04
NEEDS ANALYSIS

The needs of people bicycling within Berkeley are diverse and dependant on an individuals' level of experience, comfort, and confidence, to name a few factors. To understand the needs of people bicycling in Berkeley, this chapter examines a number of data sources including:

- Bicycle counts of the number of people bicycling at selected locations on the Berkeley bikeway network, collected annually
- Estimated bicycle trips of the number of residents who bicycle to work, school, shopping, and other non-recreational trips
- Bicycle-related collisions to understand locations potentially in need of bicycle related improvements
- Community input on challenges to bicycling in Berkeley gathered from public outreach events and the project website
- The "Four Types of Cyclists" typologies applied to people who bicycle in Berkeley based on a citywide resident survey
- Level of Traffic Stress analysis to identify locations within the existing street network that may attract or deter people from riding bicycles in Berkeley
- Bicycle demand analysis to identify existing and potential origin and destination locations for people riding bicycles
- Gap analysis to identify potential missing links in the citywide bikeway network

4.1. CENSUS DATA

United States Census data provides an overall context for bicycling activity in Berkeley. The US Census American Community Survey (ACS) commute data is a consistent source for tracking long-term journey-to-work commute trends. However, the Census only collects data on the primary mode that Berkeley residents use to travel to work, and does not count residents who use a bicycle as part of their commute (linking to a longer transit trip, for example). The Census count also excludes trips made for recreation, to run errands, or to commute to school. Census data, therefore, only tracks a portion of the total bicycle trips in Berkeley.

Table 4-1 shows the commute mode share as reported in the 2014 ACS five-year estimates. Based on this multi-year sample, Berkeley has the fourth highest commute mode share of any city in the United States with 8.5 percent of residents commuting by bicycle to work. **Table 4-2** shows the percentage of commute trips by bicycle for the top ten United States cities, according to the 2014 ACS five-year estimates.

***Table 4-1:** Mode Share for Work Commute (2014 ACS, 5-Year)*

MODE	PERCENTAGE
Bicycle	8.5%
Car, truck, or van	42.7%
Public Transportation (excluding taxicab)	20.8%
Walked	16.2%
Taxicab, motorcycle, or other means	1.4%
Worked at home	10.4%

Table 4-2: *Top US Bicycle Cities, Commute Trips by Bicycle (2014 ACS, 5-Year)*

CITY	TOTAL COMMUTE BY BICYCLE	POPULATION
Davis, CA	21.8%	66,093
Boulder, CO	10.1%	102,002
Palo Alto, CA	9.0%	65,998
Berkeley, CA	8.5%	115,688
Somerville, MA	5.3%	77,560
Cambridge, MA	6.9%	106,844
Portland, OR	6.3%	602,568
Eugene, OR	7.7%	158,131
Fort Collins, CO	6.5%	149,627
Santa Barbara, CA	6.0%	89,669

4.2 BICYCLE COUNTS

The City of Berkeley has been conducting bicycle counts along the bikeway network annually since 2000. The City's bicycle counts supplement the ACS data, which collects data on the primary mode of travel to work on an ongoing basis but does not consider those who use a bicycle as only a part of their commute trip, for recreation, or to run errands.

Following national best practices, trained volunteers conduct manual counts during the afternoon peak period from 4:00 pm to 6:00 pm on midweek days (Tuesday, Wednesday, and/or Thursday) during the fall season. At each location, observers count bicyclists as they enter the intersection and note their movement (left turn, right turn, or straight through) as well as helmet use, sidewalk riding, and observed gender of the rider to the degree possible given the limitations of observational counts.

Counts have been conducted at the following ten intersections located along the bikeway network:

- Bowditch & Channing
- Colusa & Marin
- Hillegass & Ashby
- Milvia & Channing
- Milvia & Hearst
- MLK & Russell
- Ninth & University
- Spruce & Rose
- Telegraph & Woolsey
- Virginia & California

Manual counts were conducted at select locations from 2000 to 2005 and consistently at all ten locations from 2009 to 2015. Due to staff shortages, limited or no counts were conducted from 2006 to 2008. Bicycle counts have been conducted at additional locations in various years, but the ten intersections listed above form the core subset of ongoing annual count locations. Having the same combination of intersections and data collection methods across consecutive years allows for effective analysis of changes and trends in bicycle volumes and behaviors in the city.

The City began manual counts at three additional locations in 2015:

- 9th St Path
- West St Path & Virginia
- Hearst & Oxford

Table 4-3 shows the manual bicycle counts collected at all locations and years since 2000. Overall, the average number of bicyclists at the ten intersections has increased over the years, as shown in **Figure 4-1**.

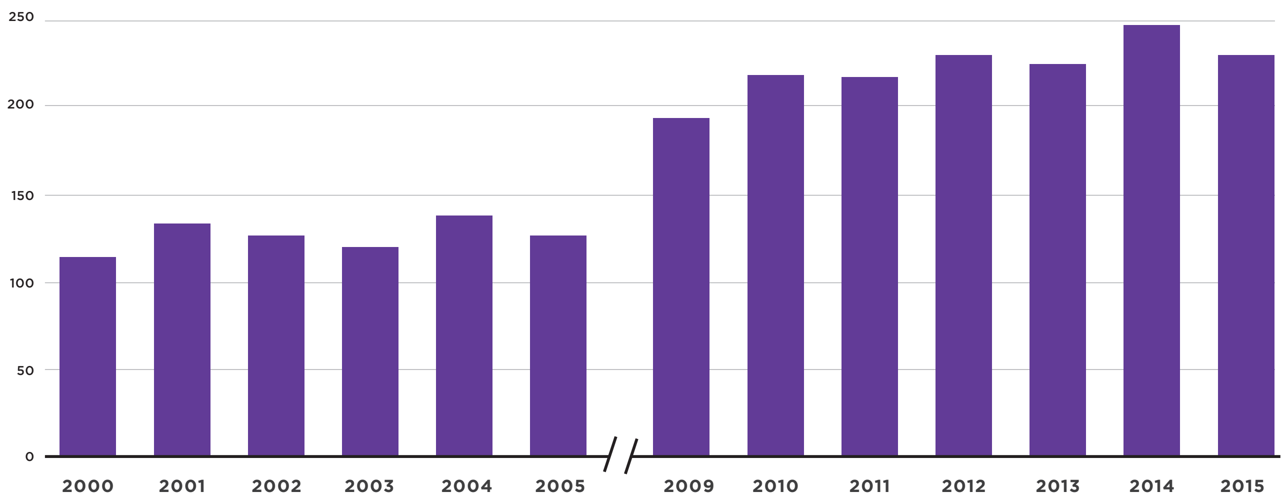
***Table 4-3:** Total Counted Bicyclists, 2-Hour Evening Peak Period, 2000-2015*

INTERSECTION	2000	2001	2002	2003	2004	2005	2009	2010	2011	2012	2013	2014	2015
Bowditch & Channing	224	258	214	229	272	187	296	305	254	274	216	308	268
Colusa & Marin	-	-	-	-	-	38	42	58	43	36	32	45	29
Hillegass & Ashby	57	-	116	-	76	105	114	138	160	144	159	125	164
Milvia & Channing	-	344	275	336	294	312	469	510	531	536	528	573	536
Milvia & Hearst	-	302	356	350	337	290	230	402	343	436	403	460	419
MLK & Russell	110	75	85	115	119	113	289	240	261	280	306	288	252
Ninth & University	44	47	65	16	75	82	80	110	107	95	152	146	150
Spruce & Rose	-	99	56	67	75	73	48	95	86	71	82	83	60
Telegraph & Woolsey	135	149	149	-	146	145	227	187	214	212	194	225	184
Virginia & California	-	47	74	84	80	108	140	140	166	202	175	204	229
Avg. of 10 intersections	**114**	**132**	**126**	**120**	**138**	**126**	**194**	**219**	**217**	**229**	**225**	**246**	**229**
Total of 10 intersections	**570**	**1,321**	**1,390**	**1,197**	**1,474**	**1,453**	**1,935**	**2,185**	**2,165**	**2,286**	**2,247**	**2,457**	**2,291**
California & Russell	30	62	59	116	91	113	105	-	-	-	-	-	-
Hearst & Oxford	-	-	-	-	-	-	-	-	-	-	-	-	284
9th Street Path	-	-	-	-	-	-	-	-	-	-	-	-	153
Virginia & West St Path	-	-	-	-	-	-	-	-	-	-	-	-	160
Grand total	**600**	**1,383**	**1,449**	**1,313**	**1,565**	**1,566**	**2,040**	**2,185**	**2,165**	**2,286**	**2,247**	**2,457**	**2,888**

Figure 4-2 shows the existing bicycle counts at various locations in Berkeley. The counts indicate that, between 2005 and 2015, there has been a 58 percent increase of people bicycling at the ten selected intersections.

The following subsections describe trends regarding bicyclist gender, helmet use, and sidewalk riding based on information gathered during the annual counts.

