growth at the edge has brought more long-distance commuting into the nine-county Bay Area (see Figure 8).

Figure 7: Population percentage change in urban areas (over 1000 people per square mile)



Source: Bay Area Council Economic Institute. "The Northern California Megaregion: Innovative, Connected, and Growing." June 2016. http://www.bayareaeconomy.org/files/pdf/The_Northern_California_Megaregion_2016c.pdf.

Figure 8: Daily commuters crossing boundary of the nine-county Bay Area, 2013



Source: Bay Area Council Economic Institute. "The Northern California Megaregion: Innovative, Connected, and Growing." June 2016. http://www.bayareaeconomy.org/files/pdf/The_Northern_California_Megaregion_2016c.pdf.

Land Use Planning Efforts

Because land use is dictated at the local level, designation as a PDA in Plan Bay Area does not necessarily mean that a location is zoned as such. In fact, within designated PDAs, the share of jobs has actually declined over the past two decades.[59] The lack of coordination between the regional and local levels creates these contradictions and may dampen potential benefits of a new crossing.

However, local planning in Oakland and San Francisco has resulted in more transit-supportive development. Oakland is currently completing a Downtown Specific Plan to make changes to zoning and land use regulations in the downtown area. The plan will complement the Lake Merritt Station Area

[59] SPUR. "The Urban Future of Work." January 2012. http://www.spur.org/publications/spur-report/2012-01-09/urban-future-work.

Specific Plan, which was adopted in 2014 and calls for residential and commercial development.[60] In San Francisco, the Mission Bay Redevelopment Plan, the Eastern Neighborhoods Plan, and the Central SoMa Plan have ushered in significant redevelopment of formerly industrial land in these neighborhoods. At the same time, 40 blocks located immediately southeast of downtown San Francisco and the Market Street corridor have been redeveloping since the creation of the Transbay Redevelopment Project Area in 2005.[61]

The Downtown Oakland Specific Plan Alternatives Report (DOSPAR) has also included consideration of reconstructing the 12 blocks of Interstate 980 into an at-grade boulevard just west of downtown. The project would reduce barriers between West Oakland and downtown, and it would free 17 acres of public land to new development or public uses. The report identifies the potential to support transit service in the corridor, connected to a new transbay crossing.

Transportation Network and Operations

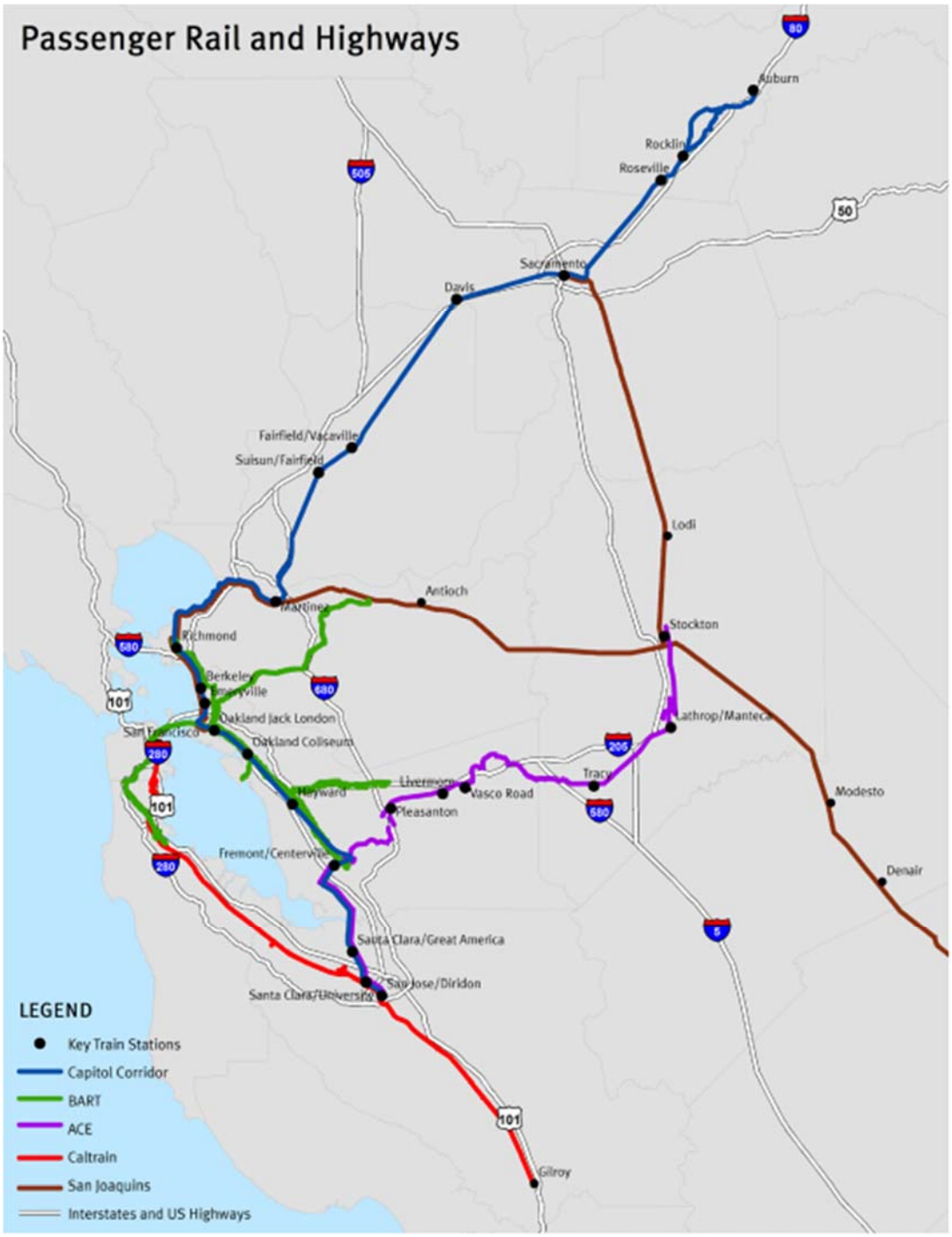
The Bay Area is served by several interstate highways, state and local roads, regional commuter rail, the BART heavy rail system, several light rail lines, local and regional buses, and ferry service (see Figure 9 for passenger rail and highway information). These services are provided by a variety of transportation agencies described in the sections below.

The primary transit agencies operating in and around the transbay corridor include the Bay Area Rapid Transit (BART) District, AC Transit, San Francisco Bay Ferry (operated by WETA), and Muni. The BART heavy rail line and AC Transit bus lines handle the bulk of transbay transit trips, while WETA ferries and a few WestCAT buses carry a small number of passengers across the Bay between San Francisco and Oakland. Muni connects transit riders between Treasure Island and San Francisco. Caltrain, Capitol Corridor, Golden Gate Transit, SamTrans, and County Connection connect to and complement the primary services in the corridor.

Figure 9: Passenger rail and highway infrastructure serving the greater Bay Area region

[60] Lake Merritt Station Area Plan website. City of Oakland. http://www2.oaklandnet.com/Government/o/PBN/OurServices/Plans/DOWD008198. Accessed 8 December 2016.

[61] San Francisco Office of Community Investment and Infrastructure. Transbay web page. http://sfocii.org/transbay. Accessed 8 December 2016.



