4. Network Connectivity Results

4.1. Base Connectivity

At the outset, we ran connectivity calculations to seven destination types and created a composite map of the average connectivity to each type of destination. As discussed in the Methods section, averaging over many types of destinations helps to overcome any particular connectivity problems the census blocks and block groups may have had from one specific direction. Figure 10 shows these results for the overall region (see the website for enlargements of the West and East valley).

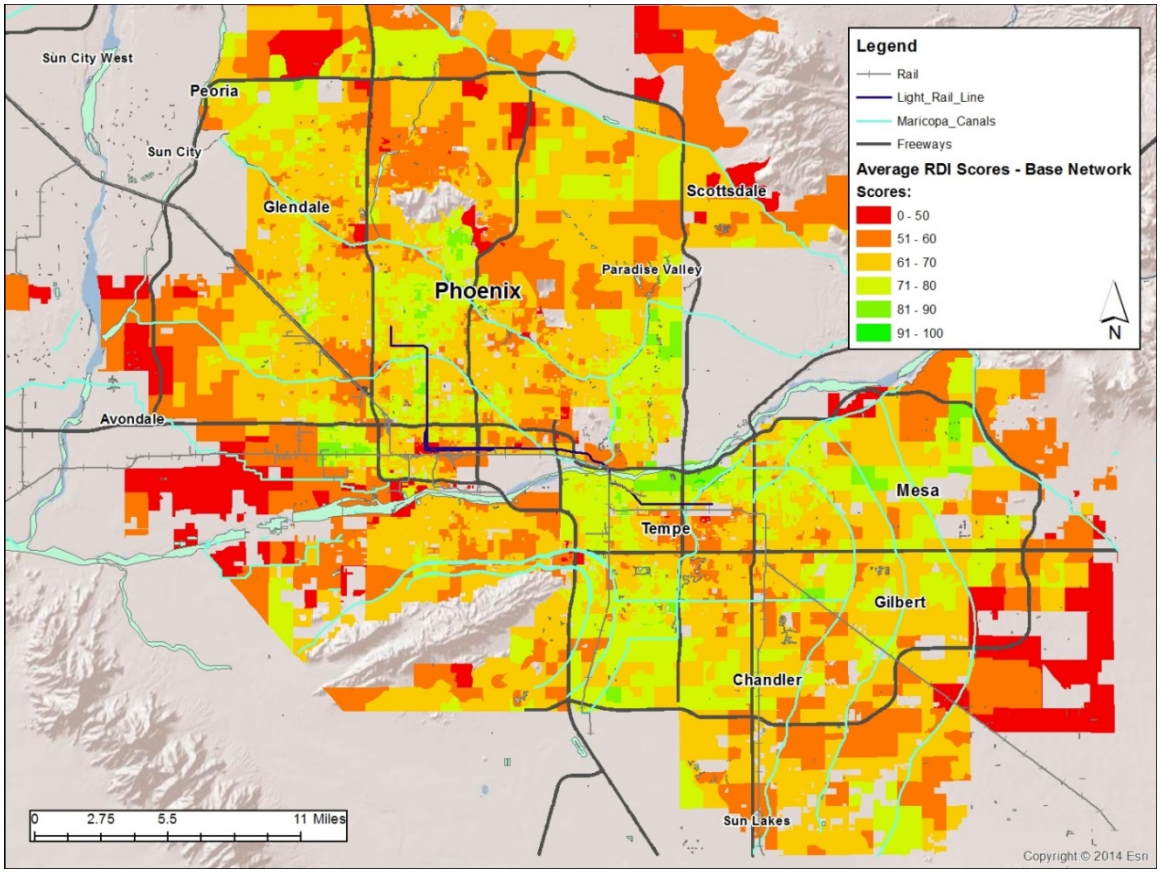

Figure 10. Average connectivity for the base network.