Figure 4-1: *Change in Annual Average Bicycle Counts, 2000-2015*



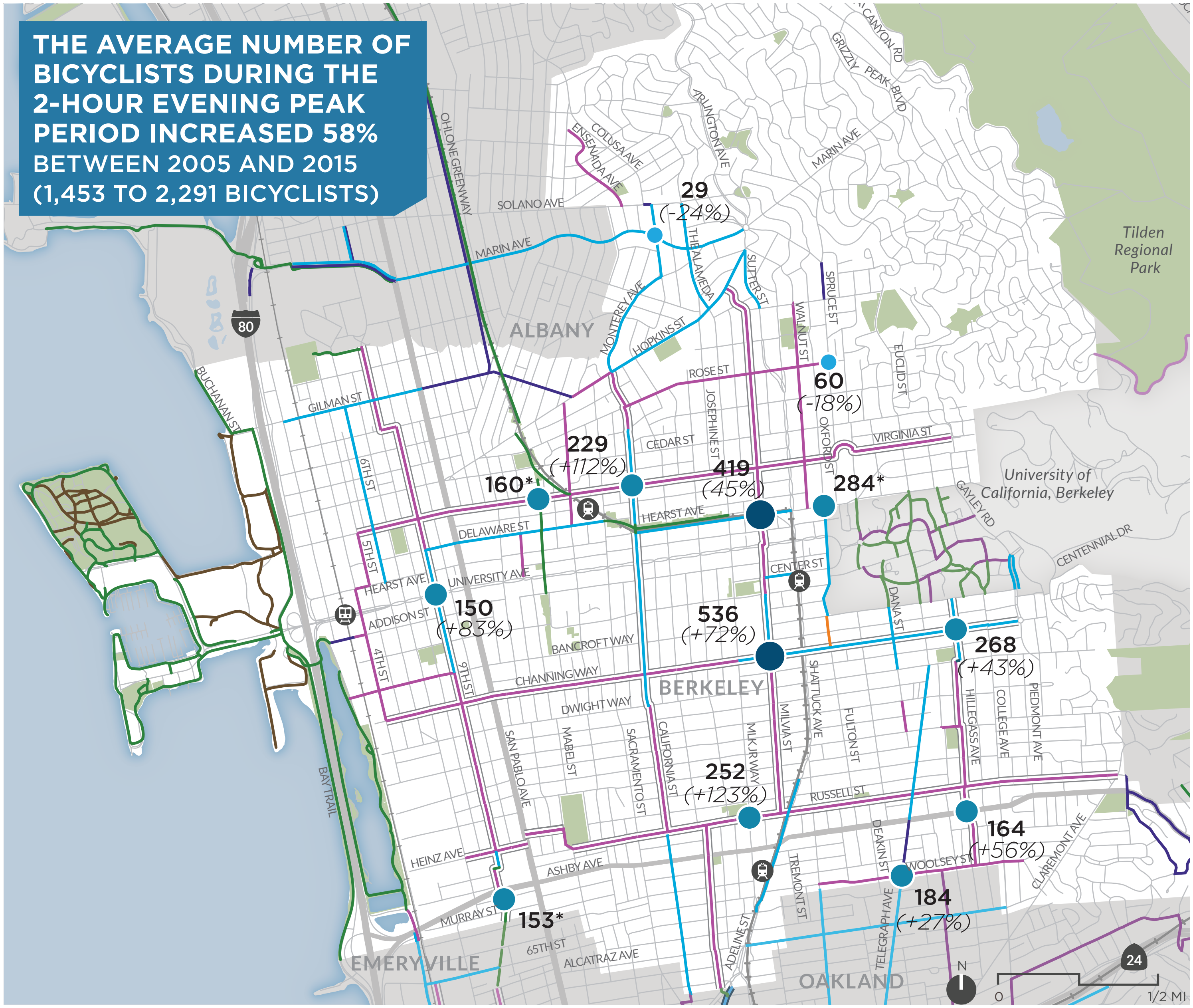


FIGURE 4-2: BICYCLE COUNTS AT SELECTED INTERSECTIONS

BIKES PER 2-HOUR PEAK PERIOD [2015]

29 to 60

61 to 284

285 to 536

**NEW 2015 COUNT LOCATION*

PAVED PATH [1A]

UNPAVED PATH [1B]

STANDARD BIKE LANE [2A]

UPGRADED BIKE LANE [2B]

SIGNAGE-ONLY [3A]

SHARROWS [3C]

BICYCLE BOULEVARD [3E]

CYCLETRACK [4A]

BICYCLE BOULEVARD NETWORK

PARK/REC

RAILROAD

BART STATION

AMTRAK STATION

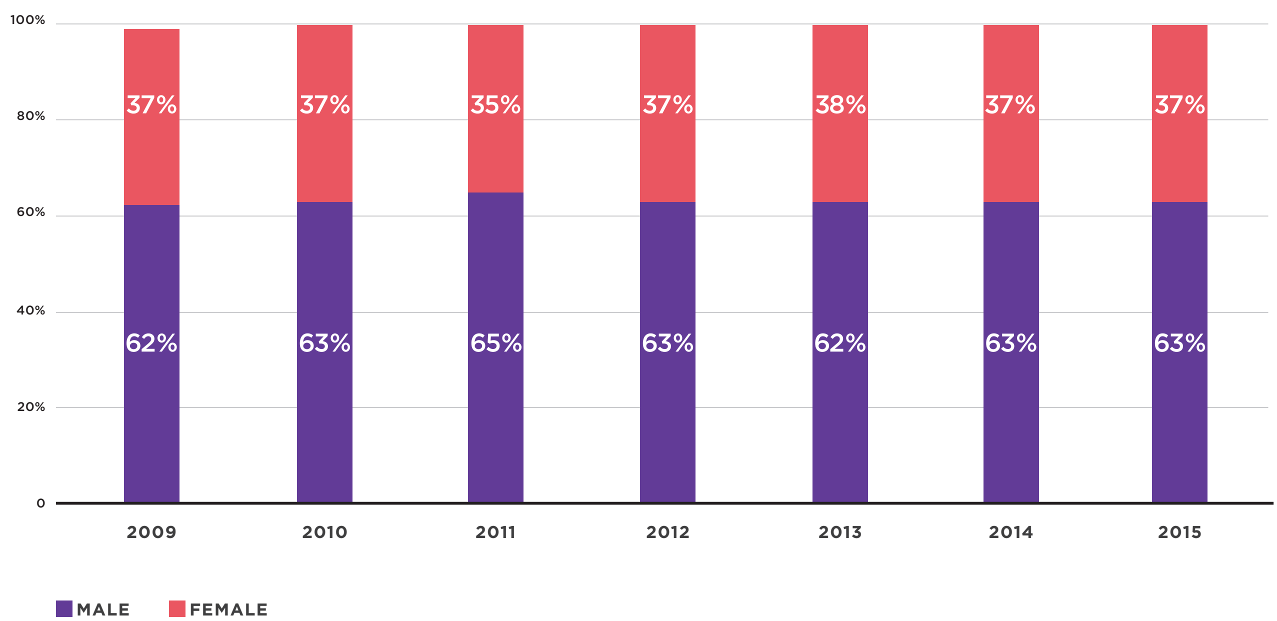
4.2.1. Gender

The gender of people bicycling has remained consistent between 2009 and 2015 (see **Figure 4-3**). In 2015, 63 percent of bicyclists were observed to be male (1,441 out of 2,291 bicyclists) which is almost identical to the 62 percent of bicyclists who were observed to be male in 2009. Recent research suggests that women may have a greater perception of safety concerns for streets without bicycle facilities[1].

1 Baker, L. 2009 - "How to get more bicyclists on the road: To boost urban bicycling, figure out what women want," Scientific American Magazine, October 16, 2009; Twaddle, H., et al., 2011 - Latent bicycle commuting demand and effects of gender on commuter cycling and accident rates, Transportation Research Record, 2190/2010, 28-36; Reeves, H. 2012 - "Spokes & soles // As infrastructure improves, more Twin Cities women bike," Southwest Journal, 11 June 2012; Akar, G., Fischer, N., and Namgung, M. 2013 - Bicycling Choice and Gender Case Study: The Ohio State University, Int. J. of Sust. Trans., Volume 7, Issue 5.

This is reflected in the observations of bicyclist gender in Berkeley, with the lowest proportion of women bicycling occurring at Spruce Street and Rose Street (22 percent) and Hearst Avenue and Oxford Street (28 percent), streets with limited bicycle accommodations. The highest proportion of women bicycling occurred at Martin Luther King, Jr. Way and Russell Street (41 percent), Colusa Avenue and Marin Avenue (41 percent), and Milvia Street and Channing Way (40 percent), streets with more robust bicycle infrastructure.

