Appendix H. Level of Traffic Stress and Bicycle Network Analysis

This memo documents the methodologies used to complete the Bicycle Network Analysis. This consists of two steps: 1) calculation of the Level of Traffic Stress for all streets and trails countywide, and 2) calculation of low stress bicycle connectivity at the census block level using the Bicycle Network Analysis tool.

DATA AVAILABILITY AND ASSUMPTIONS

Level of Traffic Stress (LTS) calculation is based upon several key factors further explained in the section below. Data for these factors was not available in all cases throughout Napa County, so it was necessary to make assumptions based on available data. This is a typical step for LTS calculations as jurisdictions throughout the country do not have full data available.

Data necessary for LTS calculation include the following:

- Number of travel lanes
- Speed limit
- Traffic volume
- Bicycle facility type
- On-street parking presence
- Width of bike lane
- Width of parking
- Centerline presence

Full data was available countywide for the following factors:

- Number of travel lanes
- Bicycle facility type

For all other factors, assumptions were made based on street classification. Classification data was provided by NVTA and covered all streets in Napa County. The following assumptions were made:

- Speed limit
    - Highway: 50 mph
    - Major Arterial: 40 mph
    - Minor Arterial: 35 mph
    - Collector: 30 mph
    - Local: 25 mph
- Traffic volume (note that volume is only used for evaluating shared lane conditions either where no facility is present, or for Bike Route (class III) facilities)
    - Highway or Major Arterial: 30,000 ADT

    - Minor Arterial: 20,000 ADT
    - Collector: 10,000 ADT
    - Local: 300 ADT
- On-street parking presence
    - Highway, Major Arterial, Minor Arterial: not present
    - Local, Collector: present
- Width of bike lane
    - 5' for all
- Width of parking
    - 8' for all
- Centerline presence
    - Highway, Major Arterial, Minor Arterial, Collector: present
    - Local: not present

All assumptions tend toward a more conservative score. That is, we assume higher volumes and minimum widths that result in a conservative estimate of a street's stress level.

After creating a comprehensive dataset, from these assumptions, the process described below was applied to all Napa County streets to rate them high or low stress. This analysis was conducted using existing bicycle facilities data and subsequently using planned facilities recommended in this Plan.

For the planned facilities LTS, all bicycle boulevards and bike lanes were assumed to be low stress. The bike lane assumptions were then reviewed manually to appropriately rate those bike lanes that are planned for higher speed, higher volume streets. In all cases, shared use paths (Class I) and separated bike lanes (Class IV) were assumed to be low stress.

Intersections are also assessed for LTS. Where low-stress streets cross high-speed, wide streets without a signal, the crossing is scored as high-stress. Where low-stress streets cross major streets at a traffic signal, the crossing stays low stress. Signal locations were available for all of Napa County.

LEVEL OF TRAFFIC STRESS

Level of Traffic Stress Background

The Level of Traffic Stress (LTS) methodology was developed in 2012 and first published in a report by the Mineta Transportation Institute (MTI). The concept in this paper was expressed as a "worst case scenario" analysis whereby the characteristic of the street segment (number of lanes, speed, bike facility presence/width, parking presence/width) that scored the highest stress level on a scale of 1 to 4 trumped the rest. The methodology has since evolved to consider the interaction of several roadway factors as outlined below. Today, streets are evaluated based on all factors without one factor trumping the rest.

Level of Traffic Stress is calculated with the Interested but Concerned user in mind. This means that streets with low volumes but high speeds that may be comfortable for a more experienced rider are considered stressful in this analysis. Many rural roads in Napa County meet this description, but because the goals of this Plan specifically reference increasing ridership, streets were evaluated with the less-frequent or non-bicyclist in mind.

LTS Methodology

Tables 1 through 3 are adapted from the most recent LTS guidance criteria published by Peter Furth, Ph.D, one of the original authors of the MTI LTS report.[1] Toole Design has used our planning and design experience to amend the tables to better reflect what we believe to be conditions contributing to rider stress. Changes to the tables are highlighted with red outlines in the tables below and include:

- Shared lane conditions with vehicles
    - Revision upwards of stress level for higher volume streets, and
    - Revision to the ADT thresholds to include a higher volume threshold for low speed streets, so lower speed street LTS scores are differentiated from higher speed streets based on the volume of traffic
- Bike lane adjacent to parking
    - Addition of a ≤ 20mph category
    - Addition of a 40+ mph category
    - Further definition between total width categories (Furth 2017 tables only include 12-14' and 15'+ categories)
    - Retention of distinction between high- and low-turnover parking areas from earlier versions of tables, though where no data are available, stress is assumed to be the higher of the two scores

In many cases, the changes that Toole Design made were either to increase the LTS score for specific situations or expand on the number of categories for speed or ADT. For example, the original LTS scoring tables for mixed traffic and one thru lane per direction included LTS scores for volumes in the following categories: 0-750, 751-1500, and 1501+ vehicles. Toole Design further broke out the ADT categories to also include explicit scores for 1501-3000, 3001-6000,6001-10000 and 10001+ vehicles. We believe that these assumptions accurately reflect the bicyclist's experience and, importantly in the case of shared lane conditions, includes the impact of traffic volume.

[1] Furth (2017). Level of Traffic Stress. Available at: www.northeastern.edu/peter.furth/criteria-for-level-of-traffic-stress

Shared Lane Conditions

Table 1, below, shows the LTS scoring for shared use facilities. These are roadways with no bicycle facility or those with a Class III bicycle facility, either a rural bike route or bicycle boulevard. It should be noted that data regarding the presence and width of shoulders was not available and is not typically incorporated into LTS analysis.

Table 1 Assessment for shared lane conditions with ADT data

Mixed traffic criteria								
		Prevailing Speed						
Number of lanes	Effective ADT*	≤ 20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50+mph
Unlaned 2-way street (no centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751-1500	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
	1501-3000	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	3000+	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
1 thru lane per direction (1-way, 1-lane street or 2-way street with centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751-1500	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
	1501-3000	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4
	3001-6000	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	6001-10000	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	10001+	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
2 thru lanes per direction	0-6000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	6001-12000	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	12001+	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
3+ thru lanes per direction	any ADT	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
* Effective ADT = ADT for two-way roads; Effective ADT = 1.67*ADT for one-way roads								

Bike Lanes and Parking

Bike lanes adjacent to parking are considered higher stress facilities when other variables (speed and number of lanes) are held constant. For instance, a bike lane on a 35mph two-lane street is scored LTS 2 if it is not adjacent to parking, regardless of width. Where the lane is adjacent to parking, it is scored LTS 3 because of the increased stress of riding next to parked cars whose doors may open into the bicyclist's path of travel and force cyclists into adjacent auto travel lane. See the two circled cells in Tables 2 and 3 for this scoring.