The overall landscape of connectivity reveals two overarching results. The first is that when averaging over the seven destination types, the connectivity by bicycle from all neighborhoods is pretty good: very few neighborhoods have average RDIs below 50. On the other hand, there are some clear areas of poor RDIs caused by significant barriers that, to most or all nearby destinations, force riders out onto major arterials with no bike lanes. **These results are promising for the prospect of improving cycling connectivity in the Valley, because it is clear where many of these barriers lie, and how to fix them.** For example, we highlight the barriers from freeways and railways in Figures 11 and 12 (next pages), all of which force riders out onto major arterials with no bike lanes and thus reduce connectivity across those barriers. Loop-202 causes some connectivity issues throughout east Phoenix, while I-17 causes barriers in south and west Phoenix. The Union Pacific (UP) rail grade through Tempe and into

Mesa causes significant barriers to connectivity throughout that area, effectively trapping an entire section of these two cities. It is especially unfortunate given that this part of Tempe and Mesa has high potential bike ridership due to the number of community college and university students.

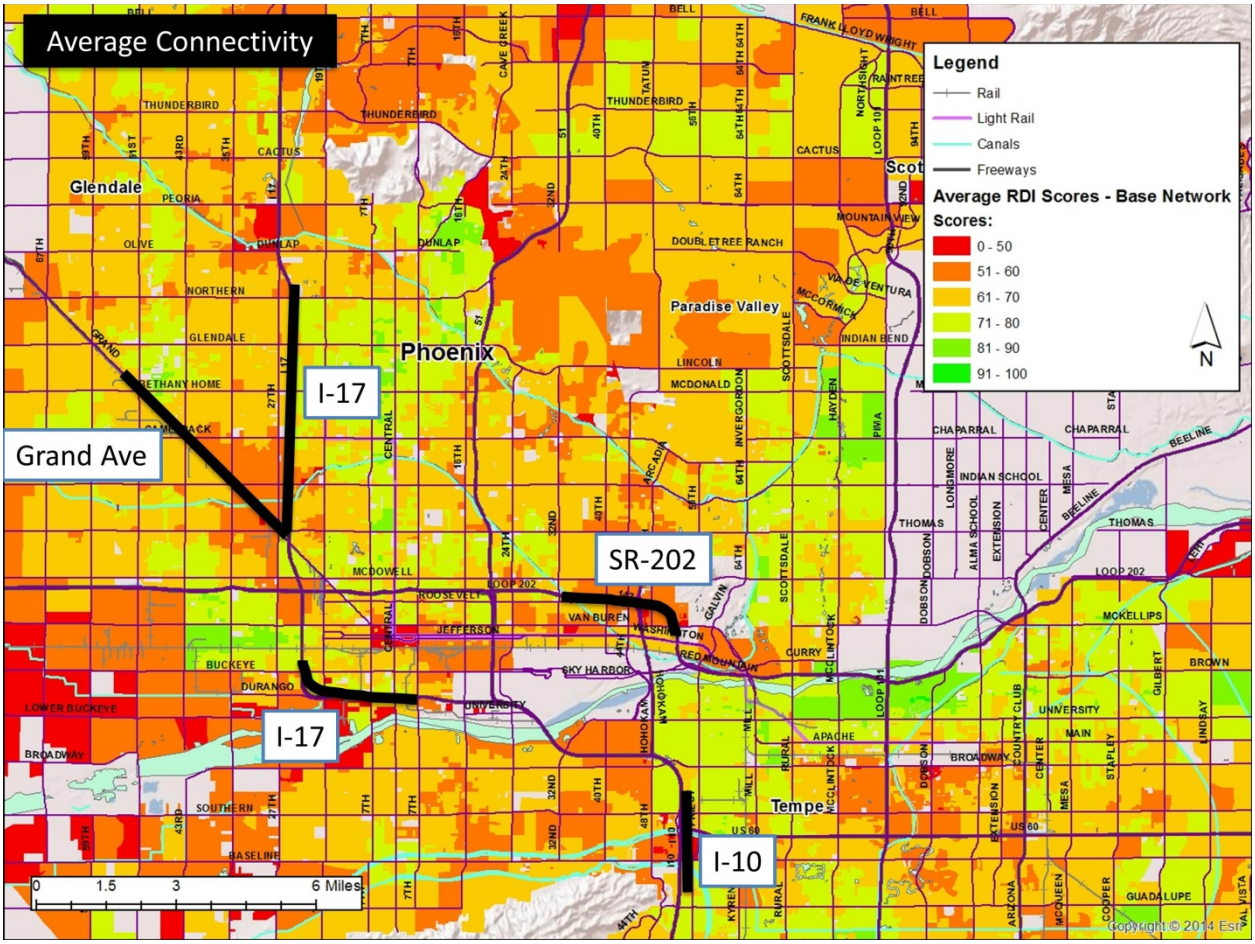

Figure 11. Key barriers to average connectivity in the Central and West Valley.