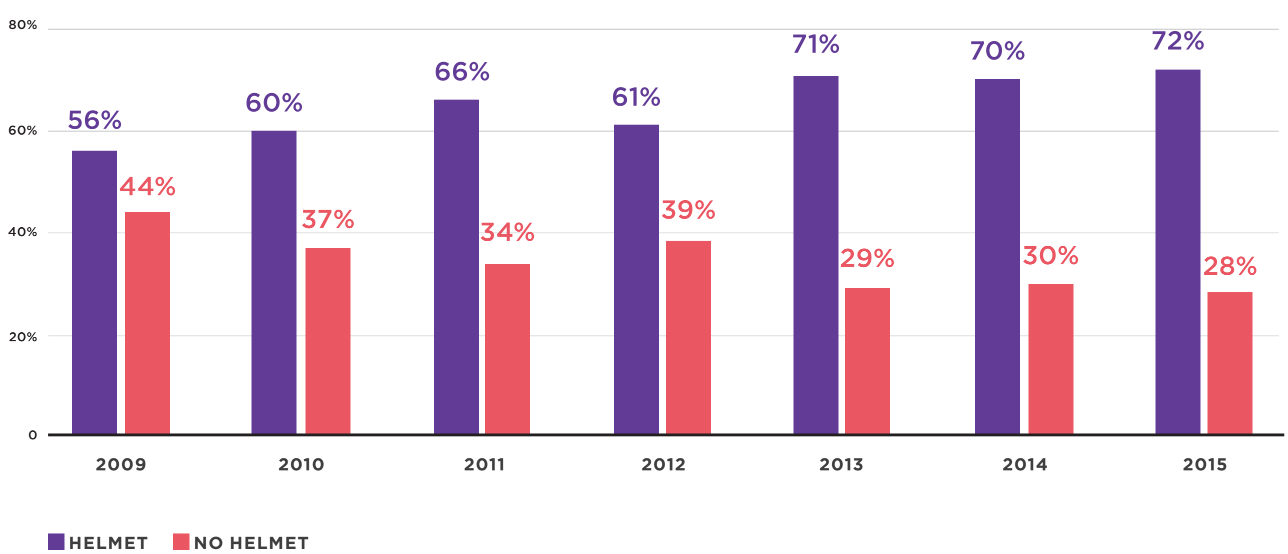
***Figure 4-3:** Bicyclist gender at 10 selected intersections (2009-2015)*



4.2.2. Helmet Usage

In 2015, 72 percent of observed bicyclists at the ten selected intersections were wearing a helmet (1,649 of 2,291 bicyclists). While the percent of bicyclists wearing helmets has fluctuated since counts began in 2009, the overall trend has been a steady 16 percent increase between 2009 and 2015 (see **Figure 4-4**). The intersections with the greatest observed helmet use between 2009 and 2015 were Spruce Street at Rose Street (80 to 90 percent) and Marin Avenue at Colusa Avenue (76 to 95 percent).

Figure 4-4: *Helmet use at 10 selected intersections (2009-2015)*

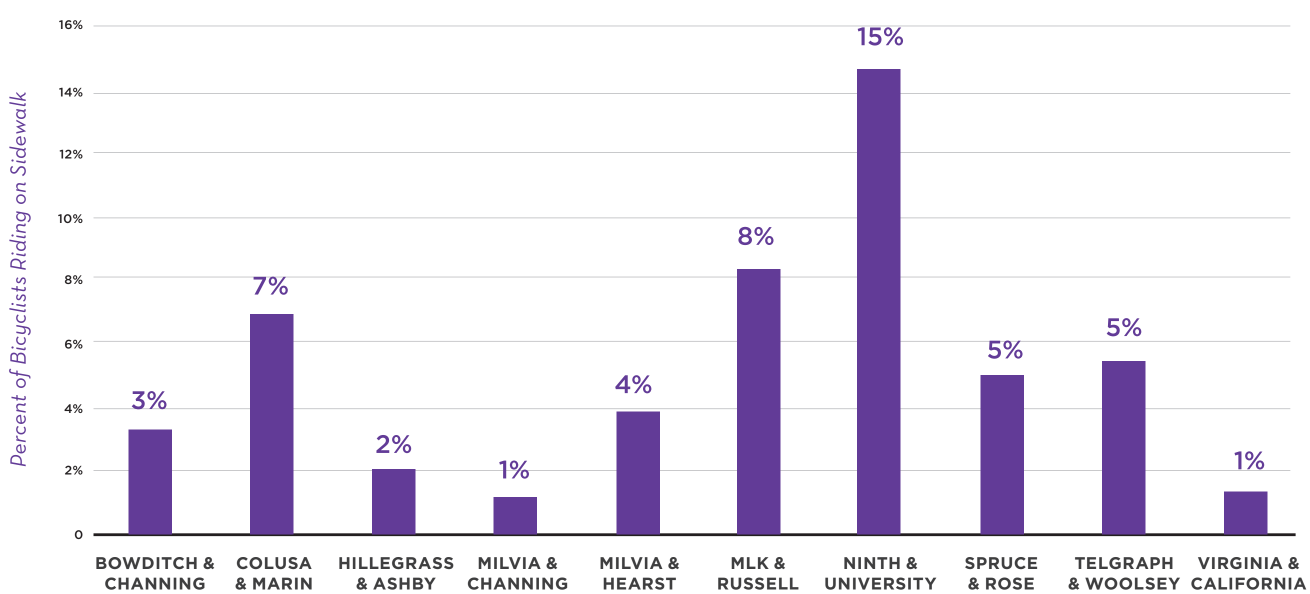


4.2.3. Sidewalk Riding

Between 2009 and 2015, the number of people riding their bicycles on the sidewalk instead of in the street was low relative to the total number of bicyclists observed at the 10 selected intersections, remaining consistently between four and five percent of all observed bicyclists. This is much lower than 16 percent observed in 2000[1]. However, observations at the intersection of 9th Street and University Avenue revealed that 15 percent of bicyclists rode on the sidewalk, with most of the sidewalk riding taking place on University Avenue, an arterial street with many activity centers and no bicycle facilities (see **Figure 4-5**).

1 Observations of sidewalk riding in 2000 included only five intersections instead of the ten intersections tracked between 2009-2015 (Bowditch and Channing, Hillegass and Ashby, Martin Luther King, Jr. and Russell, 9th and University, and Telegraph and Woolsey).

Figure 4-5: *Observed Sidewalk Riding*



4.2.4. Automated Counters

In addition to the ten selected intersections, 24-hour automated count data was collected along two paths: the West Street Path near Virginia Street and the 9th Street Path near the south Berkeley city limits. While manual bicycle counts provide a snapshot of bicycling on a single day, automated counters provide a continuous stream of ridership data to identify daily, monthly, and yearly trends. The automated counters are not able to distinguish between bicyclists and pedestrians; therefore, separate modal split factors were developed through manual observations of the count locations.
On average, the West Street Path near Virginia Street experiences just over 300 people bicycling per day and the 9th Street Path near the south Berkeley city limits experience almost 700 bicyclists per day (See **Table 4-4**).

***Table 4-4:** Interpolated Bike Counts at Selected Path Locations (October 2014 – September 2015)*

	WEST STREET PATH	9TH STREET PATH
Total Annual Bike/Ped	197,903	344,527
Total Annual Bike	108,253	252,194
Monthly Average	9,634	7,700
Daily Average	317	691
Annual Average PM Peak (4-6 PM)	52	113

4.3. BICYCLE DEMAND

A two-part bicycle demand analysis was conducted to provide a more accurate estimate of total bicycling in Berkeley as well as the geographic distribution of existing and potential bicycle trips.

4.3.1. Total Daily Bicycle Trips

The first part of the bicycle demand calculation was run using additional Berkeley-specific travel data from the ACS, the Alameda County Safe Routes to School Program, and a recent UC Berkeley travel survey. The demand model inputs are outlined below, and the results and full list of data sources are shown in **Table 4-5**:

- Number of bicycle commuters, derived from the ACS
- Work at home bicycle mode share
- Number of those who work from home and likely bicycle (derived from assumption that five percent of those who work at home make at least one bicycle trip daily)
- Bicycle to school mode share:
  - » Number of students biking to school, derived from multiplying the K-8 student population by the Alameda County bicycle to school average rate of four percent
- Number of those who bicycle to transit:
  - » Number of people who bicycle to BART or Amtrak, assuming that five percent of transit patrons use bicycles to access the station and/or their destination

Based on this model, there are an estimated 37,069 total daily bicycle transportation trips made by Berkeley residents. This number includes people who bike for work, errands, personal trips, and school trips. It does not account for purely recreational trips. Together with the ACS commute data, as well as the City of Berkeley's ongoing bicycle count data, this analysis can be used to track citywide bicycle use and demand in Berkeley over time.