Table 2 Assessment for bike lanes not adjacent to a parking lane

Bike lanes and shoulders not adjacent to a parking lane							
		Prevailing Speed					
Number of lanes	Bike lane width	≤ 25 mph	30 mph	35 mph	40 mph	45 mph	50+ mph
1 thru lane per direction, or unlaned	6+ ft	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
2 thru lanes per direction	6+ ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4
3+ lanes per direction	any width	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4

Notes

1. If bike lane / shoulder is frequently blocked, use mixed traffic criteria.

2. Qualifying bike lane / shoulder should extend at least 4 ft from a curb and at least 3.5 ft from a pavement edge or discontinuous gutter pan seam

3.Bike lane width includes any marked buffer next to the bike lane.

Table 3 Assessment for bike lanes adjacent to a parking lane

Bike lanes alongside a parking lane						
	Bike lane reach = Bike + Pkg lane width	Prevailing Speed				
Number of lanes		≤ 20 mph	25 mph	30 mph	35 mph	40+ mph
1 lane per direction	15+ ft	LTS 1	LTS 1	LTS 2	LTS 3	LTS 4
	14 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4
	12-13 ft	LTS 2	LTS 2/3*	LTS 2/3*	LTS 3	LTS 4
2 lanes per direction (2-way)	15+ ft	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
2-3 lanes per direction (1-way)		LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
other multilane		LTS 3	LTS 3	LTS 3	LTS 3	LTS 4

Notes

1. If bike lane is frequently blocked, use mixed traffic criteria.

2. Qualifying bike lane must have reach (bike lane width + parking lane width) ≥ 12 ft

3.Bike lane width includes any marked buffer next to the bike lane.

** Rating depends on parking turnover. Low turnover (i.e. residential) = LTS 2, high turnover (i.e. commercial o*

BICYCLE NETWORK ANALYSIS

Methodology

The Bicycle Network Analysis (BNA) approach allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are connectivity challenges. The BNA evaluates connectivity of each Census block within biking distance (3.1 miles, approximately 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks.[2] The BNA assumes a Census block connects to any road that either follows its perimeter or serves its interior. In practice, this means you can get to a destination whose front door is on a stressful street if you can get to a low-stress street around the corner. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking negates a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

Using information about which blocks are connected, the BNA calculates the total number of destinations accessible on the low-stress network and compares that with the total number of destinations that are within biking distance regardless of whether they are accessible via the low-stress network. Points are assigned on a scale of 0-100 for each destination type based on the number of destinations available on the low-stress network, as well as the ratio of low-stress destinations to all destinations within biking distance. The scoring places higher value on the first few low-stress destinations by assigning points on a stepped scale. Beyond the first few low stress destinations, points are prorated up to 100 based on the ratio of low-stress to high-stress routes. For example, a census block with low-stress access to only one park out of five nearby parks would receive 30 points. A census block with low-stress access to two parks out of five would receive 50 points (30 for the first park, 20 for the second). A census block with low-stress access to four parks out of five would receive 85 points (30 for the first, 20 for the second, 20 for the third, and 15 out of the remaining 30 points for connecting one of the remaining two parks).

For Census blocks where a destination type is not reachable by neither high- nor low-stress routes, that destination type is excluded from the calculations. Scores calculated on an individual Census block level enable planners to see connectivity at a granular level. However, the results can also be aggregated by weighting each block according to its population and then summarizing scores across a given area such as each city within Napa County.

[2] Destination data is pulled from Open Street Map for use in the BNA. Population data is pulled from the US Census.

Typically, BNA relies upon destination locations pulled from Open Street Map. However, the Napa County analysis used destinations specific to the interests of the county stakeholders. These included:

- Retail locations, as identified by jurisdiction staff
- Schools and colleges
- Libraries
- Post offices
- Cafes
- Hotels
- Restaurants
- Parks
- Major trailheads
- Major transit stops, defined as the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29

The BNA also includes a measure of population connectivity based on Census data and employment connectivity based on LEHD data.

The tool considers that a block is connected if a low-stress street is along any side of that block, even if the destinations actually front on the high-stress street that bounds the block. Thus, for instance, retail destinations along these major streets are considered connected to Census blocks on either side of the street. Figure 1 illustrates this concept: retail in the yellow block fronts on the high-stress (red) street. However, the block is connected to the low-stress network on the other three sides, so the blue block would be considered connected to that retail.

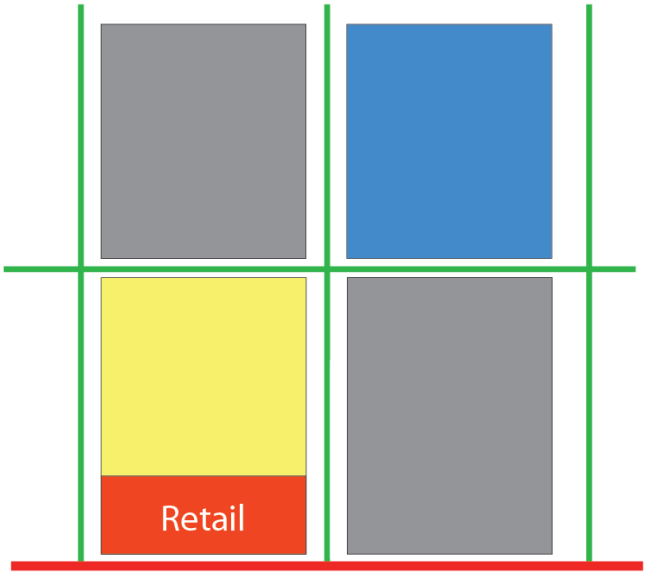


Figure 1 Schematic illustration of BNA connectivity

COMMITTEE REPORT ON CONNECTIVITY ANALYSIS

Level of Comfort Analysis

This plan assessed Napa County's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail on scoring of streets is available in Appendix H.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike.

The LTS analysis for Napa County clearly points to issues with traffic stress on the major streets—arterials and collectors—throughout the county. These are streets that carry most of the county's vehicle traffic, connecting over longer distances to major destinations. For instance, most of the retail destinations in Napa County are located on arterial streets, and they do not always have access from the rear of the parcel off a lower-speed, lower-volume street.

Though low-stress streets and trails currently make up over 50 percent of the network countywide, challenges occur where low-stress streets cross major streets without a traffic signal. In these cases, bicyclists need to wait for a long enough gap in traffic to feel safe crossing, and the wide crossing distances create greater exposure to potential crashes. When considering whether to ride somewhere, potential bicyclists will often be deterred if their route includes such a crossing.