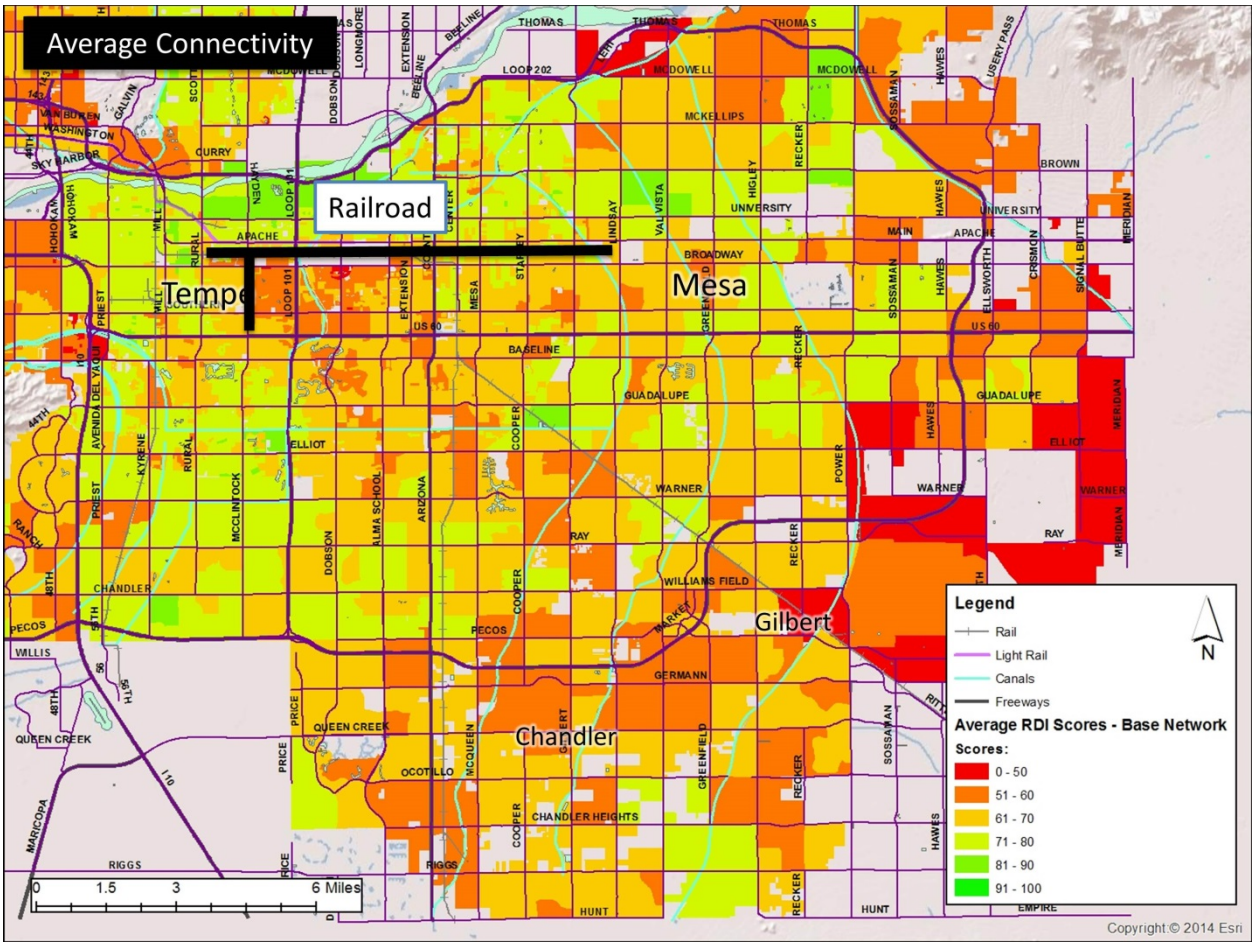

Figure 12. Key barriers to average connectivity in the East Valley.

4.2. Effect of Improvements Proposed in Four Central and East Valley Cities

To understand how much connectivity may improve from a given set of investments, we implemented a sample of network improvements from the bike plans of the cities of Mesa, Scottsdale, Tempe and Phoenix. We asked that the respective Transportation Planners per municipality list a small series of bicycle network improvement projects while limiting their ideal projects to a budget of an estimated $10 million. The purpose of this is to show that we, using ViaCity, would be able to produce significant improvements with little investment, adding additional, simple, infrastructure to the existing network. The following tables display a combination of actual and hypothetical bicycle network improvements that each city has planned or desires. (Tables 6-9, next pages)

Table 6 – Proposed Phoenix improvements

Location	Challenge	Solution
10th St & Campbell Ave	No bike/ped crossing at canal	Add bike/ped bridge over canal crossing
Loop 202 & 34th St	No bike/ped crossing at canal	Add bike/ped bridge over canal
19th Ave & Grand Canal	Non-signalized crossing	Add HAWK signal for bike/ped crossing
16th St & Highline Canal	Non-signalized crossing	Add HAWK signal for bike/ped crossing