***Table 4-5:** Interpolated Bike Counts at Selected Path Locations (October 2014 – September 2015)*

VARIABLE	FIGURE	CALCULATION AND SOURCE
Existing number of bike-to-work commuters	**4,640**	**Employed persons multiplied by bike-to-work mode share**
Existing bike-to-work mode share	8.5%	2014 ACS, 5-Year Estimates
Existing employed population	54,583	2014 ACS, 5-Year Estimates
Existing number of work-at-home bike commuters	**284**	**Employed persons multiplied by work-at-home mode share. Assumes 5% of population working at home makes at least one daily bicycle trip**
Existing work-at-home mode share	10.4%	2014 ACS, 5-Year Estimates
Existing employed population	54,583	2014 ACS, 5-Year Estimates
Existing transit bicycle commuters	**568**	**Employed persons multiplied by transit mode share. Assumes 5% of transit riders access transit by bicycle** *(Average of BART and AC Transit bike access volumes - BART Bicycle Plan Modeling Access to Transit (2012) and Alameda Countywide Bicycle Plan (2012))*
Existing transit-to-work mode share	21.0%	2014 ACS, B08301 5-Year Estimates
Existing employed population	54,183	2014 ACS, 5-Year Estimates
Existing school children bike commuters	**278**	**School children population multiplied by school children bike mode share**
Existing school children bicycling mode share	4.0%	Alameda County SR2S Program (Berkeley elementary and middle school only)
Existing school children, ages 5-14 (grades K-8th)	6,938	2014 ACS, S0101 5-Year Estimates
Existing college/graduate bike commuters	**12,778**	**College/graduate student population multiplied by college student bicycling mode share**
Existing estimated college/graduate bicycling mode share	34.0%	UC Berkeley 2014 (includes graduate students who live in and outside of Berkeley)
Existing number of college/graduate students in study area	37,581	UC Berkeley 2014 (includes graduate students who live in and outside of Berkeley)
Existing total number of bike commuters	**18,548**	**Total bike-to-work, school, college and utilitarian bike trips. Does not include recreation.**
Total daily bicycling trips	**37,096**	**Total bicycle commuters x 2 (for round trips)**

This is an order-of-magnitude estimate based on available American Community Survey data and does not include recreational trips, nor does it include trips made by people who live in other cities and work or attend school in Berkeley. It can be used as a secondary analysis method to track bicycle usage estimates over time.

4.3.2. Bicycle Demand Map

The estimate of daily bicycle trips shown in **Table 4-4** is a useful metric to track over time; however, for planning purposes it is also important to understand the geographic potential for bicycle trips. Spatial analysis of the proximity and density of trip generators (where people live) and trip attractors (where people work, shop, play, access public transit, and go to school) can help identify areas with high potential demand for bicycle activity in Berkeley. The list of data inputs is shown in **Table 4-6**.

Figure 4-6 overlays trips generators and trip attractors into a single composite sketch of bicycling demand in Berkeley: the darker the color, the higher the demand for bicycling. The current bikeway network is overlaid on the demand map to illustrate how well current bikeways provide coverage and connectivity to high demand areas. The results can be used to identify network gaps and to prioritize bicycle projects in areas of high trip demand.

***Table 4-6:** Bicycle Demand Map Inputs*

DEMOGRAPHIC DATA	• Population Density • % of Bike/Ped Commuters • % of Households Without Vehicles
EMPLOYMENT DATA	• Retail Employment Density • Educational Services Employment Density • Health Care and Social Assistance Employment Density • Arts, Entertainment, and Recreation Employment Density
SHOPPING AND RECREATION DATA	• Retail Corridors • Parks • Schools • Libraries • Museums
TRANSIT DATA	• Bus Stops • Train Stops • Transit Hubs

As shown, the majority of the downtown and major street corridors have high demand for bicycling, including Shattuck Avenue, University Avenue, Sacramento Street (north of Allston Way), Telegraph Avenue, portions of San Pablo Avenue, and the areas around the BART and Amtrak stations. Berkeley's system of bikeways has historically been developed around a lower-stress residential street Bicycle Boulevard network, with many major streets lacking bikeways. **Figure 4-1** shows that the current bikeway network, while providing coverage across most parts of the city, doesn't directly connect to many of the highest demand areas for bicycling, including commercial street corridors and the perimeter of the UC Berkeley campus. In many cases, only a block or two separates the designated bikeway from the high demand commercial street destinations; however, that "last block" gap can be a significant barrier to residents accessing their destination and choosing to make a trip by bicycle. Last block gaps may force people to ride along high-stress streets without bikeways, and can contribute to unsafe cycling behaviors such as wrong-way riding and sidewalk riding as people seek to take the most direct route to their destination.

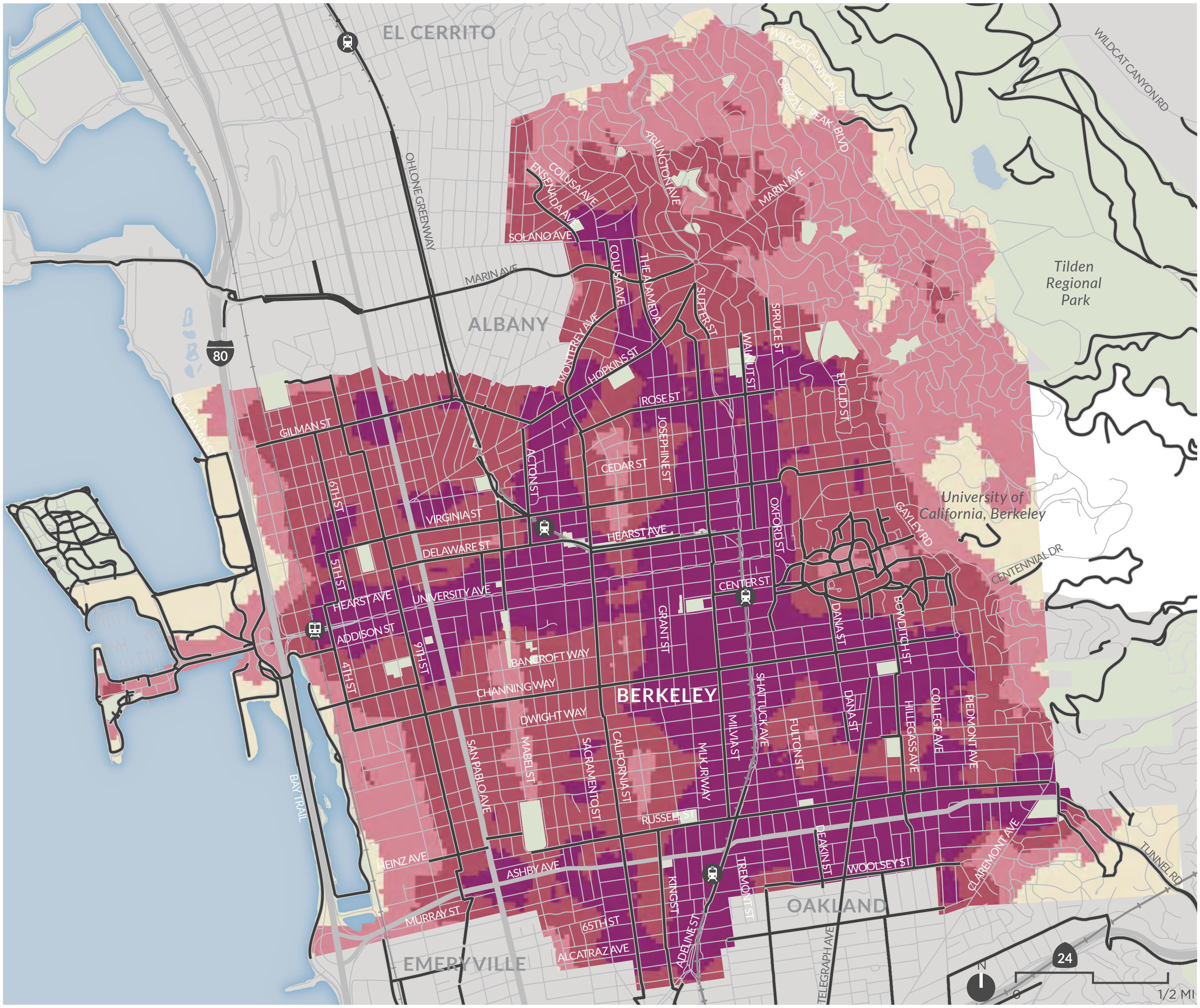


FIGURE 4-6: COMPOSITE BICYCLE DEMAND

BICYCLE DEMAND PROFILE

LOW DEMAND — HIGH DEMAND

EXISTING BIKEWAYS

BART STATION

AMTRAK STATION

4.4. COLLISION ANALYSIS

Bicycle-related collisions and collision locations in Berkeley were analyzed over the most recent twelve-year period of available data, 2001-2012. A bicycle-related collision describes a collision involving a bicycle with a second party (e.g. motor vehicle, pedestrian, stationary object) or without a second party (e.g., the person riding a bicycle has a solo-crash due to slippery road conditions or rider error). The term "collision location" describes a geographic location where at least one collision was recorded over the twelve-year period.