A more detailed review of LTS analysis results is provided for each jurisdiction in Chapters 6-11.

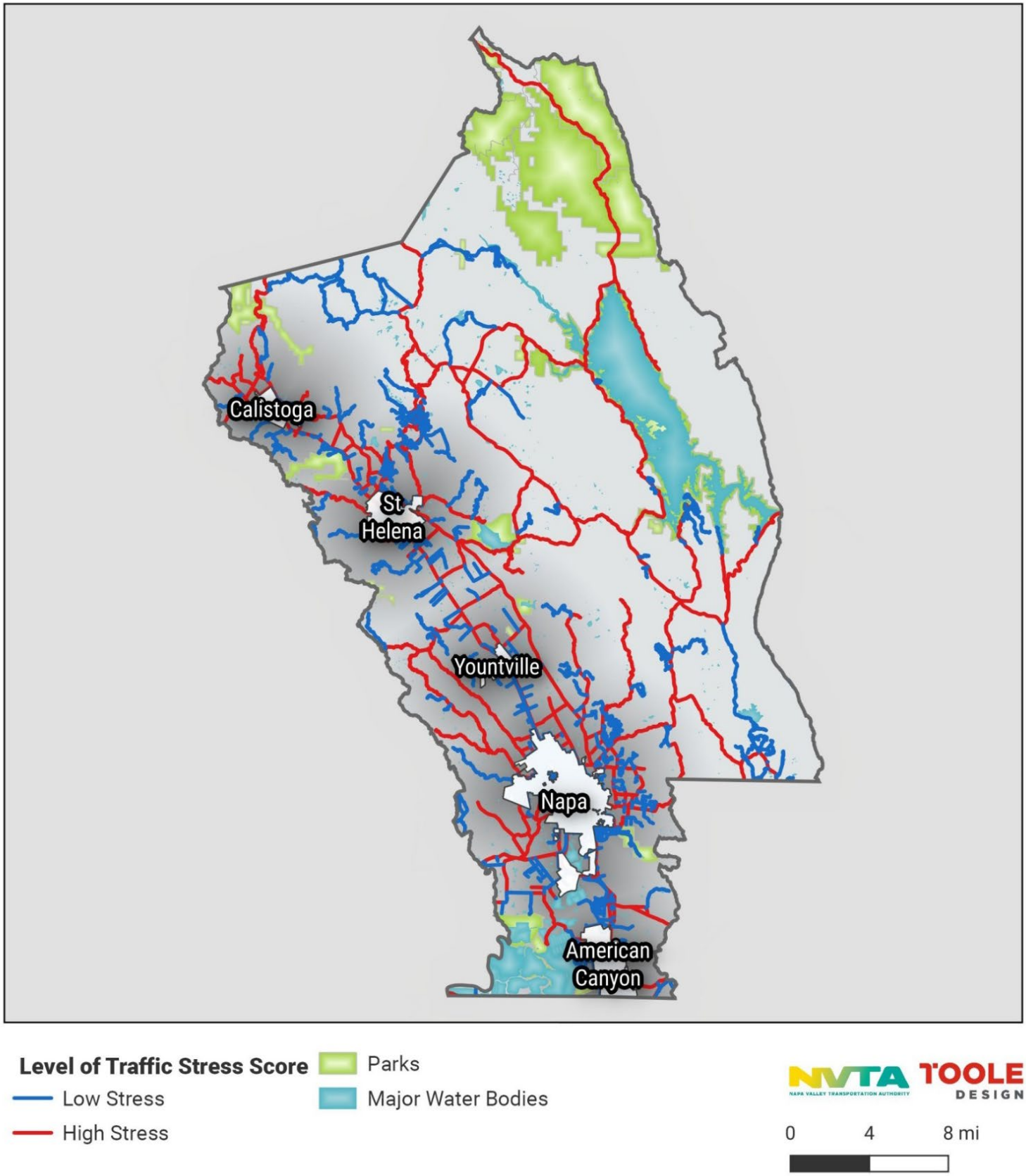


Figure 3.15 Level of Traffic Stress Results for Existing Bicycle Facilities

Connectivity Analysis

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of the county is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores in and across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[3]

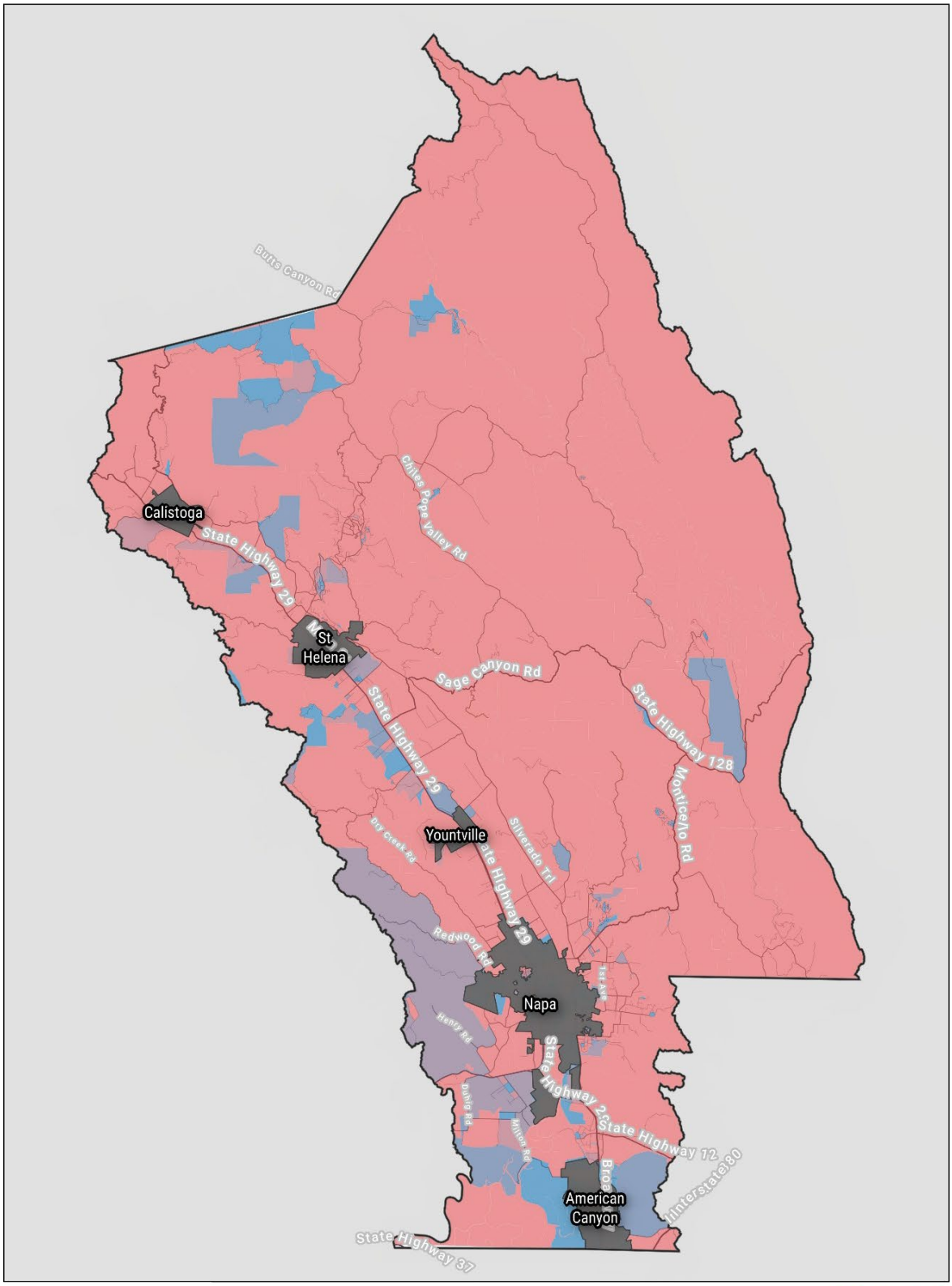
As can be seen from the map below (Figure 3.16), low-stress access across the county is generally better within urban areas. Underlying street network connectivity is better in these areas than rural ones, and that inherent characteristic often translates to better connectivity scores regardless of existing bicycle infrastructure on that street network.

Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = OK Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

Some low-volume rural roads are also rated as low stress for bicycling and so are shown to provide better connectivity in outlying areas where there are few destinations. However, overall Napa County scores a population-weighted BNA of 33 today.

[3] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.



Destination Access (0-100)

- 0 - 20
- 20 - 35
- 35 - 50
- 50 - 75

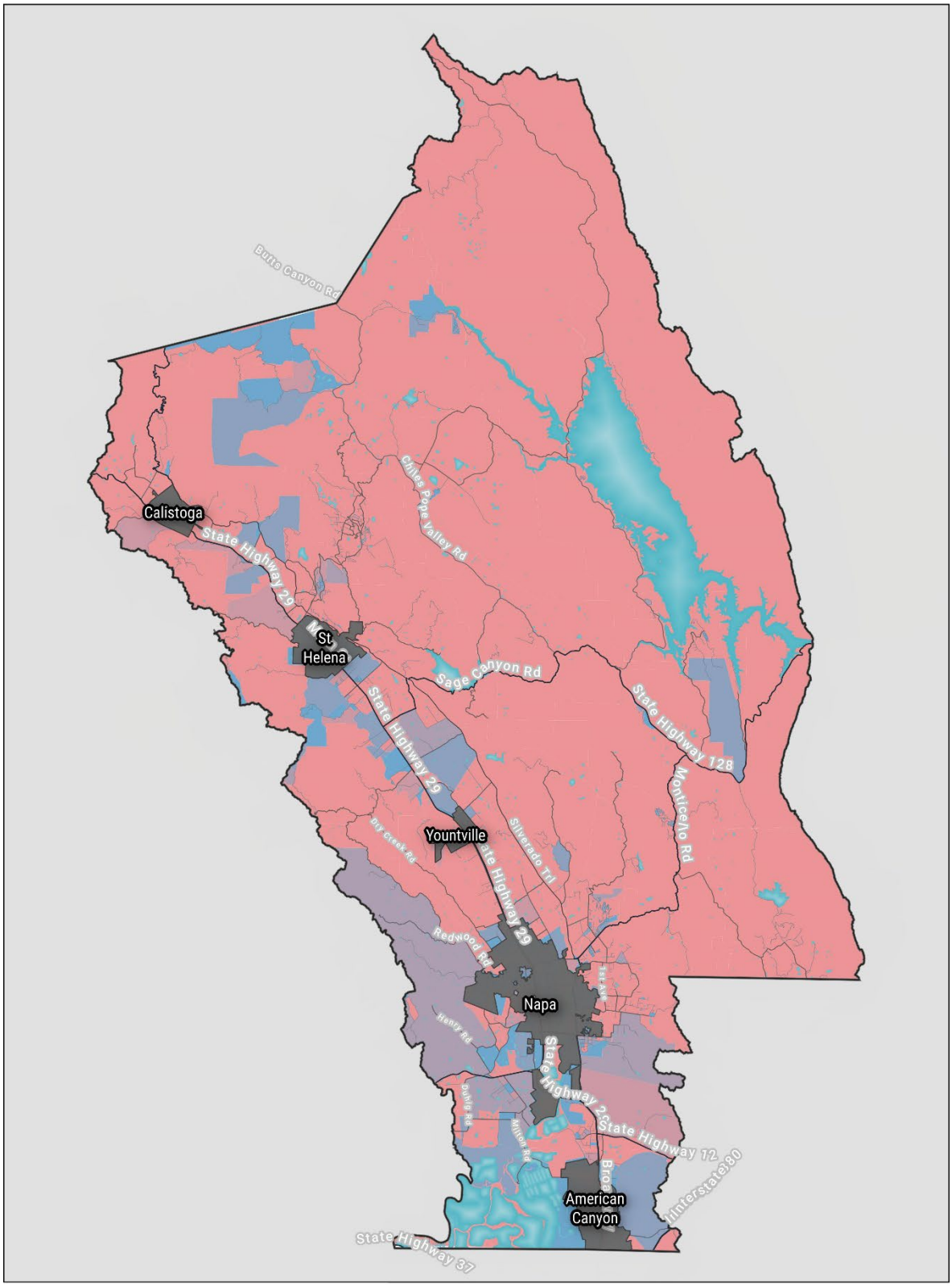
Figure 3.16 Bicycle Network Analysis Results for Existing Bicycle Network

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. The BNA was also used to analyze two possible iterations of the proposed bicycle network, and those results are discussed in Chapter 5.

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, and urban and suburban bike lanes were assumed to be low-stress facilities. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below, implementation of these relatively low-cost on-street facilities creates a visible improvement in connectivity within the urban parts of the county.