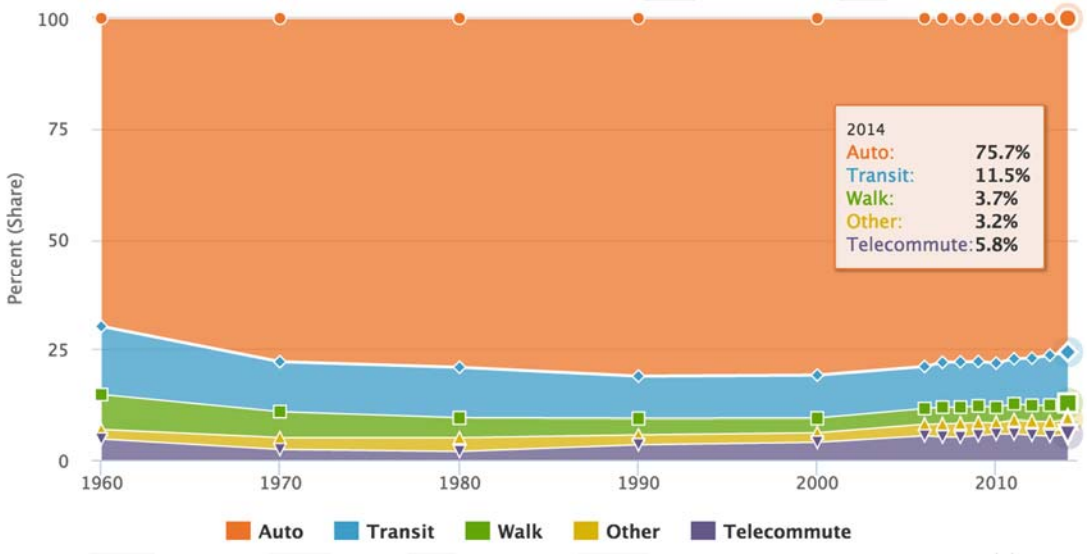
Source: Bay Area Council Economic Institute. "The Northern California Megaregion: Innovative, Connected, and Growing." June 2016. http://www.bayareaeconomy.org/files/pdf/The_Northern_California_Megaregion_2016c.pdf.

Urban development and transportation patterns were concentrated early in the Bay Area's history, but suburbanization and highway construction beginning in the 1950s led to sprawling residential patterns and more commuting from outside of the region's big cities. In the early 1980s, a number of

corporations left downtown locations to settle in suburban office parks, which further intensified daily commute patterns.

As a result of these land use patterns, the average Bay Area commute time continues to increase year-over-year, reaching 30 minutes in 2014.[62] Most Bay Area residents rely on the private automobile for work trips, as shown in Figure 10. Transit use accounts for 12% of work trips but only 3% of all travel.[63] This distinction makes sense because transit is most competitive relative to driving during peak periods of heavy traffic. Even so, drive-alone commuters spend an average of 27 minutes traveling, compared to transit commuters' 49 minutes.[64]

Figure 10: Work trips by mode share for nine-county Bay Area



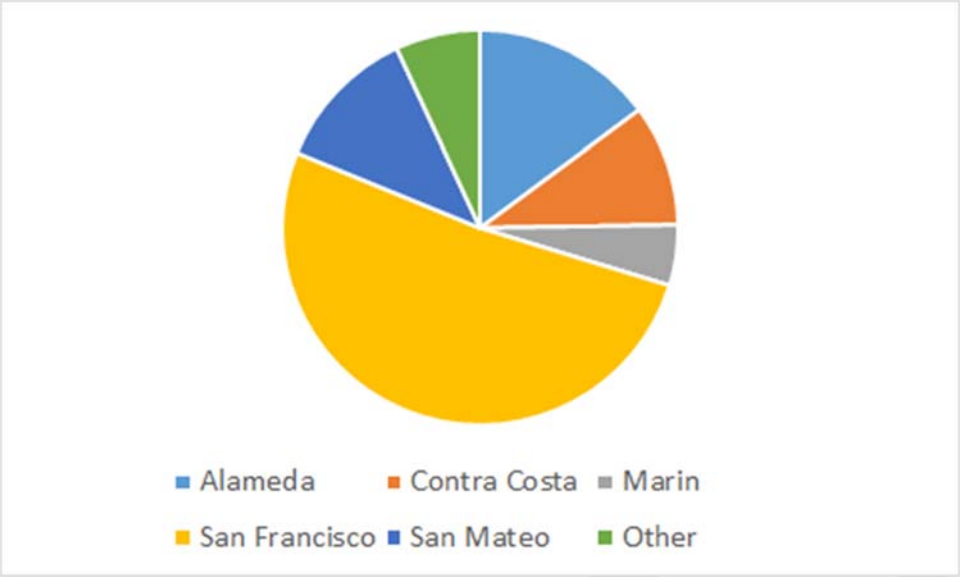
Source: MTC Vital Signs, http://www.vitalsigns.mtc.ca.gov/commute-mode-choice

Transbay Corridor

Given its significant employment concentration, San Francisco is a major destination for commuters (see Appendix C for more charts and figures on transbay commute patterns). The largest share of workers commuting into San Francisco come from Alameda and San Mateo counties (Figure 11). During the morning peak period, approximately 27,000 people per hour travel westbound into San Francisco on BART, compared to 14,200 people per hour on the Bay Bridge (Figure 12). Of the Bay Bridge commuters, 2,700 people per hour are on AC Transit or WestCAT transbay buses. An additional 1,300 people per hour commute on WETA ferries in the morning peak period.[65]

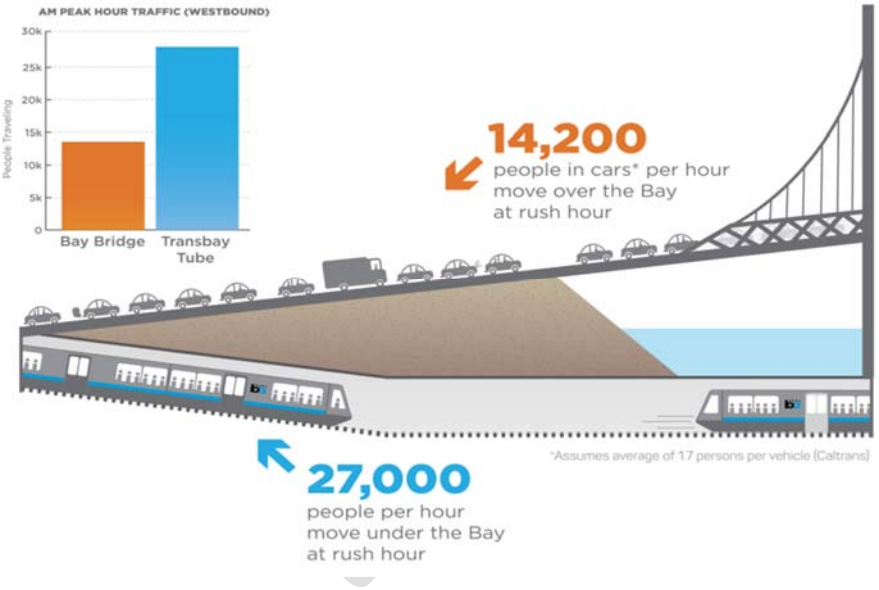
Figure 11: Origin county for workers commuting to San Francisco

[62] http://www.vitalsigns.mtc.ca.gov/commute-time
[63] http://www.spur.org/sites/default/files/publications_pdfs/SPUR_Seamless_Transit.pdf
[64] http://www.vitalsigns.mtc.ca.gov/commute-time
[65] Metropolitan Transportation Commission. "Core Capacity Transit Study Briefing Book." July 2016. http://mtc.ca.gov/sites/default/files/CCTS_BriefingBook_FINAL_WEB.pdf.