7th St & Highline Canal	Non-signalized crossing	Add HAWK signal for bike/ped crossing
12th St & Highline Canal	No bike/ped crossing at canal	Add bike/ped bridge over canal

Table 7 – Proposed Scottsdale improvements

Location	Challenge	Solution
McDowell Rd (various)	Missing gaps in bike lanes	Add bike lanes to connect gaps
Thomas Rd from 73rd St to 64th St	Missing bike lanes	Add bike lanes
68th St from Thomas Rd to Indian School Rd	Missing bike lanes	Add bike lanes
Scottsdale Rd (various)	Missing gaps in bike lanes	Add bike lanes to connect gaps
CAP Canal & Loop 101	Missing infrastructure along canal; No bike/ped crossing at canal	Develop infrastructure along canal; Add bike/ped bridge at canal crossing
Pima Rd from Indian Bend Rd to McDowell Rd	Missing bike lanes	Add bike lanes

Table 8 – Proposed Tempe improvements

Location	Challenge	Solution
Broadway Rd from Mill Ave to Priest Dr	Missing bike lanes	Add bike lanes
Southern Ave from 48th St to Loop 101	Missing bike lanes	Add bike lanes
McClintock Dr from Southern Ave to Loop 202	Missing bike lanes	Add bike lanes
Western Canal & Baseline Rd	No bike/ped crossing at Baseline Rd	Add grade separated bike/ped bridge at Baseline Rd crossing
Union Pacific Railroad & Country Club Way/Smith Rd	No bike/ped crossing at rail line	Add grade separated bike/ped crossing over rail line

Table 9 – Proposed Mesa improvements[6]