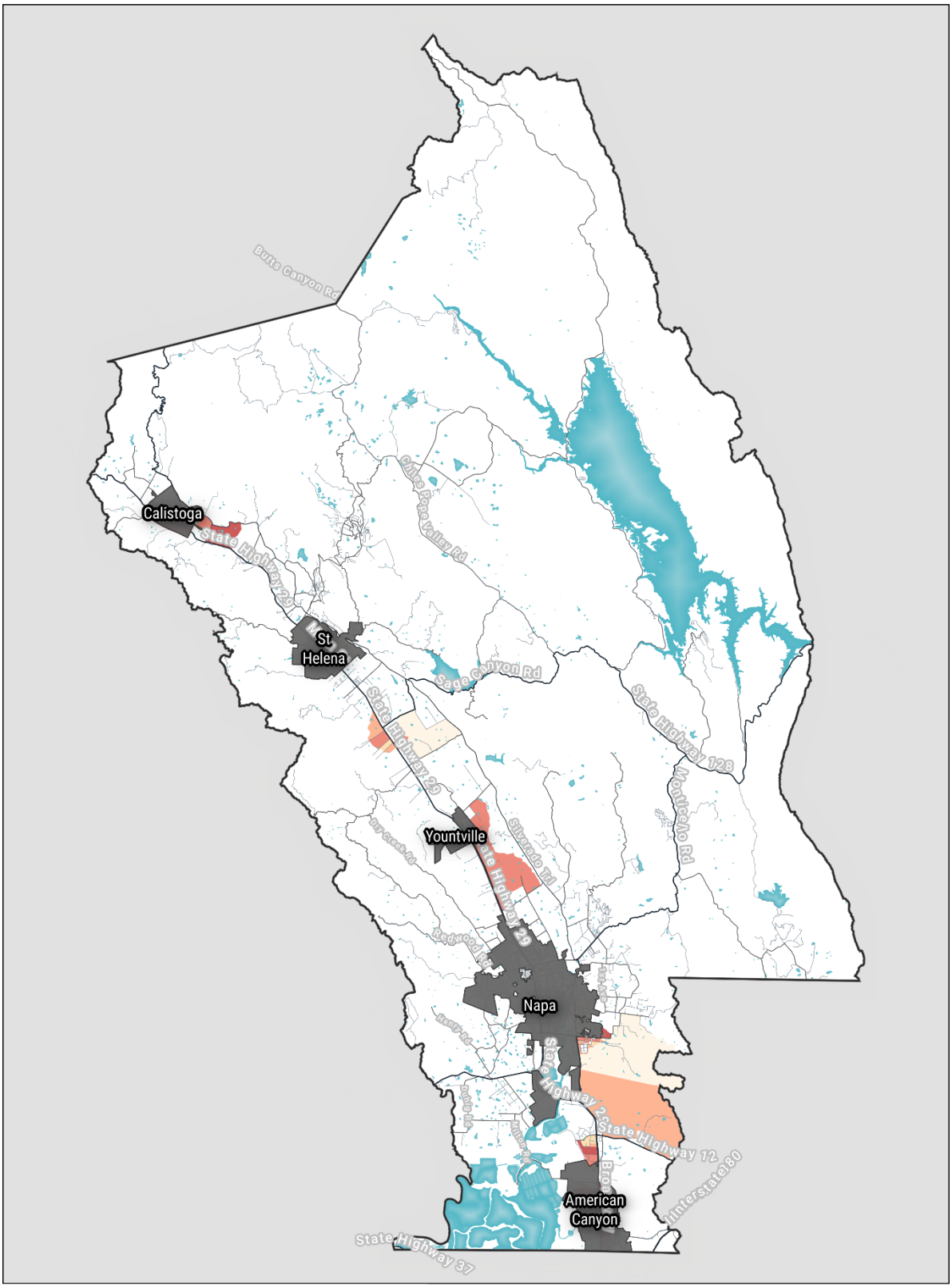
When the recommended Class I facilities are added in to the implementation network, connectivity improves further. However, many of these paths will be long-term projects so the demonstrable improvements of non-Class I facilities are worth noting. The map on the following page illustrates the future connectivity with implementation of just on-street facilities (Figure 5.3). The subsequent map (Figure 5.4) illustrates the improvement in connectivity when shared use path (Class I) facilities are also constructed.



Destination Access (0-100)

- 0 - 20
- 20 - 35
- 35 - 50
- 50 - 75
- 75 - 100

Major Water Bodies



Destination Access Improvement

- 0% - 0.5%
- 0% - 4%
- 4% - 19%
- 19% - 92%
- 92% +

Major Water Bodies

NVTA NAPA VALLEY TRANSPORTATION AUTHORITY

TOOLE DESIGN

Level of Comfort and Bicycle Network Analysis

This Plan assessed American Canyon's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[4]

[4] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

Many streets, about 78 percent, in American Canyon today can be considered comfortable for most people riding a bike (see Figure AC.4). Local streets connect to one another and to nearby existing trails within neighborhoods, but the remaining 22 percent of the network is high-stress streets divide the city. Broadway (SR 29) and American Canyon Road are key barriers. Additional streets within neighborhoods are considered higher stress as well because of their traffic volumes and lack of dedicated bicycle facilities.

The stress level of streets and crossings impacts people's ability to access destinations throughout American Canyon which is represented in the following BNA map (Figure AC.5). Areas on either side of Broadway tend to be less well connected than other parts of the city. Areas near existing off-street trails such as along Wetlands Edge and the trail near Canyon Oaks Elementary School, and within neighborhoods with predominantly low-stress streets are better connected. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = Fair Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