Collision data for this report was generated from the California Statewide Integrated Traffic Report System (SWITRS). Because SWITRS combines records from all state and local police departments, data varies due to differences in reporting methods. It is important to note that the number of collisions reported to SWITRS is likely an underestimate of the actual number of collisions that take place because some parties do not report minor collisions to law enforcement, particularly collisions not resulting in injury or property damage. Although under-reporting and omissions of "near-misses" are limitations, analyzing the crash data can illustrate trends both spatially and in behaviors (motorist and cyclist) or design factors that cause bicycle collisions in Berkeley. A map of bicycle-related collision density from 2001 to 2012 is shown in **Figure 4-6.**

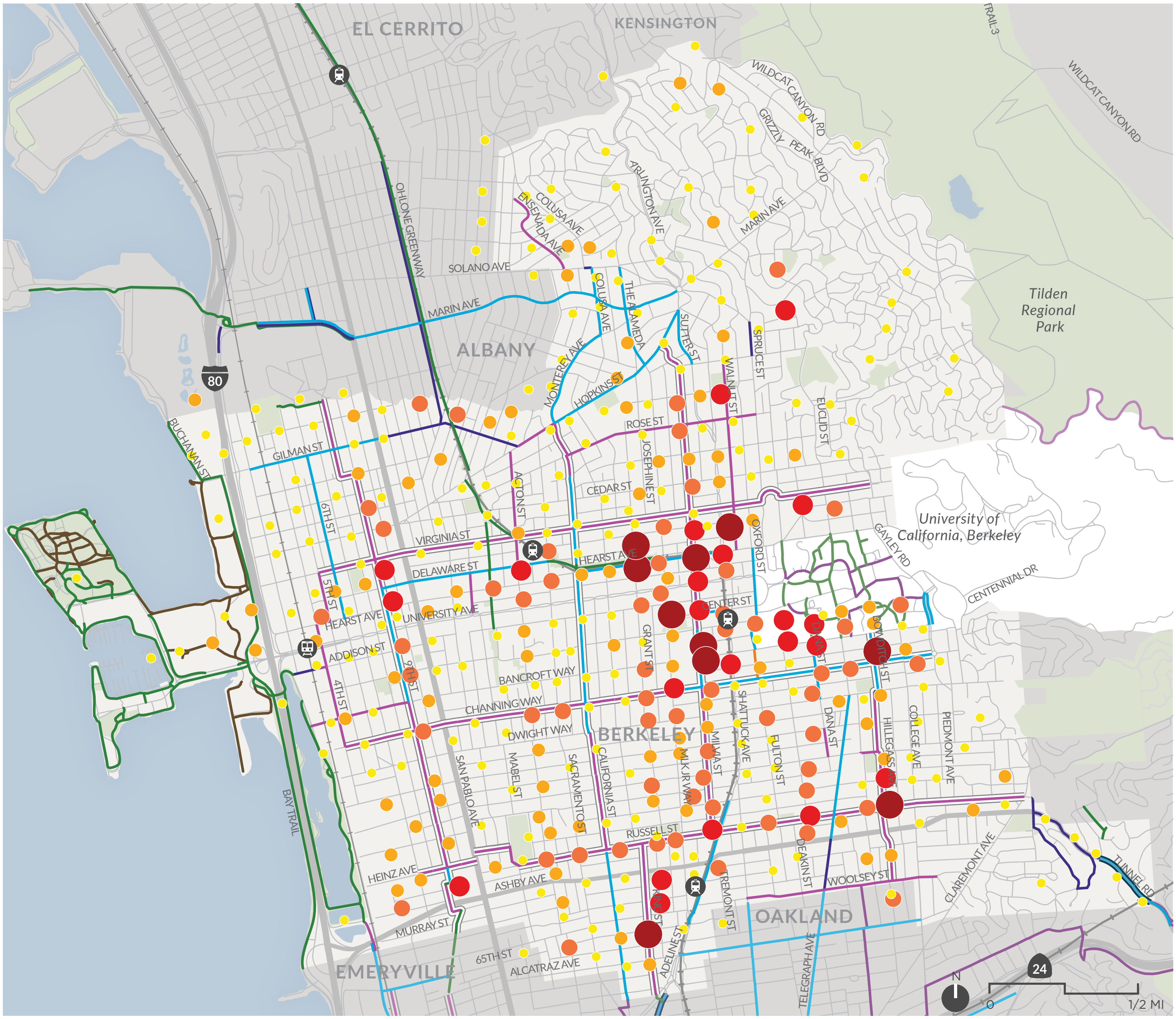


FIGURE 4-7: BICYCLE COLLISION DENSITY

NUMBER OF BICYCLE-INVOLVED COLLISIONS, 2001 to 2012

1 - 3
4 - 6
7 - 10
11 - 14
15 - 22

PAVED PATH [1A]
UNPAVED PATH [1B]
STANDARD BIKE LANE [2A]
UPGRADED BIKE LANE [2B]
SIGNAGE-ONLY [3A]
SHARROWS [3C]
BICYCLE BOULEVARD [3E]
CYCLETRACK [4A]

BICYCLE BOULEVARD NETWORK

PARK/REC
RAILROAD
BART STATION
AMTRAK STATION

The analysis of reported bicycle-related collisions can reveal patterns and potential sources of safety issues, both design and behavior-related. These findings can provide the City of Berkeley with a basis for infrastructure and program improvements to enhance bicycle safety. A list of primary findings is below, and described in the following sections. A more detailed collision analysis is included in Appendix B.

- Between 2001 and 2012, there were 1,773 total reported bicycle collisions in Berkeley.
- Bicycle-involved collisions were concentrated along **roadway segments without bikeway infrastructure near major activity centers** such as commercial corridors, UC Berkeley, and Ashby BART station. This suggests that people bicycling in Berkeley are willing to ride on routes without bikeway infrastructure if it is the most direct and accessible route to their destination.
- On streets with bikeway infrastructure, **Milvia Street had the highest number of total collisions** between 2001 and 2012, which suggests that programmatic and design changes may be necessary to accommodate the mix of roadway users along this downtown Bicycle Boulevard.
- Along Bicycle Boulevards, the **highest density of collisions occurred where the Bicycle Boulevard crossed a major arterial** such as Shattuck Avenue, University Avenue, College Avenue, and Martin Luther King Jr Way. This finding aligns with public input, which called for improved crossings of Bicycle Boulevards at major streets.
- Collisions resulting in **severe injuries were concentrated at intersections**, particularly along Ashby Avenue, Adeline Street, College Avenue, and Channing Way.
- Approximately **50 percent of reported collisions involved bicyclists between the ages of 20 and 39**, over representing the Census' reported total number of residents within this age range by roughly 10 percent. This may be the most common age of people who bicycle in Berkeley. This finding may also suggest that targeted programming for college students and young professionals could help reduce collisions for which the person bicycling is at fault.
- The most common factors resulting in a bicycle-involved collision were a right-of-way violation, hazardous violation, unsafe speed, and improper turning. Potential collision mitigation strategies to address these violations may include bikeway channelization along major arterials, distracted driving programming, additional strategies to slow people riding bicycles on non-Bicycle Boulevards with steep downhill slopes, and improved intersection design. Further definition on these collision factors are included below.

4.5. PUBLIC OUTREACH

The project involved an extensive public engagement process which included two public open houses, regular updates to the Bicycle Subcommittee of the Transportation Commission, information tables at nearly a dozen local community events (e.g., farmers' markets, street fairs), outreach at the 2015 and 2016 Bike to Work Day events, a project website with an ongoing comment page, and a bicycling preference survey. Over 1,000 comments were received throughout the process from gathering existing conditions through review of the public draft plan document.

The main themes public input indicated support for include:

- Safer crossings at major streets along the Bicycle Boulevard network
- Designated bikeways along major street corridors, especially those serving downtown and campus area
- Physical separation in bikeway design along major streets, along corridors and at intersections
- Improved pavement quality along the entire bikeway network

4.6. BICYCLING PREFERENCE SURVEY

As part of the public outreach, a survey was conducted of Berkeley residents asking about their interests, current habits, concerns, and facility preferences around bicycling. The survey used address-based random sampling to ensure responses were representative of the Berkeley population.[1] Survey staff interviewed 660 Berkeley residents between March 2 and March 28, 2015, yielding a margin of error of +/- 4 percent and a confidence level of 95 percent.[2]

The survey was modeled closely after *Four Types of Bicyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential*, a study completed by Professor Jennifer Dill from Portland State University.[3] Surveys were administered door-to-door and were presented on tablet computers which included pictures to better convey different street types and other concepts relevant to the survey.

Interviews were conducted during the evening hours of 4:00 PM through 7:30 PM on weekdays and during the afternoon on weekends to ensure greater participation among all demographic groups, especially commuters who would be returning home from work. During the weekday evenings, interviewers were careful to stop before it became too dark outside so as not to appear threatening.

One goal of the survey was to include UC Berkeley students in the respondent pool, as they compose a large percentage the city's population. In addition to the interviews with students that occurred as a result of door-to-door interviewing, outreach representatives conducted interviews at several of the university's dormitories.