Location	Challenge	Solution
Dobson Rd from Southern Ave to Tempe Canal	Missing bike lanes	Add bike lanes
Broadway Rd (various)	Missing bike lanes	Add bike lanes
Extension from Southern Ave to Broadway Rd	Missing bike lanes	Add bike lanes
Southern Ave (various)	Missing bike lanes	Add bike lanes
Stapely Rd (various)	Missing bike lanes	Add bike lanes
University Dr from Higley Rd to Power Rd	Missing bike lanes	Add bike lanes
Brown Rd at Hawes & Loop 202	Missing bike lanes/paths	Add bike lanes/paths
Northwest community at Brown Rd & Loop 202	Missing bike paths	Add bike paths

[6] Proposed improvements for Mesa were developed by the research team.

Figure 13 shows the resulting changes in connectivity in each neighborhood due to these network changes. We found significant improvements in connectivity both in the vicinity of projects and further way "downstream" of the projects – sometimes extending for many miles.

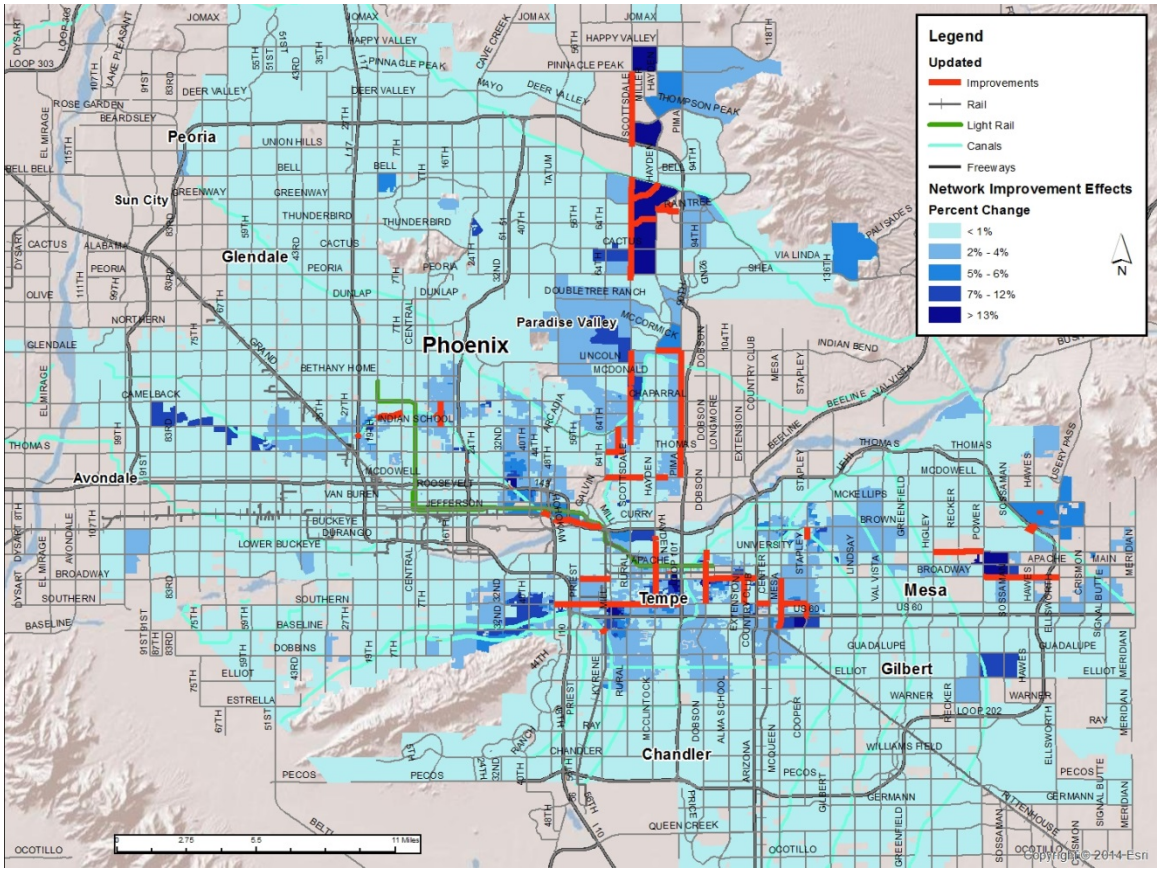

Figure 13. Improvements in connectivity resulting from a selection of network improvements taken from city bike plans.