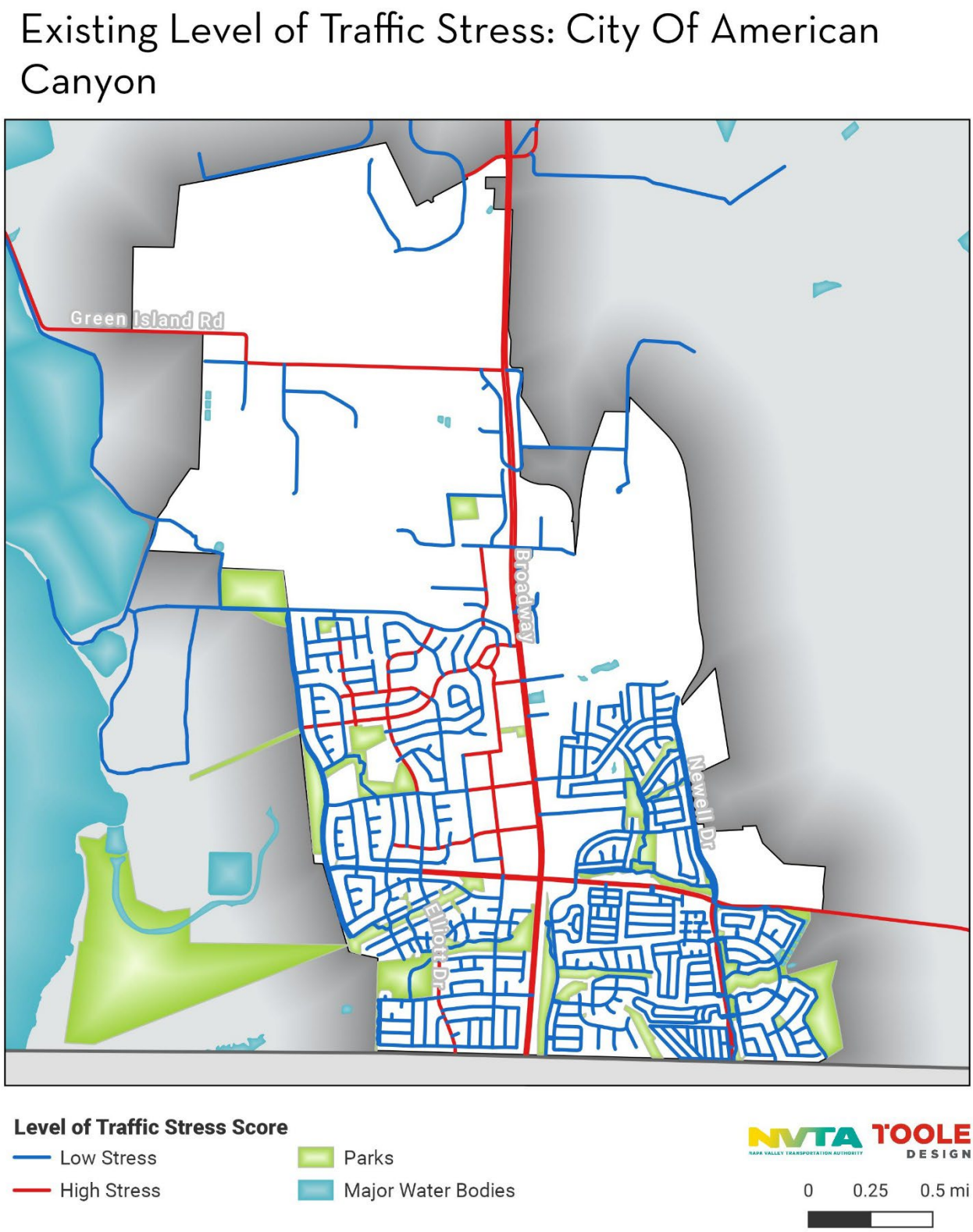


Figure AC.4. Existing Level of Traffic Stress in American Canyon

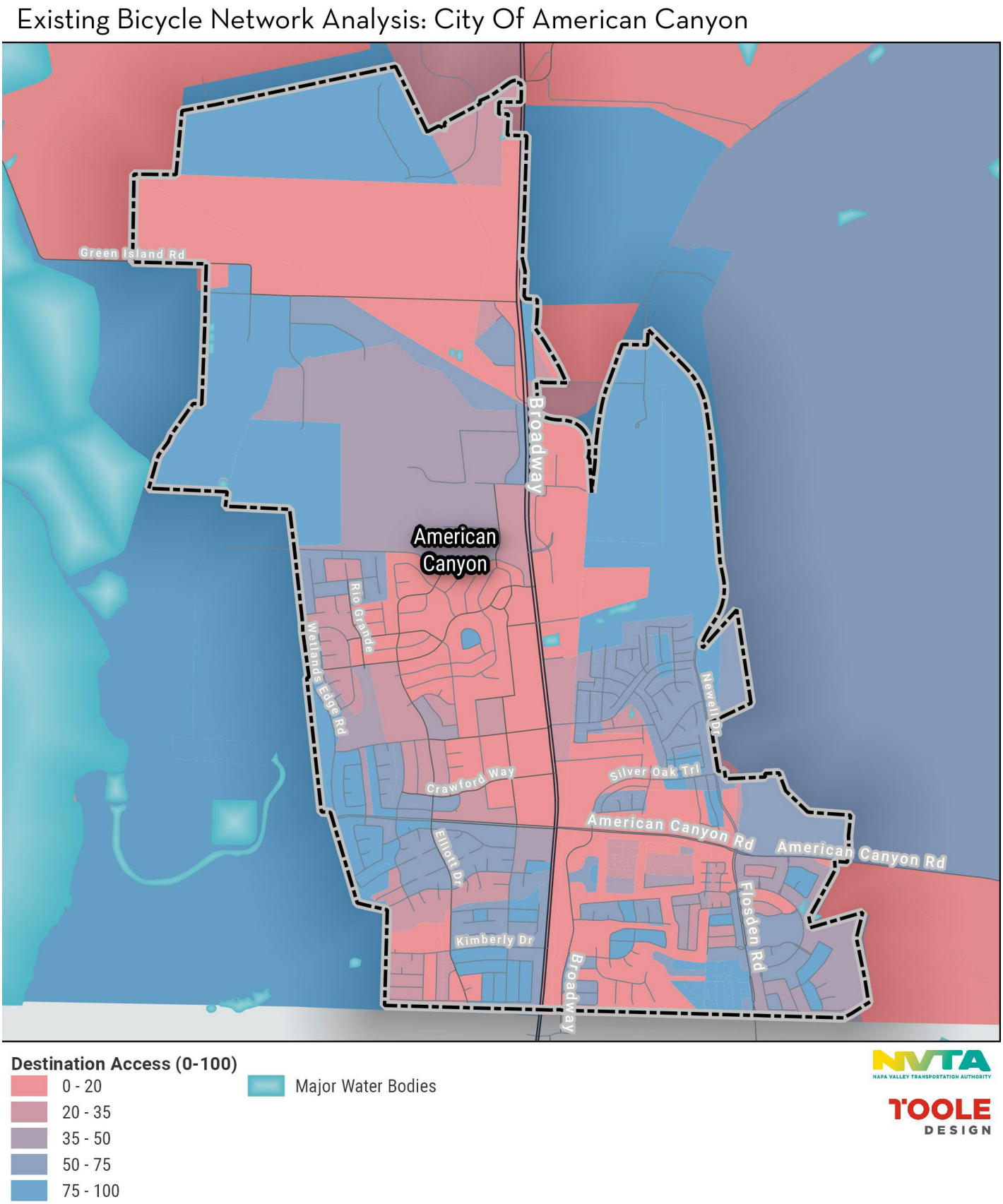


Figure AC.5. Bicycle Network Analysis Results for Existing Network

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures AC.8 and AC.9, implementation of these relatively low-cost on-street facilities creates a visible improvement in connectivity within the City of American Canyon.