4.6.1. Categorizing People Who Bicycle in Berkeley

To understand the potential demand for bicycling in Berkeley, respondents were sorted into groups based both on their current bicycling behavior and their bicycling comfort level on different facility types and roadway conditions. This allowed for comparing responses between groups to help reveal which factors affect one's decision to ride a bicycle, particularly related to different roadway conditions and bikeway facility types. These categories of bicyclists are described below.

1 The survey firm Civinomics used the publicly available zoning map of the City of Berkeley to categorize each street based upon its zoning designation. Streets were then randomly selected from each zoning category in proportion to the number of residents who live within each category. Each street within a certain zoning designation had an equal chance of being selected compared to other similarly zoned streets in the same area. Some streets have multiple zoning designations through multiple jurisdictions. In such a case, the street is separated out by designation and jurisdictional area and treated as multiple streets.

2 A 95% confidence interval means that if the same population is sampled on numerous occasions and interval estimates are made on each occasion, the resulting intervals would bracket the true population parameter in approximately 95% of the cases.

3 Dill, J. and N. McNeil. (2012) Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential. http://web.pdx.edu/~jdill/Types_of_Cyclists_PSUWorkingPaper.pdf.

BICYCLING COMFORT LEVEL

Bicycling comfort level is based on a classification system originally developed by Portland City Bicycle Planner Roger Geller. Geller's "Four Types of Transportation Cyclists" classified the general population of the city into categories of transportation bicyclists by their differing needs and bicycling comfort levels given different roadway conditions. Geller's typologies have been carried forward into several subsequent studies in cities outside Portland at the national level, and were used in the City of Berkeley analysis for consistency with national best practices and comparison to other top cycling cities. Under Geller's classification, the population of a city can be placed into one of the four following groups based on their relationship to bicycle transportation: "Strong and Fearless," "Enthusiastic and Confident," and "Interested but Concerned." The fourth group are non-bicyclists, called the "No Way No How" group.

These categories are meant to guide efforts to assess an area's market demand for bicycling as a means of transportation, such as commuting to work and running errands.

Table 4-7: *Four Types of Bicyclists*

TYPE OF BICYCLIST	DESCRIPTION
Strong and Fearless	This group is willing to ride a bicycle on any roadway regardless of traffic conditions. Comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities.
Enthusiastic and Confident	This group consists of people riding bicycles who are confident riding in most roadway situations but prefer to have a designated facility. Comfortable riding on major streets with a bike lane.
Interested but Concerned	This group is more cautious and has some inclination towards bicycling, but is held back by concern over sharing the road with cars. Not very comfortable on major streets, even with a striped bike lane, and prefer separated pathways or low traffic neighborhood streets.
No Way No How	This group comprises residents who simply are not interested at all in bicycling may be physically unable or don't know how to ride a bicycle, and they are unlikely to adopt bicycling in any way.

4.6.2. Survey Results

The survey found that three percent of Berkeley residents are *Strong and Fearless* bicyclists, 16 percent are *Enthusiastic and Confident*, 71 percent are *Interested but Concerned*, and 10 percent fall into the *No Way No How* category. In other words, 90 percent of Berkeley residents already bicycle or would consider bicycling if the right bikeway facility or roadway conditions were available. That is a larger percentage than any other city that has conducted a similar study, including Portland, as shown in **Figure 4-8**.

In *Four Types of Bicyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential*, Professor Dill outlines a method for creating a profile of a city's population based on Geller's categories. Having done this, planners can then analyze responses to a number of other questions by the different types of bicyclists to better understand the factors that motivate people to bicycle.

A respondent's assignment to one of the four groups depended on their answers to how comfortable they would feel bicycling on various hypothetical street scenarios, e.g. a paved path separate from the street, a two lane commercial street with no bikeway, a four lane commercial street with buffered bicycle lanes, etc. Whether someone indicated that they would like to bicycle more than they currently do, as well as whether they had bicycled in the last month and whether they were physically able to bicycle also determined how some respondents were sorted.

Figure 4-8: *Four Types of Bicyclists*

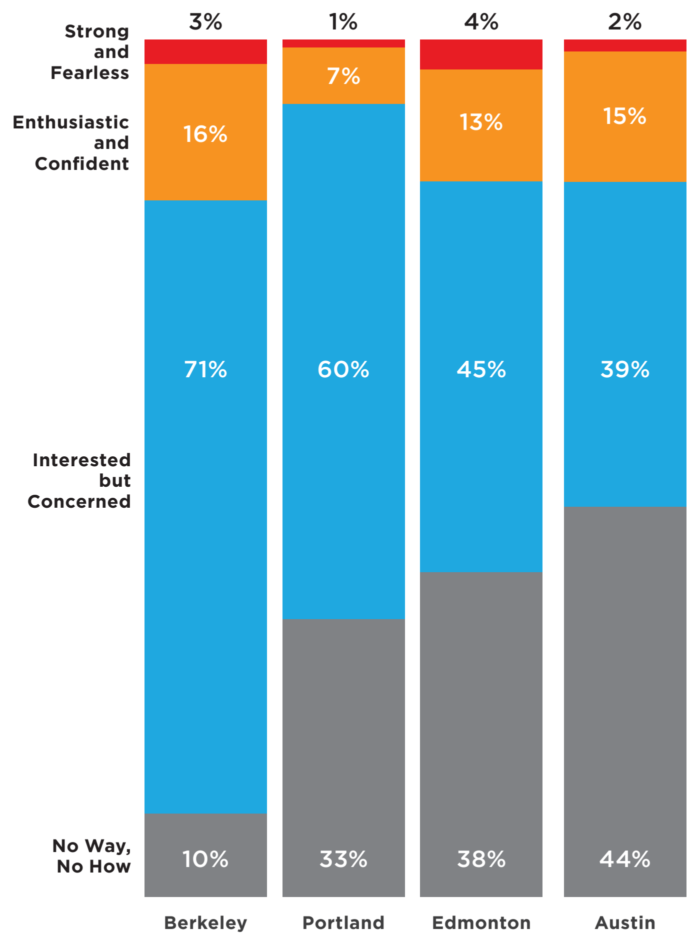


Figure 4-9: *Bicyclist Level of Comfort*

**Level of comfort on bicycle facilities as reported by survey respondents who were identified as Interested but Concerned*

4.7. LEVEL OF TRAFFIC STRESS

INTERESTED BUT CONCERNED BICYCLISTS IN BERKELEY

Seventy-one percent of Berkeley residents were classified as *Interested but Concerned*, which means the majority of Berkeley residents would be willing to bike if the right bikeway facilities were provided. Addressing barriers from this group would yield the greatest return on bicycle facility investment.

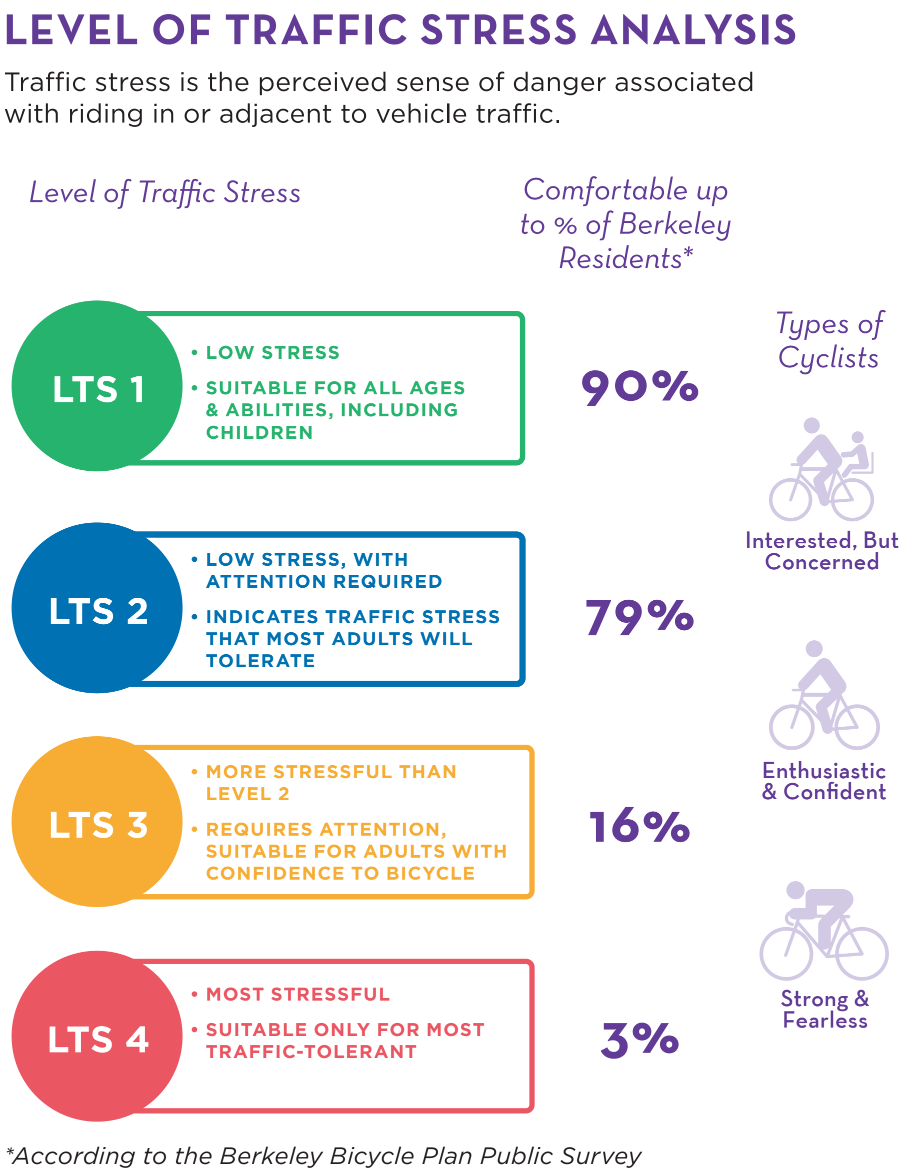
Asked to describe their subjective level of comfort riding on different types of streets, survey results showed that *Interested but Concerned* bicyclists become significantly more comfortable as separated bicycle facilities were added to roadways. For example, when asked about riding on a two lane commercial shopping street, the *Interested but Concerned* riders responded that they would be very uncomfortable if there were no bicycle facility, somewhat comfortable if a bicycle lane was added, and very comfortable if there were a bicycle lane separated from traffic by a curb or parked cars.