Source: Produced by students in the Fall 2016 Transportation Planning Studio using MTC travel model data, 2010 Baseline Conditions; "Other" includes Napa, Santa Clara, Sonoma and Solano counties.

Figure 12: BART estimate of travel on the transbay crossings in the morning peak hour



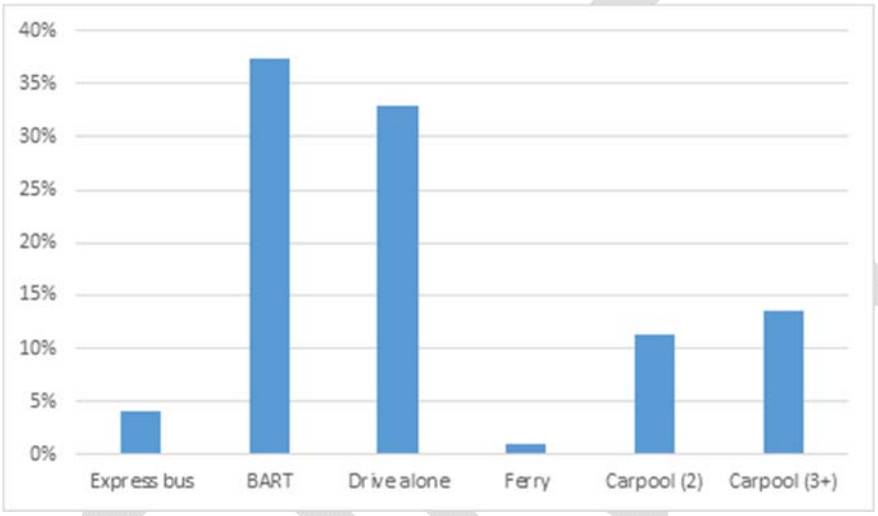
Source: "Next Stop: Good TOD." Presented by BART at the San Jose SPUR Forum. 7 July 2016. Retrieved from http://www.spur.org/sites/default/files/events_pdfs/2016.07.07%20-%20Next%20Stop%20Good%20TOD.pdf.

Interstate 80 is at capacity during the peak period, with cars queued at the Bay Bridge Toll Plaza throughout the morning peak period. AC Transit is also operating near its approximately 3,000 riders per hour capacity across 30 transbay routes. The primary constraint on bus capacity is the Temporary Transbay Terminal, which does not have room to accommodate additional buses. When the new

Transbay Transit Center opens, additional capacity could allow for up to 7,300 passengers per hour. Additional dedicated bus access lanes on the eastern Bay Bridge approach could also help achieve capacity, speed, and reliability increases.

As shown in Figure 13 below, approximately 37% of transbay travelers use BART and 33% drive alone. MTC's Core Capacity Study suggests that AM peak period transbay westbound travel is already over capacity at 105%. [66] Moreover, BART is at 110% capacity and the Bay Bridge's auto capacity is at 100%.[67] The demand for transbay travel continues to grow; over a 5-year period from 2010 to 2015, peak direction demand for BART grew by 44%.[68] Express bus service ridership has grown by 40% between 2010 and 2015.[69] Given projections of future employment and population growth in the Bay Area, the transbay corridor is not expected to support capacity needs.

Figure 13: Mode share estimate for travel in the transbay corridor

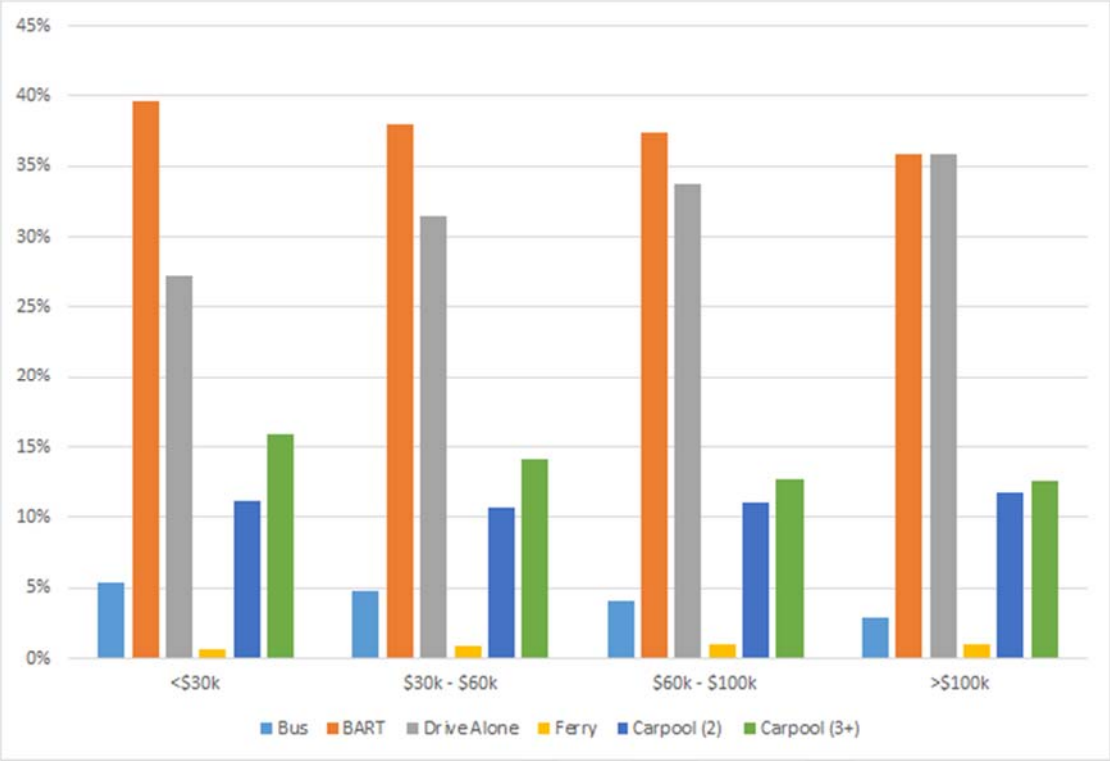


Source: Produced by students in the Fall 2016 Transportation Planning Studio using 2010 MTC travel model data. This model estimates transbay mode share by combining all trips that are eastbound from San Francisco County to Contra Costa, Alameda or Solano counties, and combines all westbound trips from the latter counties to San Francisco Counties.

Among transbay travelers, approximately 36% of those travelers making more than $100,000 drive alone, while only 27% of those making less than $30,000 drive alone. Lower income travelers (less than $30,000) are more likely to be taking BART than higher income travelers (more than $100,000), as shown in Figure 14. Travel mode use also varies by race and ethnicity. Using on-board ridership survey data, Figure 15 shows how the distributions of riders systemwide on BART, AC Transit, Muni, and Caltrain vary by race and ethnicity. White/Caucasian travelers constitute the majority or plurality of riders on BART, Muni, and Caltrain, while African American/Black travelers account for 39% of AC Transit ridership (the highest such share).