For example, infrastructure improvements to the Grand Canal around I-17 cause improvements in connectivity out to beyond 75th Avenue, while infrastructure improvements in north Scottsdale caused a similar fanning out of connectivity improvements extending over a longer geography. There, improving bike infrastructure along Scottsdale Rd. has significant impacts both near the road and west into Paradise Valley. Infrastructure improvements at the border of west Tempe and south Phoenix create improved connectivity extending as far west as 7th Street in Phoenix. Improvements in central Tempe and west Mesa cause a significant part of those cities to experience improved connectivity. These results show that small and well-placed network improvements can have large effects on connectivity for a large number of current and potential bike riders. This corroborates the actual experiences of riders today, where certain areas of the region are not easy to bike to—not because of distances, but because of real and perceived barriers and the need to ride in dangerous situations.

4.3. Student Ideas for Improved Connectivity to Light Rail Stations

Students in a graduate transportation class at ASU were asked to look at areas of poor connectivity to light rail stations and recommend a few network improvements to address those issues. Figure 14 zooms in on the RDI scores for existing connectivity to light rail stations. The class focused on four areas with noticeable poor connectivity in Figure 14: (A) 19th Avenue and Camelback; (B) 24th Street and Van Buren; (C) 40th Street and Van Buren; and (D) East Tempe and Mesa.