Taken altogether, the Report's findings indicate the potential for significant ridership growth. With carefully planned infrastructure investments and outreach campaigns that target the needs of the Interested but Concerned group of bicyclists, Berkeley has the potential to experience a substantial increase in bicycle riding.

Building on the bicycling preference survey and user typologies, a Level of Traffic Stress (LTS) analysis was conducted for Berkeley's roadway network. Traffic stress is the perceived sense of danger associated with riding in or adjacent to vehicle traffic; studies have shown that traffic stress is one of the greatest deterrents to bicycling. The less stressful—and therefore more comfortable—a bicycle facility is, the wider its appeal to a broader segment of the population. A bicycle network will attract a large portion of the bicycling population if it is designed to reduce stress associated with potential motor vehicle conflicts and if it connects people bicycling with where they want to go. Bikeways are considered low stress if they involve very little traffic interaction by nature of the roadway's vehicle speeds and volumes (e.g., a shared low-traffic neighborhood street) or if greater degrees of physical separation are placed between the bikeway and traffic lane on roadways with higher traffic volumes and speeds (e.g., a separated bikeway or cycletrack on a major street).

An LTS Analysis is an objective, data-driven evaluation model which identifies streets with high levels of traffic stress, gaps in the bicycle network, and gaps between streets with low levels of traffic stress. **Figure 4-10** shows a summary of LTS analysis factors. More information about the LTS Analysis can be found in **Appendix C: Level of Traffic Stress**.

***Figure 4-10:** LTS analysis factors*



The level of traffic stress scores were mapped to illustrate the low stress connections and gaps throughout Berkeley. It is important to note that people tolerate different levels of stress; a strong and fearless bicyclist will feel less stress than an interested but concerned bicyclist. The LTS results map approximates the user experience for the majority of Berkeley residents, however people may have differing opinions of traffic stress depending on their own experiences.

4.7.1. LTS Findings

Figure 4-11 shows the LTS results of the major roadways and on-street bicycle network in Berkeley. Major roadways, such as San Pablo Avenue and Martin Luther King Jr. Way, have high LTS scores, indicating they are the most stressful for people riding bicycles. Many of the existing on-street bicycle network segments in Berkeley consist of relatively low stress streets that are acceptable for travel by some children (LTS 1) and the majority of adults (LTS 2). These are primarily neighborhood street Bicycle Boulevards. However, high stress roadways and intersections bisect this low stress network and create barriers for people who bike along the Bicycle Boulevards or want to access major service and commercial corridors, effectively lowering the corridor LTS score and dramatically reducing comfort.

The low stress streets that have an LTS score of 1 or 2 are shown in **Figure 4-12**. These are the streets on which nearly all types of people should feel comfortable riding bicycles. As shown, Berkeley has good coverage with a network of low stress bikeways. California Street, 9th Street and Hillegass Avenue provide north-south connections; Virginia Street, Channing Way and Russell Street provide east-west connections. However, there are gaps in the low stress network, including a section on the Milvia Avenue Bicycle Boulevard, a lack of low stress connections north and south of Virginia Street and between Channing Way and Russell Street, and surrounding the UCB campus.

High-stress intersections are often a result of a bikeway crossing a major roadway where the intersection design or stop-control is insufficient. For example, Channing Way, an LTS 2 Bicycle Boulevard, crosses Sacramento Street, which is a high-volume roadway. Sacramento Street traffic does not stop, and people riding bicycles must traverse multiple lanes of traffic to continue. As such, an "Interested but Concerned" cyclist may feel comfortable biking on Channing Way, but this journey becomes far more stressful upon reaching Sacramento Street. While many "enthusiastic and confident" or "interested but concerned" Berkeley residents endure such stressful crossing conditions out of necessity, only the three percent of Berkeley residents who identify as "strong and fearless" would actually feel comfortable bicycling on Channing Way across Sacramento Street. High-stress intersections become impediments for individuals traveling on the bike network, and likely inhibit the 16 percent of "enthusiastic and confident" and the 71 percent of "interested but concerned" residents from biking more frequently, or at all. As is, there are very few continuous low stress segments that provide access entirely across Berkeley.

Figure 4-13 shows low stress (LTS 1 and 2) streets and intersections with high stress (LTS 4) gaps. This map helps illustrate how low stress streets in Berkeley's on-street network are often disconnected by high stress roadways and intersections. A continuous low stress network is essential for bicyclists of all abilities to travel easily throughout the street network.

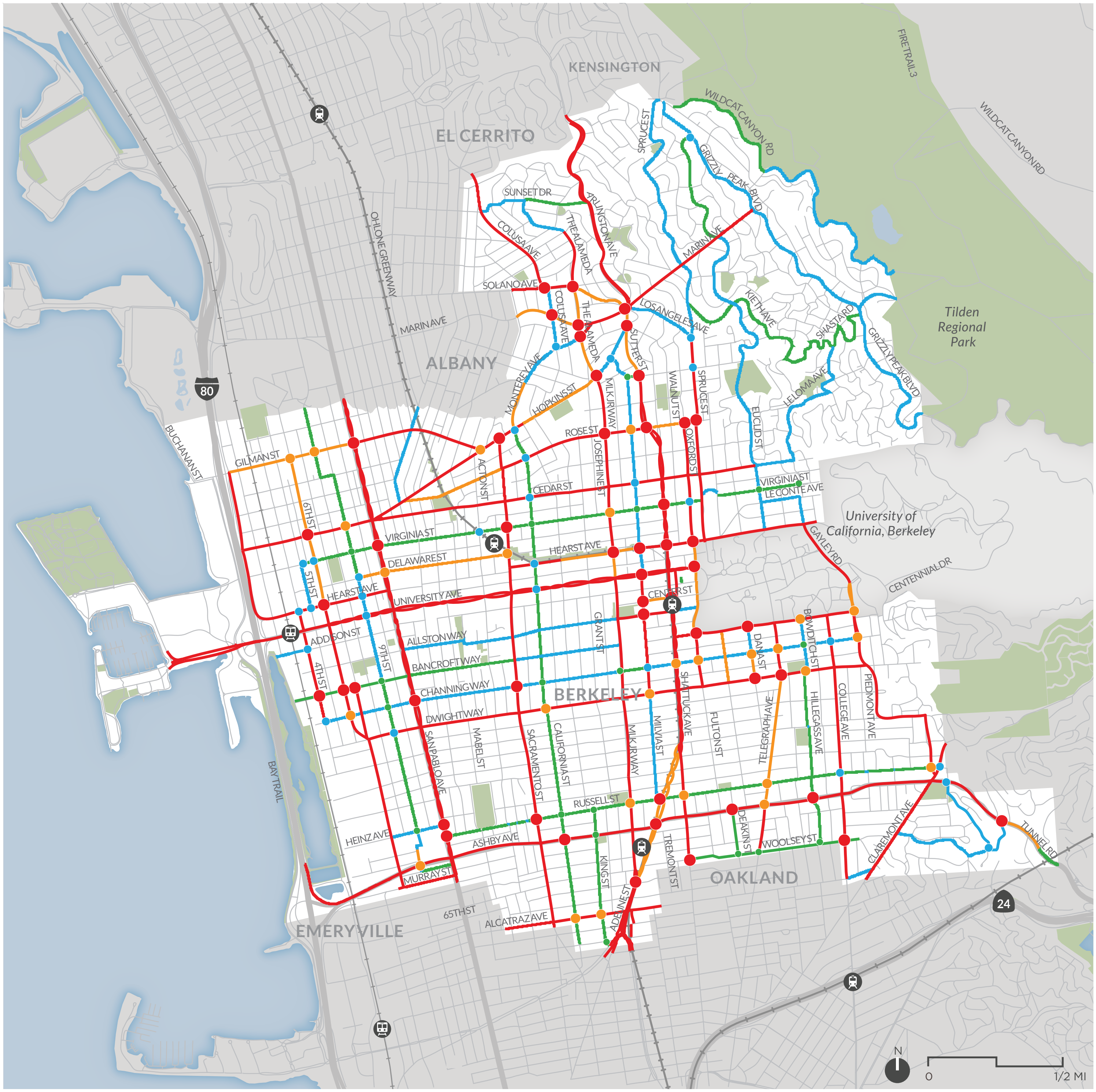


FIGURE 4-11: LEVEL OF TRAFFIC STRESS

CORRIDORS

- LTS 1 - ALL AGES AND ABILITIES
  (Up to 90% of Berkeley residents)
- LTS 2 - INTERESTED BUT CONCERNED
  (Up to 79% of Berkeley residents)
- LTS 3 - ENTHUSIASTIC AND CONFIDENT
  (Up to 16% of Berkeley residents)
- LTS 4 - STRONG AND FEARLESS
  (Up to 3% of Berkeley residents)