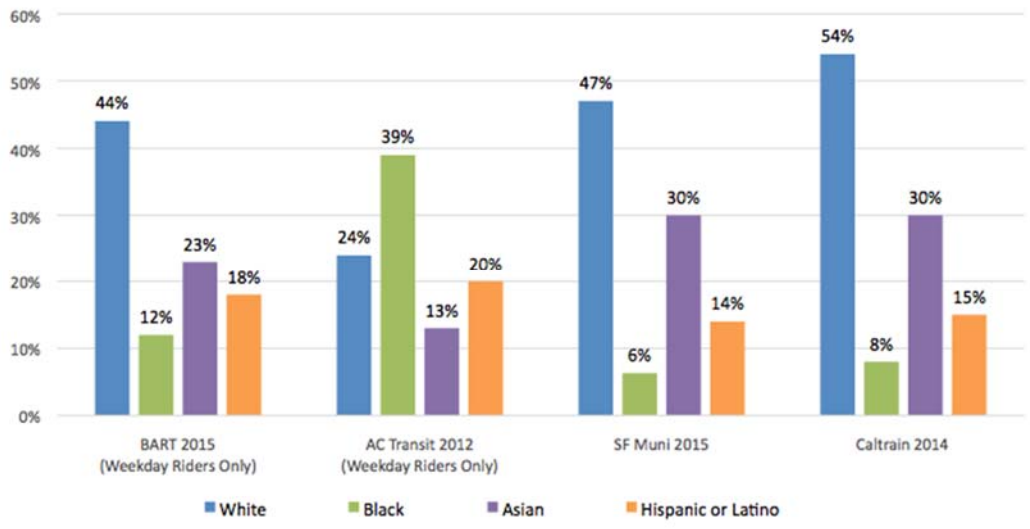
[66] http://mtc.ca.gov/sites/default/files/CCTS_TransbayCapacityandDemandSummary_FINAL.pdf
[67] http://mtc.ca.gov/sites/default/files/CCTS_TransbayCapacityandDemandSummary_FINAL.pdf
[68] http://mtc.ca.gov/sites/default/files/CCTS_TransbayCapacityandDemandSummary_FINAL.pdf
[69] http://mtc.ca.gov/sites/default/files/CCTS_TransbayCapacityandDemandSummary_FINAL.pdf

Figure 14: Transbay mode share by income, 2010



Source: Produced by students in the Fall 2016 Transportation Planning Studio using MTC travel model data.

Figure 15: Systemwide passenger race/ethnicity by transit provider



Source: Produced by students in the Fall 2016 Transportation Planning Studio using MTC travel model data.

These travel patterns provide a better understanding of the current needs around transbay travel, particularly in regards to travel by income, race and ethnicity.

BART Operational Challenges

The BART transbay tube, with one track in each direction, is the only rail corridor between San Francisco and the East Bay. The lack of redundancy for a critical rail line makes the system vulnerable to catastrophic delay, with a single mechanical failure blocking or delaying trains throughout the system. BART also does not operate overnight rail service to allow for track maintenance, which limits access to jobs for late evening and early morning shift workers.

BART is already at or above capacity at rush hour in the peak direction on its transbay routes. Trains often carry more than 115 passengers per car, exceeding the maximum capacity of 107 passengers established by policy.[70] Overall BART ridership has risen to about 440,000 passengers per day, a five-year increase of 100,000, which is stretching the limits of the system's ability to operate reliably.[71] From 2012 to 2015, BART delays lasting longer than 15 minutes increased 26% while on-time performance dropped from 96% to 87%.[72] Primary causes of delay are problems with railcars, trackside equipment, police activity, and medical emergencies.

There are a number of improvement projects expected to improve BART service including higher capacity train car replacement and a new train control system. These have not been fully funded, but Bay Area residents recently showed support for financing system improvements when voters passed a $3.5 billion bond in November 2016 to fund such core system renewal projects. However, the impact of such improvements may still be limited. MTC has projected that potential BART improvements together with major transbay bus expansion will nonetheless be unable to meet peak transbay ridership demands past 2030 under a moderate growth scenario.

In the long term, there is also a significant maintenance challenge that impacts potential project analysis and consideration: BART officials have stated that at some point the existing BART tube will need to be rehabilitated or replaced, implying a very long period of downtime which would not be sustainable under current or projected travel patterns.[73] At one SPUR event, multiple experts stressed, "It isn't a question of 'if' the area needs a second [transit] crossing. It's a question of how to build it."[74]

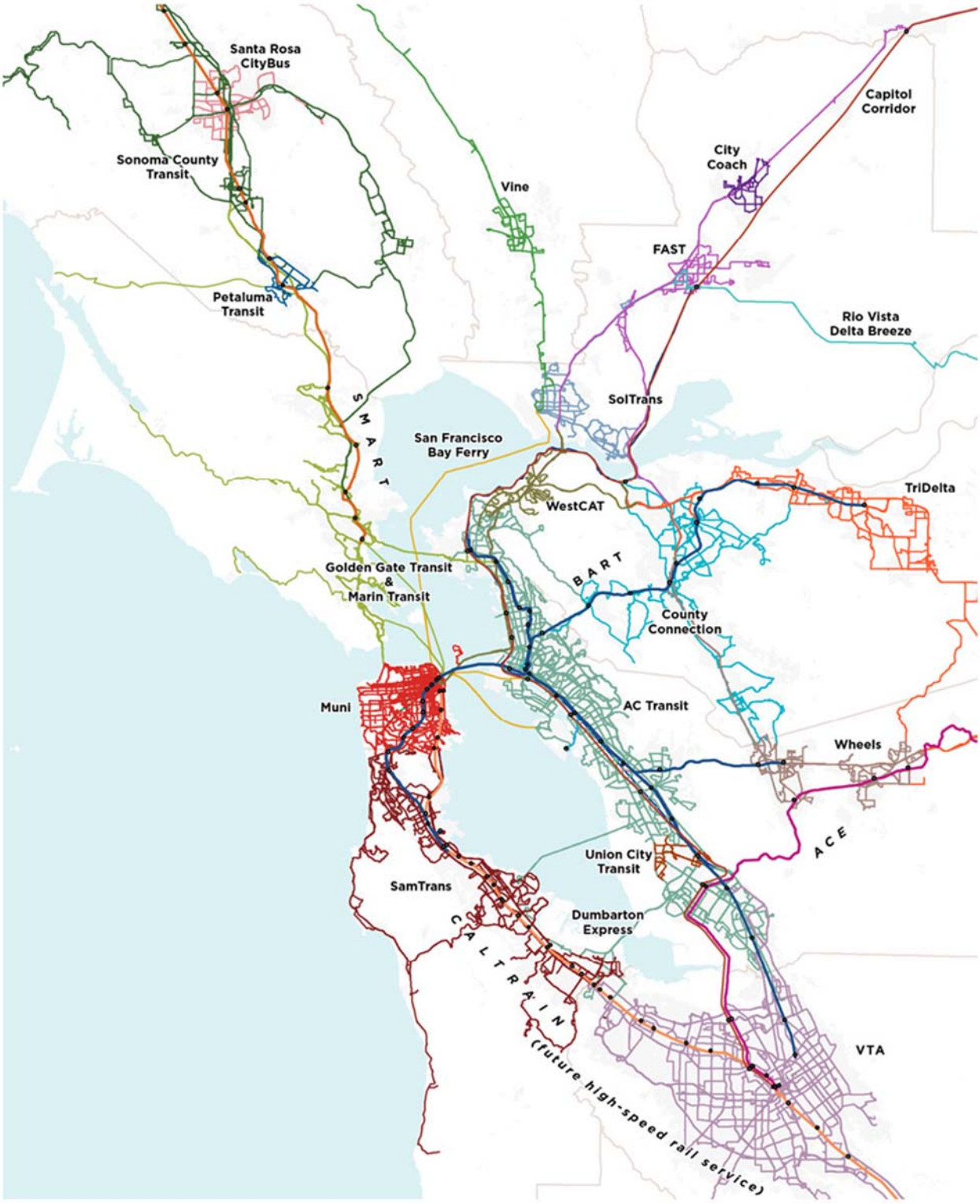
Regional and Intermodal Connections

Rail and transit regional connections are notoriously weak in the Bay Area. This fragmentation is in part due to the sheer number of local transit agencies, each with different fare structure and operational