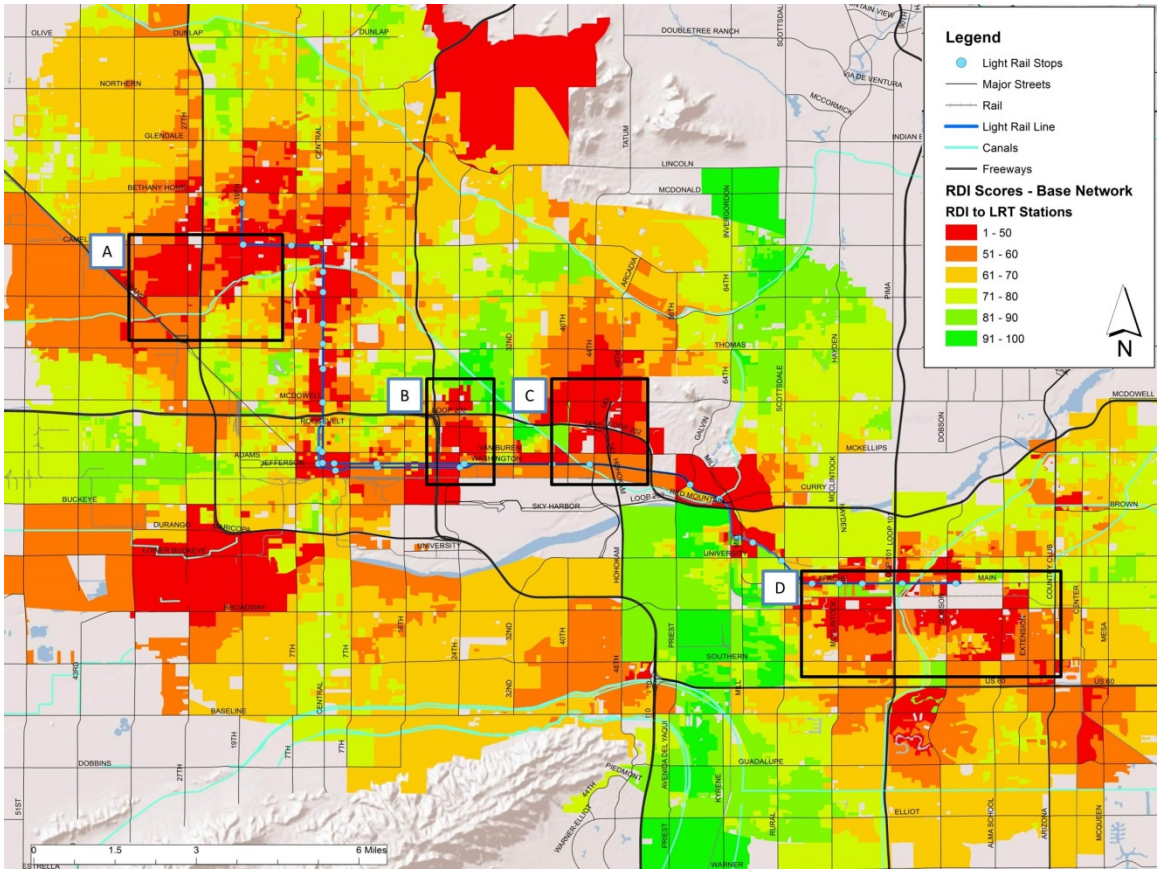

Figure 14. Existing connectivity to 4 light rail stations: (A) 19th and Camelback; (B) 24th Street and Van Buren; (C) 40th Street and Van Buren; and (D) East Tempe and Mesa.

Several key connectivity problems were identified in these four areas. Major issues were found in East Tempe and West Mesa in the area of the railroad grade between Apache and Main and Broadway. This barrier effectively forces all cyclists out onto the major arterials for north-south connectivity, thus reducing the relative connectivity in the area. The SR-202 caused similar barrier effects in east Phoenix, while the lack of bike lanes in and around the 19th and Camelback light rail stations caused problems there. These issues are addressed in the network improvement proposals listed in Table 10 (next page) and mapped in Figure 15 (page 33).

Table 10 –Student proposed bicycle infrastructure for improving connectivity to LRT stations

Location	Problem	Solution
West Mesa	North-South connectivity through the industrial corridor just east of the Loop-101	Add two bike paths through the industrial zones and over rail to connect Broadway to Main (Light rail)
West Mesa	North-South connectivity just east of the Loop-101	Add two bike lanes on Dobson and Alma School
West Mesa	East West Connectivity	Add bike lane to Broadway Rd.
West Mesa to East Tempe	Connectivity across the Loop-101	Add bike lanes to bridge cross at Alameda over the Loop-101
East Tempe	North-South connectivity between Broadway and Apache east of Rural	Add two bike paths between Broadway to Apache (Light rail); one near Los Feliz Rd. and one near Dorsey Lane.
East Tempe	East West Connectivity	Add bike lane to Broadway Rd.
East Phoenix	General Connectivity	Add bike lanes to 24th, 32nd, 40th and 44th Streets and along Van Buren
Phoenix (19th at Camelback)	General Connectivity	Add bike lanes to 19th and Camelback near intersection

These additions to the bicycle infrastructure would significantly improve the connectivity of some areas to light rail, as shown in Figure 15 (next page).