INTERSECTIONS

- LTS 1 - ALL AGES AND ABILITIES
  (Up to 90% of Berkeley residents)
- LTS 2 - INTERESTED BUT CONCERNED
  (Up to 79% of Berkeley residents)
- LTS 3 - ENTHUSIASTIC AND CONFIDENT
  (Up to 16% of Berkeley residents)
- LTS 4 - STRONG AND FEARLESS
  (Up to 3% of Berkeley residents)

PARK/REC

RAILROAD

BART STATION

AMTRAK STATION

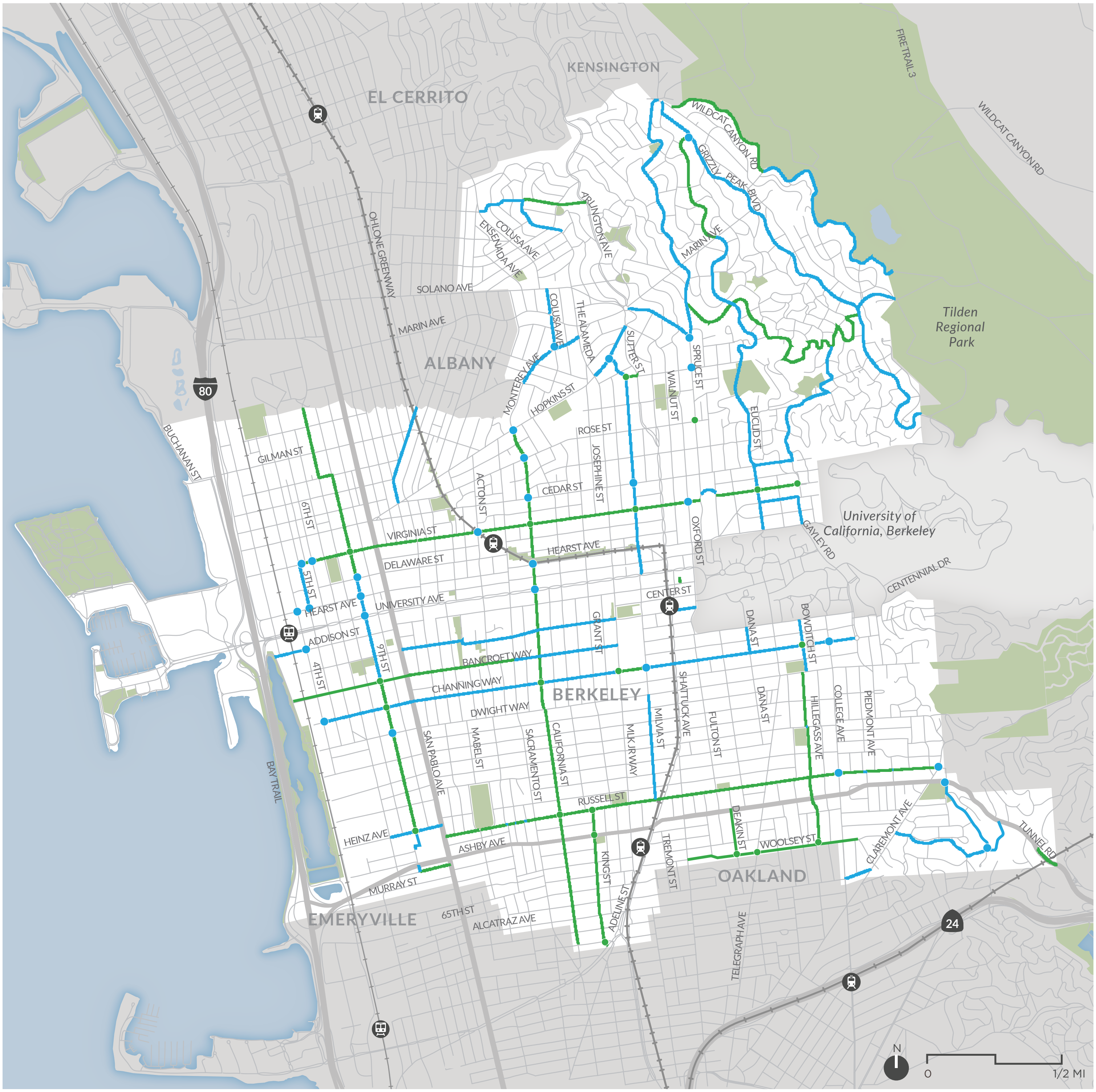


FIGURE 4-12: LOW STRESS NETWORK COVERAGE

CORRIDORS	*INTERSECTIONS*
LTS 1 - ALL AGES AND ABILITIES	LTS 1 - ALL AGES AND ABILITIES
LTS 2 - INTERESTED BUT CONCERNED	LTS 2 - INTERESTED BUT CONCERNED

PARK/REC | RAILROAD | BART STATION | AMTRAK STATION

FIGURE 4-13: LOW STRESS NETWORK & INTERSECTIONS WITH HIGH STRESS NETWORK & INTERSECTION GAPS

CORRIDORS	*INTERSECTIONS*
LTS 1 - ALL AGES AND ABILITIES	LTS 1 - ALL AGES AND ABILITIES
LTS 2 - INTERESTED BUT CONCERNED	LTS 2 - INTERESTED BUT CONCERNED
NETWORK GAPS	***INTERSECTION GAPS***
LTS 3 - ENTHUSIASTIC AND CONFIDENT	LTS 3 - ENTHUSIASTIC AND CONFIDENT
LTS 4 - STRONG AND FEARLESS	LTS 4 - STRONG AND FEARLESS

PARK/REC
RAILROAD
BART STATION
AMTRAK STATION

4.7.2. LTS Conclusion

The Level of Traffic Stress results demonstrate the importance of assessing a citywide bikeway not only for connectivity, but also for its ability to serve the diverse needs of its users. Although the current Berkeley bikeway network provides good overall coverage of low stress bikeways through the Bicycle Boulevards, the presence of high-stress gaps (segments and intersections) along these routes likely inhibit many Berkeley residents who identify as “enthusiastic and confident” and “interested but concerned” from bicycling.

To serve all types of people riding bicycles, an on-street bikeway network must provide continuous low stress LTS 1 and LTS 2 segments and intersections, from end to end. A single high stress gap on an otherwise low stress facility can deter use. By pinpointing and prioritizing the exact high-stress locations that likely dissuade people riding bicycles, this Plan can focus on identifying the improvements that will bring the high-stress LTS 3 and LTS 4 gaps down to low stress LTS 1 and LTS 2 levels, thereby removing the barriers to bicycling for a larger proportion of Berkeley residents.

4.8. INFORMING THE RECOMMENDATIONS

The findings of the needs analysis chapter in terms of demand, collisions, and particularly the Level of Traffic Stress provide quantitative data that directly inform the project recommendations in the next chapter. This Plan focuses on making improvements to address identified gaps in the network:

1. **High-stress gaps** occur on the bikeway network where a bikeway segment or intersection has a high-stress score of LTS 3 or LTS 4. On the Bicycle Boulevard network, any bikeway segment or intersection with a score of LTS 2 or above is considered a high-stress gap. The Bicycle Boulevard network is presumed to be a primarily low stress network for bicyclists of all ages and abilities.
2. **Bikeway network demand gaps** are missing bikeway segments where there is high demand but no existing bikeway. Examples include a neighborhood with a deficiency of bikeway access, or a commercial street that has a density of destinations but lacks a bikeway.

Project recommendations in the following chapter focus on making crossing improvements and segment upgrades along the existing LTS 1 and 2 network (primarily Bike Boulevards) to ensure a continuous low stress experience from end-to-end of the facility, as well as upgrading existing higher stress segments of bikeways (primarily Class II bike lanes on major streets) to a lower-stress facility type. Several additional facility segments are recommended in order to provide better network coverage and connectivity in high demand areas.

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