[70] Metropolitan Transportation Commission. "Core Capacity Transit Study Briefing Book." July 2016. http://mtc.ca.gov/sites/default/files/CCTS_BriefingBook_FINAL_WEB.pdf.
[71] Cabanatuan, Michael. "BART shutdown underscores aging system's overwhelming problems." San Francisco Chronice. 17 March 2016. http://www.sfchronicle.com/bayarea/article/BART-shutdown-underscores-aging-system-s-6916061.php. Accessed 6 December 2016.
[72] Batey, Eve. "BART's Breakdowns and Delays, By The Numbers." SFist. 2 March 2015. http://sfist.com/2015/03/02/barts_breakdowns_and_delays_by_the.php. Accessed 6 December 2016.
[73] Rudick, Roger. "SPUR Meeting Pushes Second Transbay Tube." Streetsblog SF. 20 April 2016. http://sf.streetsblog.org/2016/04/20/spur-meeting-pushes-second-transbay-tube/.
[74] Rudick, Roger. "SPUR Meeting Pushes Second Transbay Tube." Streetsblog SF. 20 April 2016. http://sf.streetsblog.org/2016/04/20/spur-meeting-pushes-second-transbay-tube/.

focus. Figure 15 and Figure 16 show the service areas and operating characteristics of 24 different transit providers around the Bay Area.

Figure 16: Bay Area transit service lines by operator



Source: Seamless Transit (SPUR, 2015)

Figure 17: Operating characteristics by transit operators (brands)

Primary Transit Brand(s) *Governing Transit Agency*	Transit Types	Year Formed	Annual Ridership[4]	Total Annual Costs[5]
Muni *San Francisco Municipal Transportation Agency*	Bus, trolley bus, light rail, historic streetcar, cable car, paratransit	1912	223,701,000	$684 million
BART / *San Francisco Bay Area Rapid Transit District*	Heavy rail	1972	126,603,000	$569 million
AC Transit, Dumbarton Express *Alameda-Contra Costa Transit District*	Bus, paratransit	1960	55,235,000	$327 million
VTA / *Santa Clara Valley Transportation Authority*	Bus, light rail, paratransit	1972	44,244,000	$320 million
Caltrain / *Peninsula Corridor Joint Powers Board*	Heavy rail	1992	15,596,000	$112 million
SamTrans / *San Mateo County Transit District*	Bus, paratransit	1975	12,446,000	$114 million
Golden Gate Transit, Marin Transit[6] *Golden Gate Bridge, Highway and Transportation District, Marin Transit*	Bus, ferry boat service, paratransit	Bridge District 1928, Marin Transit 1964	9,203,000	$105 million
The County Connection *Central Contra Costa Transit Authority*	Bus, paratransit	1980	3,297,000	$31 million
Santa Rosa CityBus / *City of Santa Rosa*	Bus, paratransit	1958	2,809,000	$11 million
Tri Delta Transit *Eastern Contra Costa Transit Authority*	Bus, paratransit	1977	2,741,000	$21 million
Wheels / *Livermore Amador Valley Transit Authority*	Bus, paratransit	1986	1,727,000	$15 million
SolTrans / *Solano County Transit*	Bus, paratransit	2011	1,394,000	$10 million
Sonoma County Transit / *County of Sonoma*	Bus, paratransit	1958	1,361,000	$13 million
WestCAT / *Western Contra Costa Transit Authority*	Bus, paratransit	1977	1,282,000	$9 million
Capitol Corridor *Capitol Corridor Joint Powers Authority and BART*	Heavy rail	1998	1,250,000[7]	$30 million
Fairfield and Suisun Transit (FAST), Solano Express / *City of Fairfield*	Bus, paratransit	1975	1,049,000	$10 million
Altamont Commuter Express (ACE) *San Joaquin Regional Rail Commission*	Heavy rail	1998	940,000	$16 million
San Francisco Bay Ferry *Water Emergency Transportation Authority*	Ferry boat service	2007	607,000	$24 million
VINE *Napa County Transportation and Planning Agency*	Bus, paratransit	1974	550,000	$7 million
City Coach / *City of Vacaville*	Bus, paratransit	1981	508,000	$2 million
Union City Transit / *City of Union City*	Bus, paratransit	1974	505,000	$4 million
Petaluma Transit / *City of Petaluma*	Bus, paratransit	1976	318,000	$2 million
Rio Vista Delta Breeze *City of Rio Vista Transit Services*	Bus, paratransit	1978	13,000	$0.5 million
SMART / *SMART Rail*	Heavy rail	2002	Not yet in service	n/a
(future high-speed rail service) *California High-Speed Rail Authority*	Heavy rail	1996	Not yet in service	n/a

Source: Seamless Transit (SPUR, 2015)

The lack of coordination among systems results in a poor user experience, gaps and service duplication. The BART, Caltrain, and Capitol Corridor systems, for example, have only limited connections at the end of BART lines (Millbrae and Richmond stations, respectively), located well outside of the core service areas.

Sea Level Rise and System Resilience

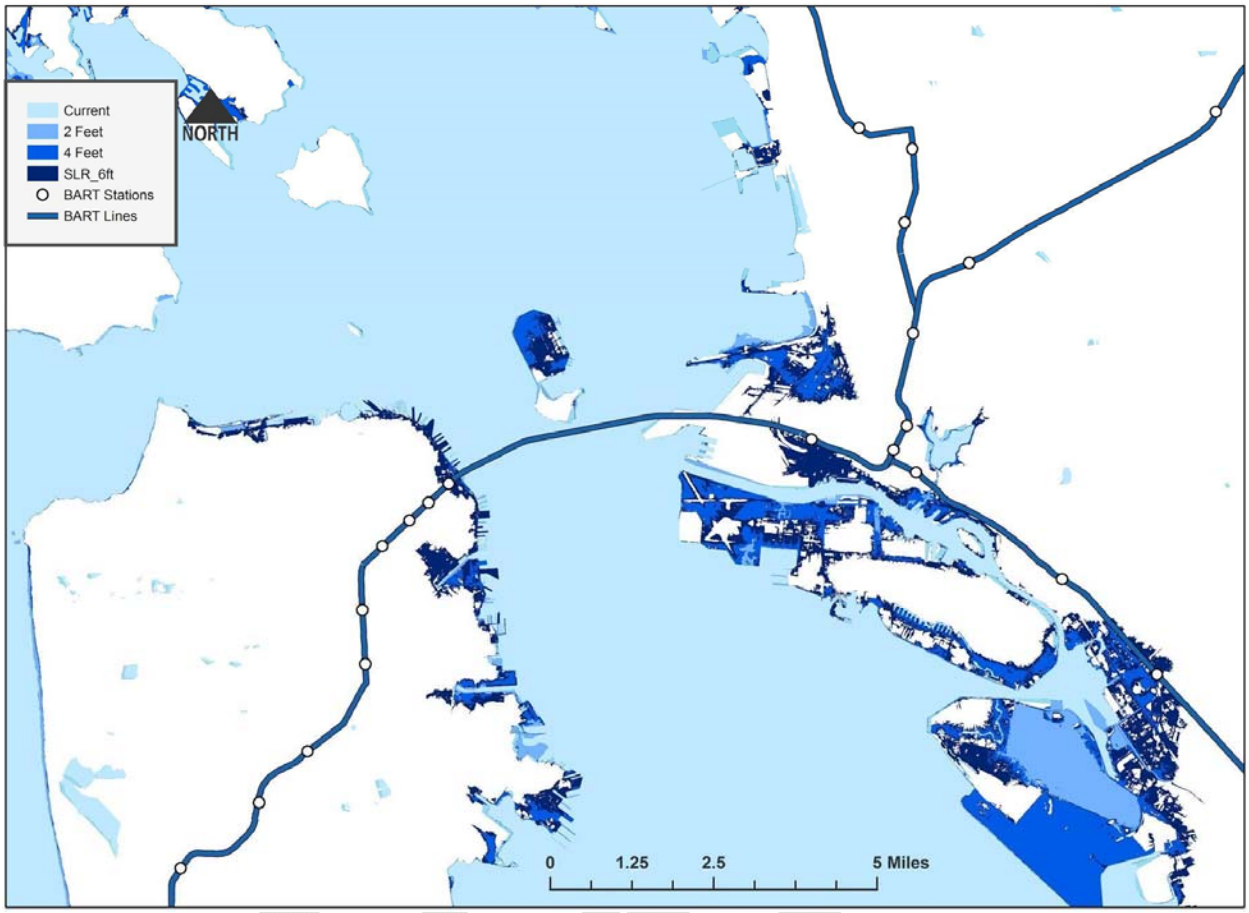
The Bay Area's distinctive geography and diverse urban forms together produce unique challenges for ensuring resilient transportation in the transbay corridor. As a coastal region, the Bay Area faces potential effects of sea level rise due to climate change. Thus, parts of the Bay Area that are adjacent to the ocean and the San Francisco Bay are at highest risk of water inundation. Sea level rise is anticipated to be as much as 4.5 feet by 2100 (Cayan, California Energy Commission, Scripps Institution of Oceanography, & California Climate Change Center, 2012).