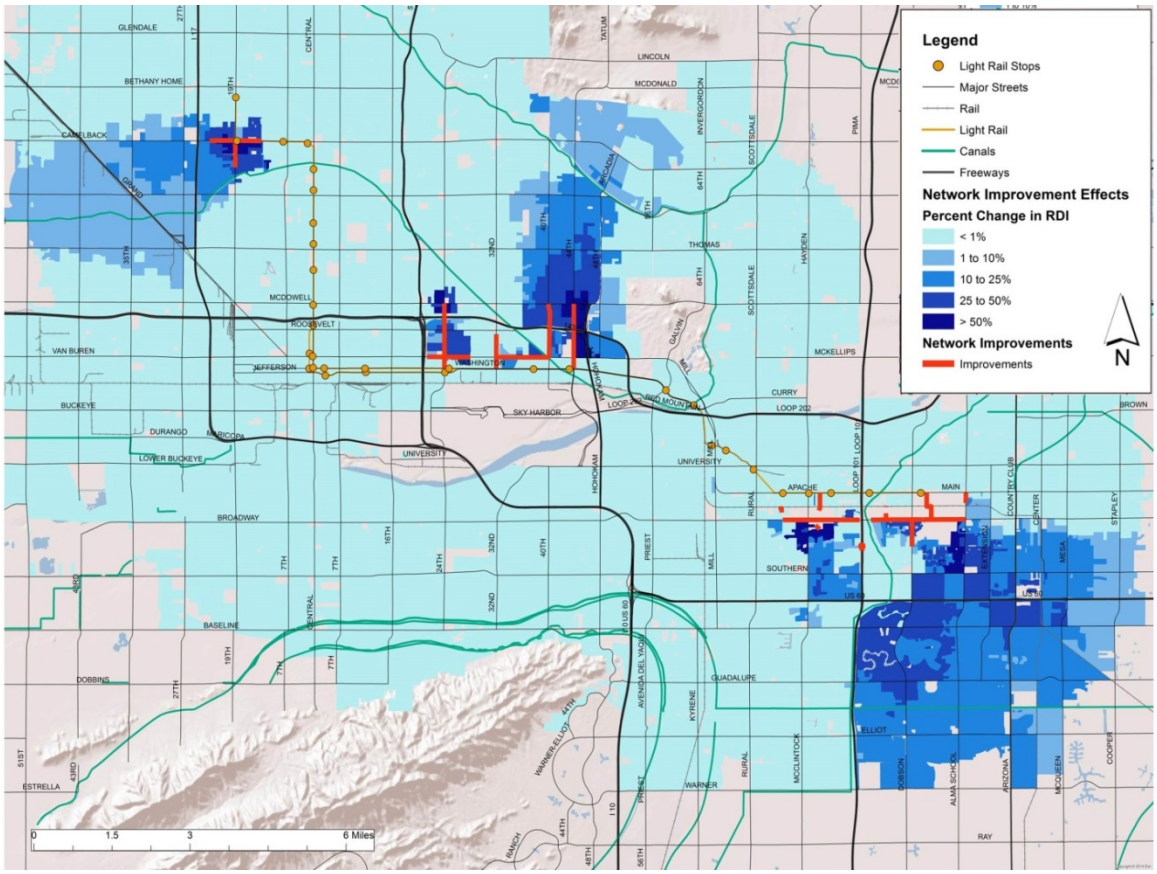

Figure 15. Percent improvement of RDI scores over the base case for student-proposed bicycle infrastructure. Change in RDI is for connectivity exclusively to Light Rail stations—other destination types were not considered here.

These results are notable in several ways. First, adding railroad crossings and bike lanes to arterial streets can improve connectivity by as much as 50%. This is a significant improvement that would be likely, in our opinion, to influence behavior. (Note that the percentage RDI improvement is much higher (over 50%) in Figure 15 than in Figure 13 (over 13%) because Figure 13 presented the *average* RDI improvement over the full suite of destinations studied, whereas 15's RDI changes were designed specifically for the light rail stations and measured only to the light rail destinations.) Second, infrastructure improvements can improve connectivity for neighborhoods miles away from where the projects are built. Third, the RDI improvement diminishes, in percentage terms, with increasing distance from where the projects are built.[7] The improvements have the greatest percentage impact on neighborhoods close to the stations. Because light rail greatly extends the number of destinations accessible by bicycle, infrastructure improvements targeted at connectivity to stations should be a priority.

[7] Projects will tend to reduce distance (or impedance) by an absolute amount, which reduces the denominator of the RDI by a set amount. The larger the numerator of the RDI (the Euclidean distance), the smaller the effect on the total RDI by reducing the denominator (impedance of the best route) by the same set amount.