As Figure 18 shows, critical components of the transbay corridor and large parts of Alameda Island, the Financial District and the Central Waterfront are all at risk. Even with just two feet of sea level rise, the combination of a higher shoreline and a strong storm could affect adjacent communities and infrastructure if adequate mitigation measures are not taken. Research on BART and vulnerability to climate change has found that critical infrastructure, including the West Oakland Portal, is vulnerable to water damage in the event of sea level rise and/or a storm surge (Federal Transit Administration, 2013).

To help mitigate the effects of potential flooding, BART relies on storm drainage systems in the communities in which its infrastructure is located to mitigate effects on system assets including stations. There is currently a range of conditions near BART assets due to different municipalities' prioritization of upgrading and maintaining storm drainage systems. In addition to BART assets, other important regional transit assets and connections are vulnerable. This includes existing Capitol Corridor rail in the East Bay, AC Transit hubs in Oakland and Alameda and low-lying sections of I-80 that feed onto the Bay Bridge.[75] These natural and built environment factors raise concerns over the long-term viability of BART assets, including in the transbay corridor.

Figure 18: Sea level rise scenarios in the Bay Area

[75] See MTC's collection of SLR scenario maps here for more information and examples: http://mtc.ca.gov/sites/default/files/Chapter_6_Sea_Level_Rise_Maps.pdf



Source: Map produced by students in the Fall 2016 Transportation Planning Studio using floodplain maps provided by ABAG Resilience Program.

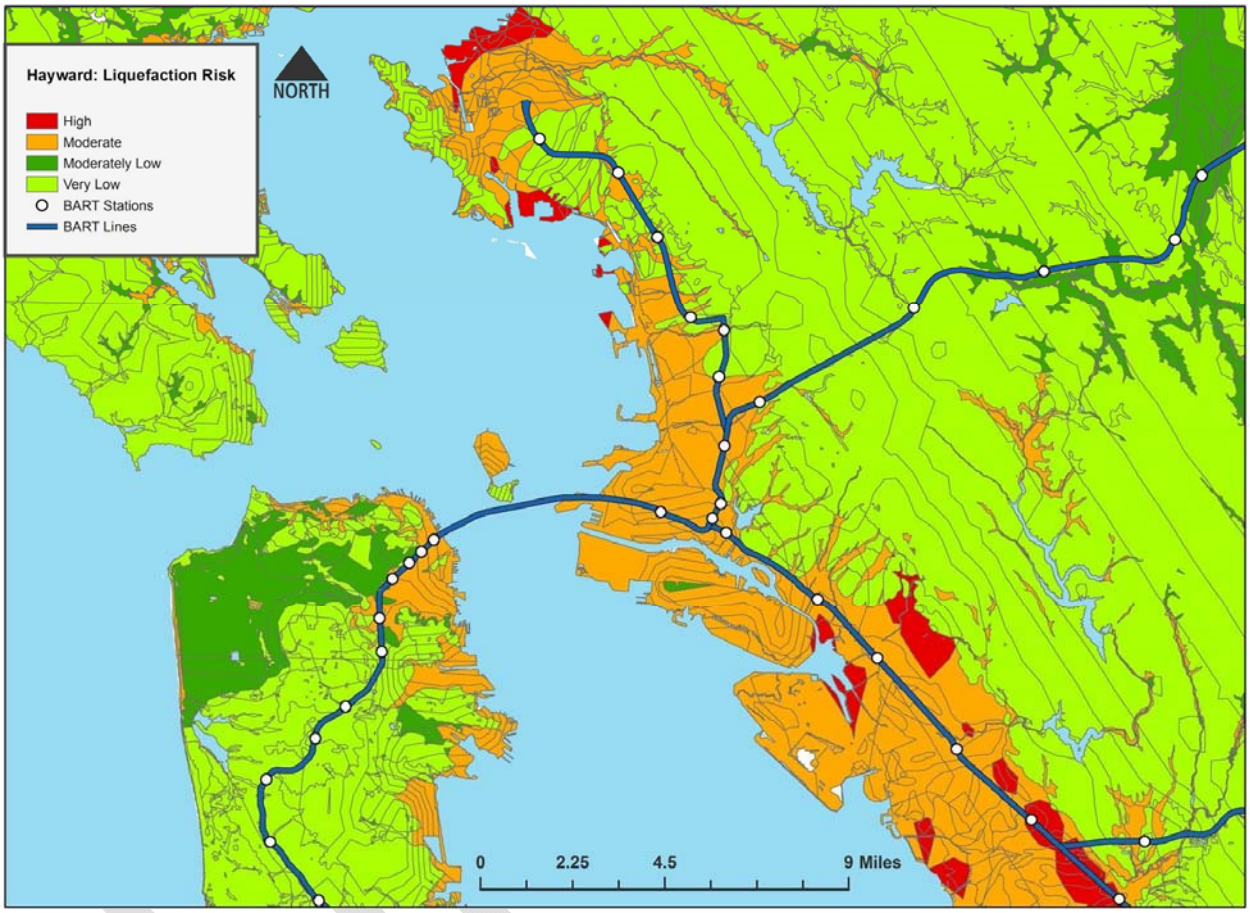
The Bay Area also is notable for vulnerability to seismic damage, which has serious implications for infrastructure planning. The region's position at the confluence of the Pacific and North American tectonic plates creates a high risk for earthquakes. Multiple fault lines crisscross Bay Area communities, including the San Andreas, Hayward and Calaveras faults. A major earthquake in the Bay Area's near future is very likely. Recent research estimates that there is a 72% chance of an earthquake of a magnitude of greater than 6.7 before 2043 in the Bay Area (Aagaard et al., 2016).

Vulnerability related to earthquakes is exacerbated by soil liquefaction risk. Soil liquefaction can cause serious structural damage as soil loses its strength during an earthquake. As Figure 19 illustrates, many coastal areas are at high risk of soil liquefaction. In the transbay corridor, land that is both the location of critical transportation infrastructure such as the Oakland Wye as well as residential and commercial development is at high risk of soil liquefaction in a seismic event (Knudsen, Wentworth, & Geological Survey, 2000).

Recent assessments suggest that the transbay tube is potentially vulnerable to structural failure in the event of a large earthquake, endangering the safety of BART personnel and riders while also presenting a serious risk to the overall transportation network due to the criticality of the tube (Bechtel Infrastructure Corporation, Howard, Needles, Tammen & Bergendoff, & San Francisco Bay Area Rapid

Transit District, 2002). To address this, BART directors have recently approved a quarter of a billion dollars to improve the safety of the Transbay Tube over the next two years.[76]

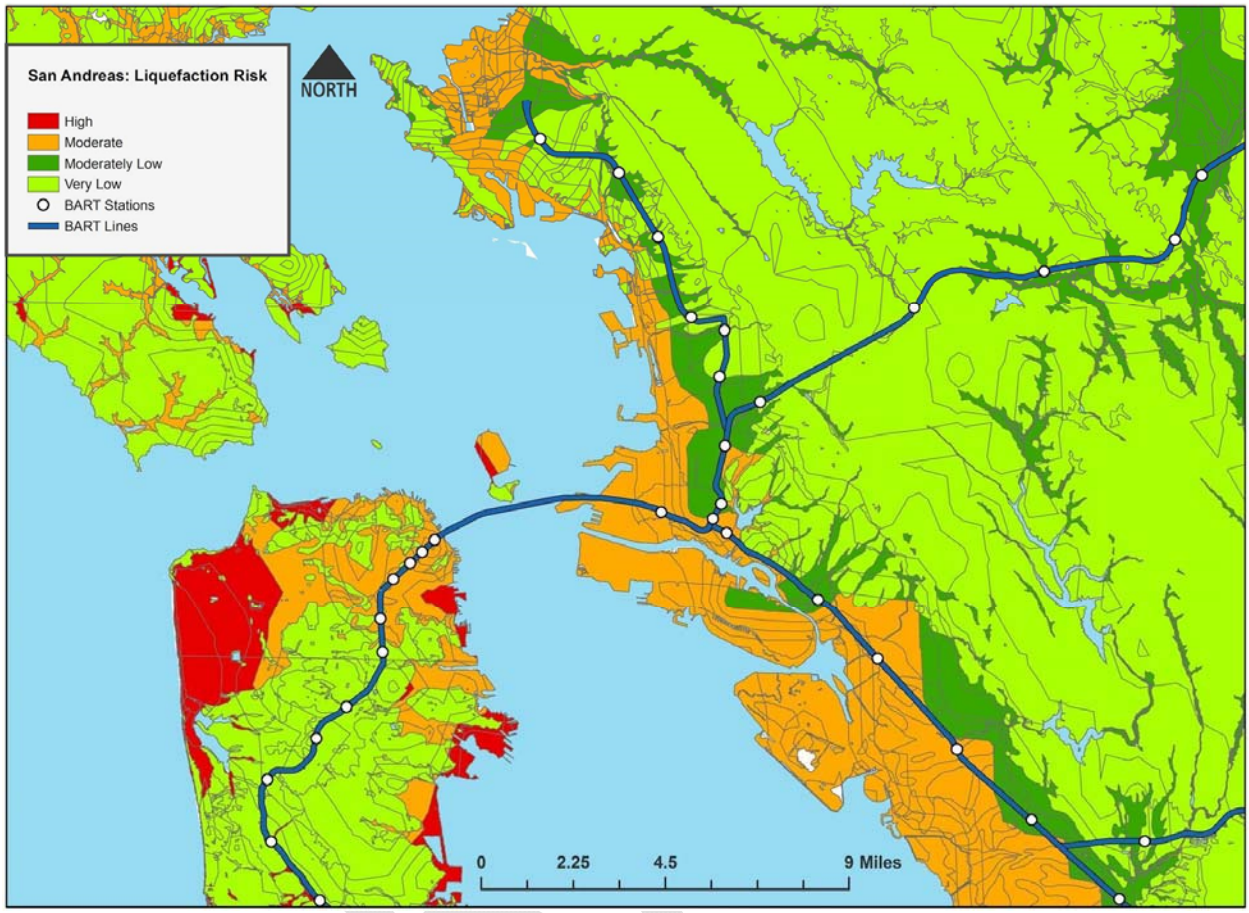
Figure 19: Liquefaction risk for the Hayward Fault



Source: Map produced by students in the Fall 2016 Transportation Planning Studio using data provided by ABAG Resilience Program.

Figure 20: Liquefaction risk for the San Andreas Fault

[76] See coverage here: http://www.sfgate.com/bayarea/article/Commuters-beware-BART-has-2-year-plan-to-10661176.php



Source: Map produced by students in the Fall 2016 Transportation Planning Studio using data provided by ABAG Resilience Program.

Vulnerability in the system is not only created through the potential of a natural disaster, but it is also due to ongoing, chronic maintenance issues. The system regularly experiences highly publicized delays due to operation and maintenance issues.[77] As the only rail system that connects San Francisco and the East Bay, current transbay transit options contain poor redundancy of service. This creates the conditions for potentially catastrophic delay in the event of a disaster or system failure (Metropolitan Transportation Commission, 2016). This is further exacerbated by the current alignments of the network in which multiple lines converge at the Oakland Wye. This makes the transportation system more vulnerable due to the amount of transit that is dependent on a specific part of the network (BART, 2013). This combination of lack of redundancy, continued operations issues and vulnerability to disruption is a potential threat to the Bay Area's economic development and quality of life. The recent

[77] For example, see KRON4's coverage of two recent system-wide delay caused by this issue. KRON4. (2016, October 14). "BART experiencing system wide delays Friday." Retrieved from http://kron4.com/2016/10/14/bart-delays-reported-in-oakland-due-to-equipment-failure. KRON4. (2016, July 20). Major BART delays in Hayward, Fremont due to equipment problems. Retrieved from http://kron4.com/2016/07/20/major-bart-delays-in-hayward-fremont-due-to-equipment-problems/

passage of Measure RR will begin to address some aspects of maintenance issues on the BART system, including over three billion dollars to address critical safety infrastructure.[78]

Public Health

Transportation systems have public health implications, including the diseases, injuries, and/or fatalities associated with traffic collisions, air pollutants emitted from vehicles, the reliability of public transit, and how well the system supports active transportation. Often these health burdens are not distributed equitably and low-income communities and communities of color are disproportionately burdened. A study by the Bay Area Regional Health Inequities Initiative (2008) found stark differences in life expectancy within the region as West Oakland residents are expected to live an average of 10 years less than residents of the Berkeley Hills and residents of Bayview/Hunters Point are expected to live an average of 14 years less than people who live in Russian Hill.[79] Focusing more specifically on transportation-related health also shows disparities, Alameda County residents living in neighborhoods with higher levels of poverty have been shown to have higher pedestrian injury and death rates than residents of more wealthy neighborhoods (See Figure 21).[80] Similarly, in San Francisco, corridors with high concentrations of serious and fatal traffic injuries have been shown to be located disproportionately in communities of concern.[81]

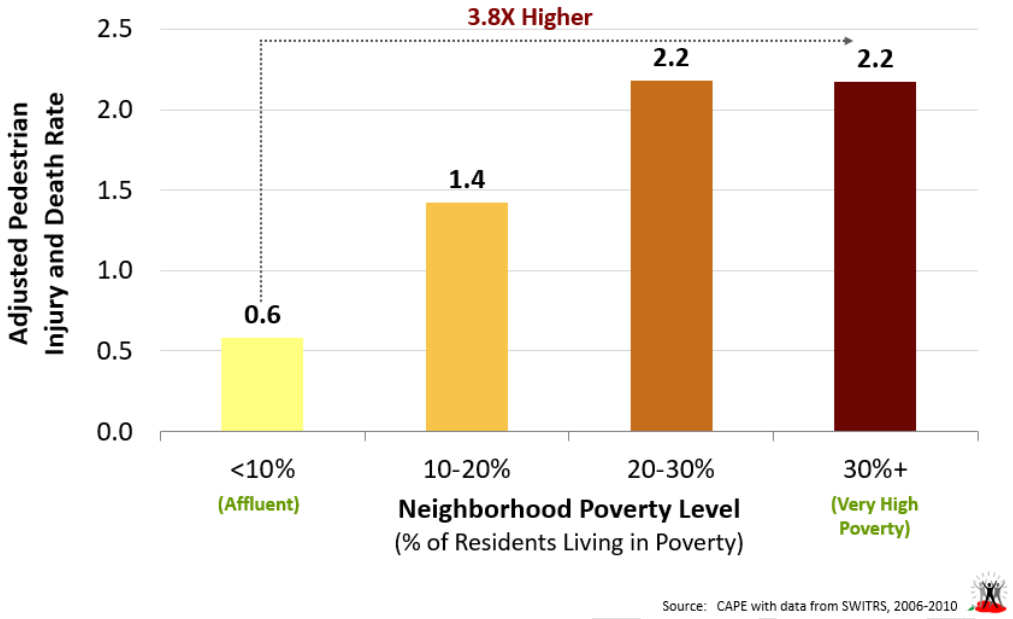
Figure 21: Rates of pedestrian injuries and deaths by neighborhood poverty level in Alameda County

[78] For a more detailed breakdown of Measure RR, see: https://spurvoterguide.org/sf-nov-16/measure-rr-bart-bond/

[79] Bay Area Regional Health Inequities Initiative (BARHII). (2008). *Health Inequities in the Bay Area*. Oakland, CA. Retrieved from http://barhii.org/wp-content/uploads/2015/09/barhii_hiba.pdf

[80] Alameda County Public Health Department. (2013). *How Place, Racism, and Poverty Matter for Health in Alameda County Presentation*. Retrieved from http://www.acphd.org/data-reports/reports-by-topic/social-and-health-equity.aspx

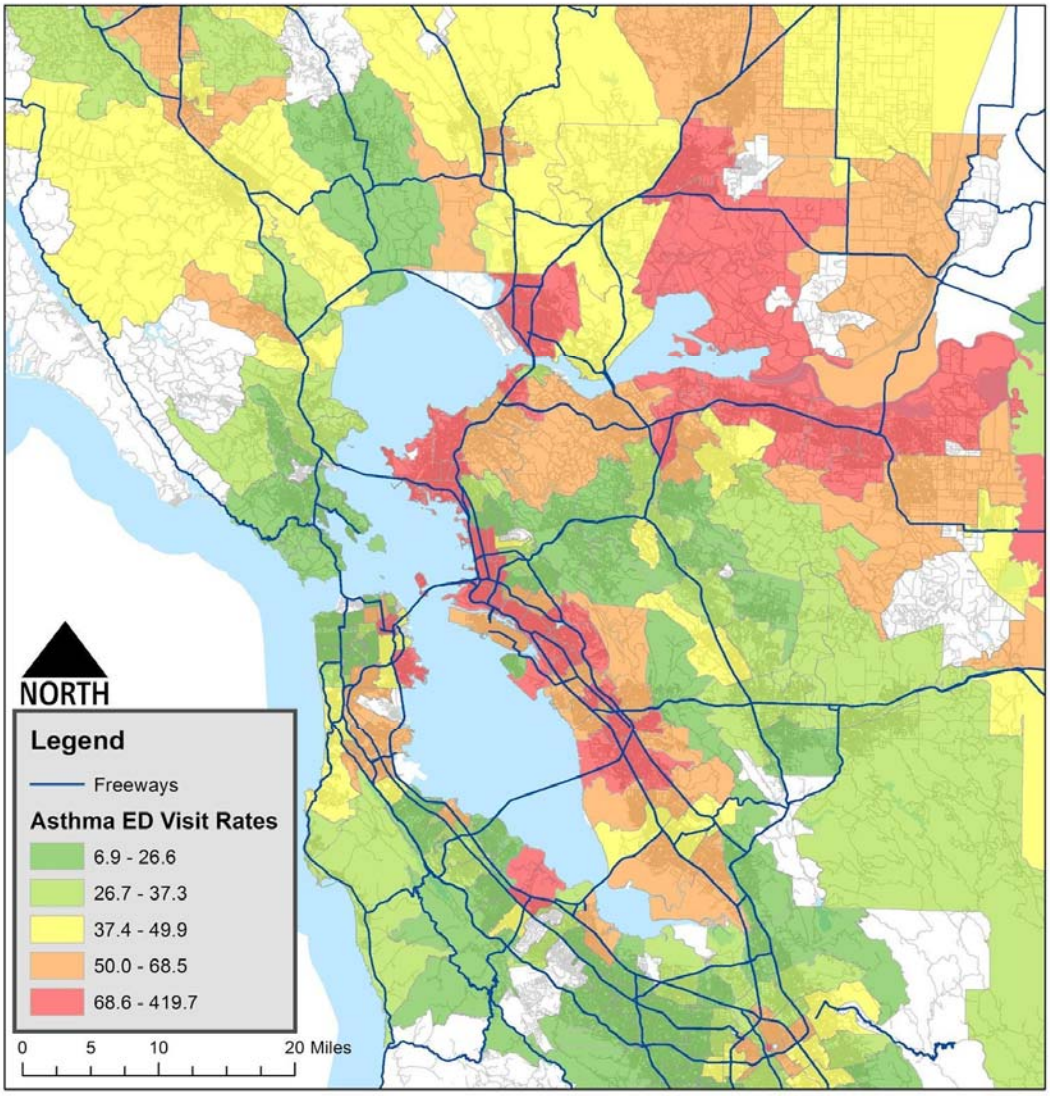
[81] City and County of San Francisco. (2015). *Vision Zero San Francisco Two-Year Action Strategy*. City and County of San Francisco. Retrieved from https://www.sfmta.com/sites/default/files/projects/2015/vision-zero-san-francisco.pdf



Source: Alameda County Public Health Department, 2013.

Health inequities have also been shown with regards to the impacts of air pollutants emitted from the Bay Area transportation system. The residents of West Oakland, who live near the Port of Oakland, and multiple freeways, including the approaches to the Bay Bridge, are "exposed to 3 times more diesel particles than the rest of the Bay Area", (Alameda County Public Health Department, 2013). Figure 22 shows that the residents of West Oakland, as well as many other areas in the Bay Area near freeways, are among those experiencing the highest rates of emergency department visits due to asthma.

Figure 22: Asthma emergency department visit rates (age-adjusted) by zip code, 2012



Source: Reproduced by Studio using data from California Department of Public Health [82]

[82] California Department of Public Health. (n.d.). Asthma Emergency Department Visit Rates by ZIP Code 2012. California Department of Public Health. Retrieved from https://chhs.data.ca.gov/Diseases-and-Conditions/Asthma-Emergency-Department-Visit-Rates-by-ZIP-Cod/5f6i-kert