When the recommended Class I facilities are added in to the implementation network, connectivity improves further. Within American Canyon, the construction of shared use paths on either side of Broadway creates significant connectivity improvements. The map on the following page (Figure AC.10) shows the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I).

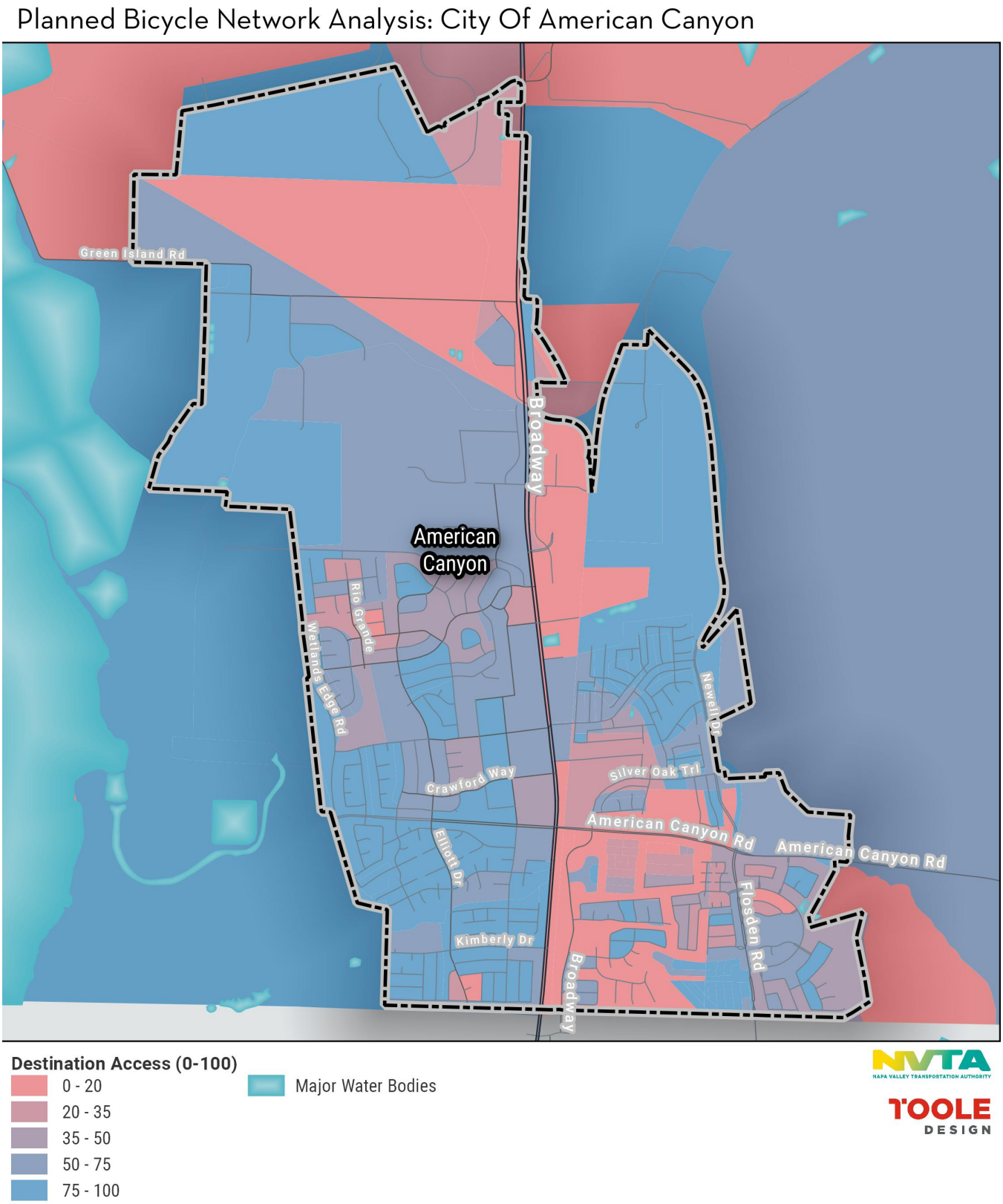


Figure AC.8. BNA Results from On-Street Facility Implementation

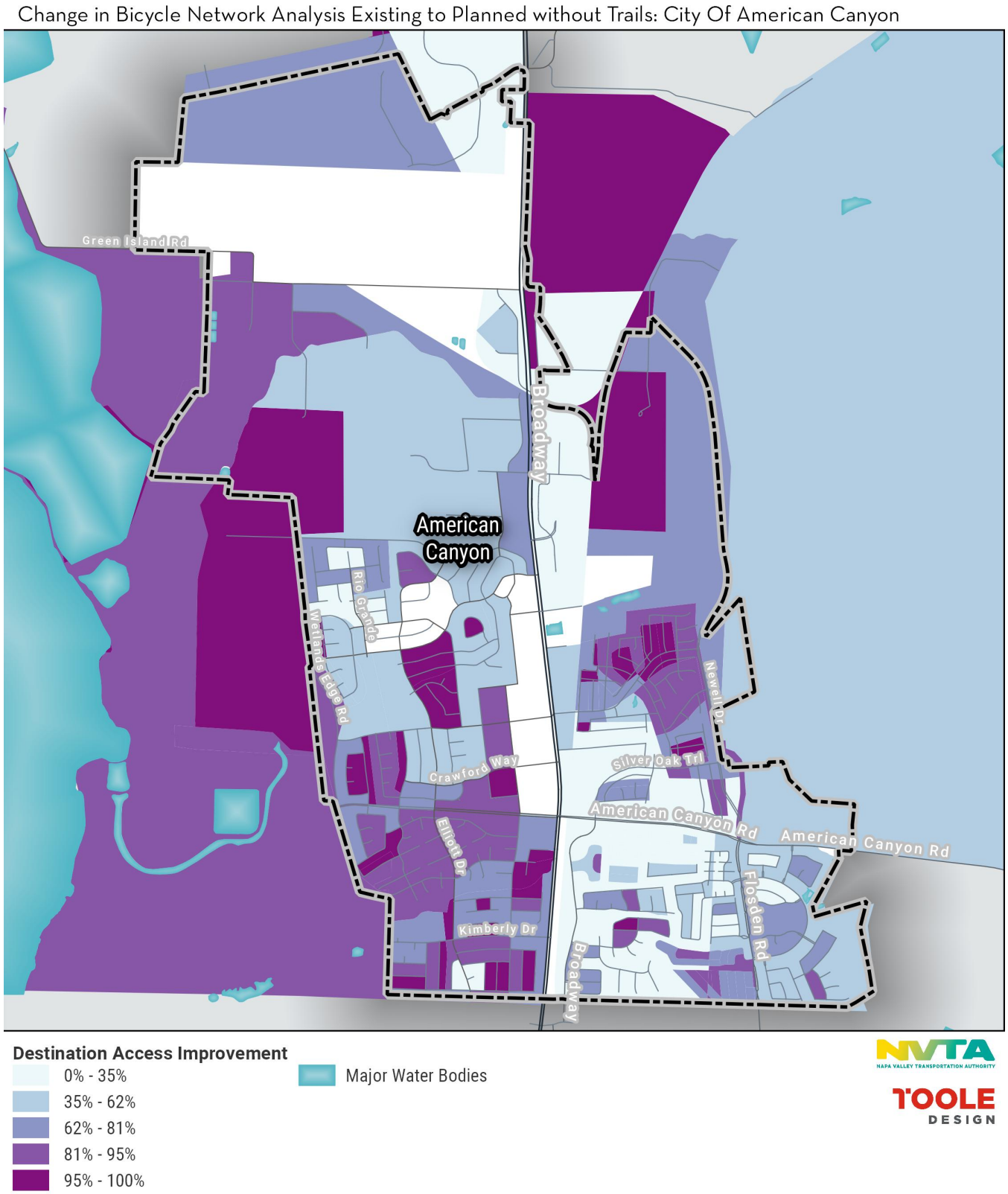


Figure AC.9. Improvement in BNA Score from On-Street Facility Implementation

Change in Bicycle Network Analysis Planned with and without Trails: City Of American Canyon

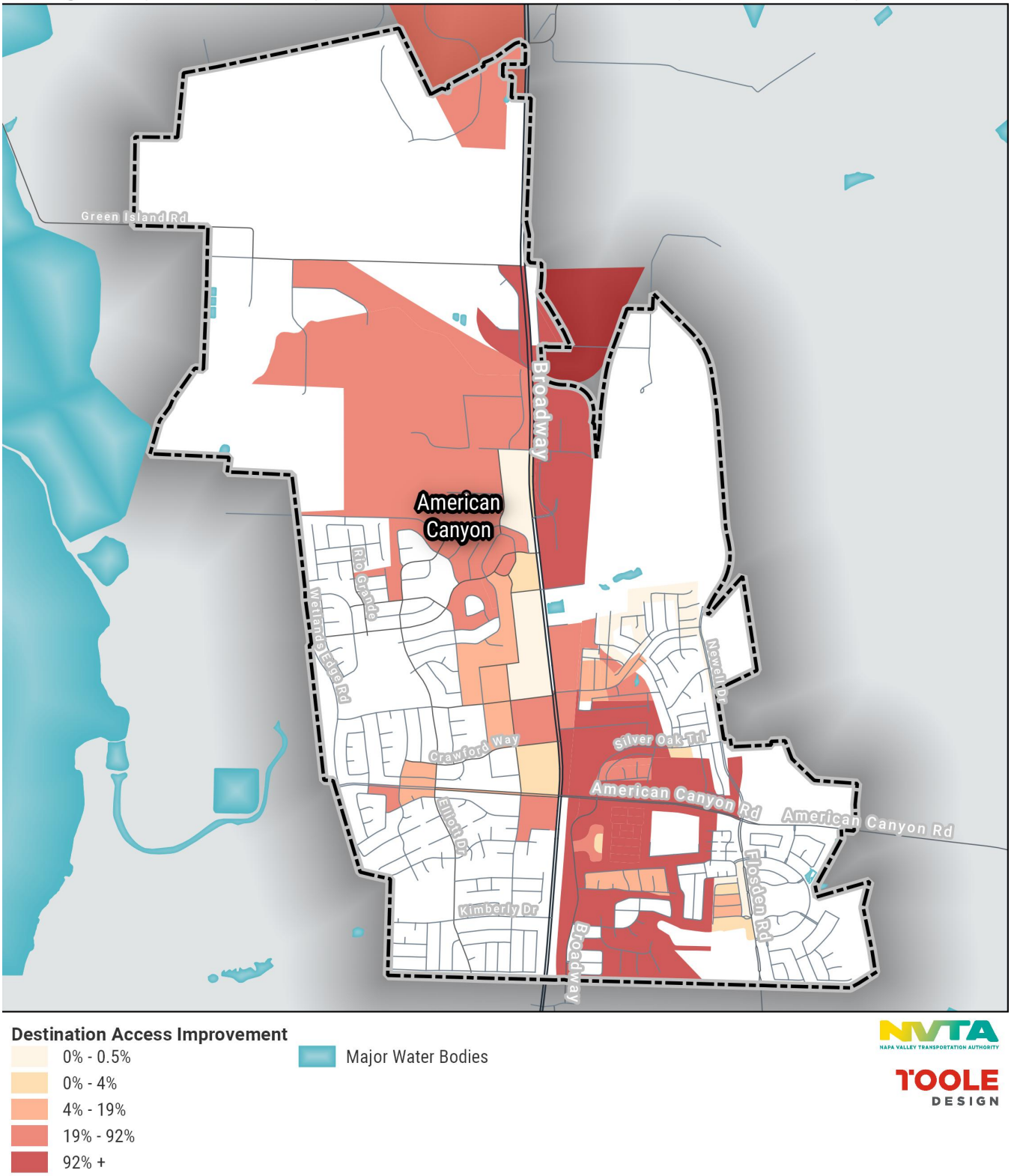


Figure AC.10. Improvement in BNA Score from Shared Use Path Implementation

Level of Comfort and Bicycle Network Analysis

This plan assessed Calistoga's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[5]

[5] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

Many streets, about 83 percent, in Calistoga today can be considered comfortable for most people riding a bike (see Figure C.4). Local streets connect to one another and to nearby existing trails within neighborhoods, but the remaining 17 percent of the network is high-stress streets that divide and ring the city. In particular, Lincoln Avenue, the main street in Calistoga currently presents a high-stress environment for Interested but Concerned riders. Riding anywhere outside of Calistoga currently is also difficult for these less experienced riders because there are no low-stress connections across city boundaries. The future Vine Trail will connect to the south, however today it ends at Dunaweal Lane.

The stress level of streets and crossings impacts people's ability to access destinations throughout Calistoga which is represented in the following BNA map (Figure C.5). Overall, connectivity within the city itself is quite good at an average score of 60. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = OK Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

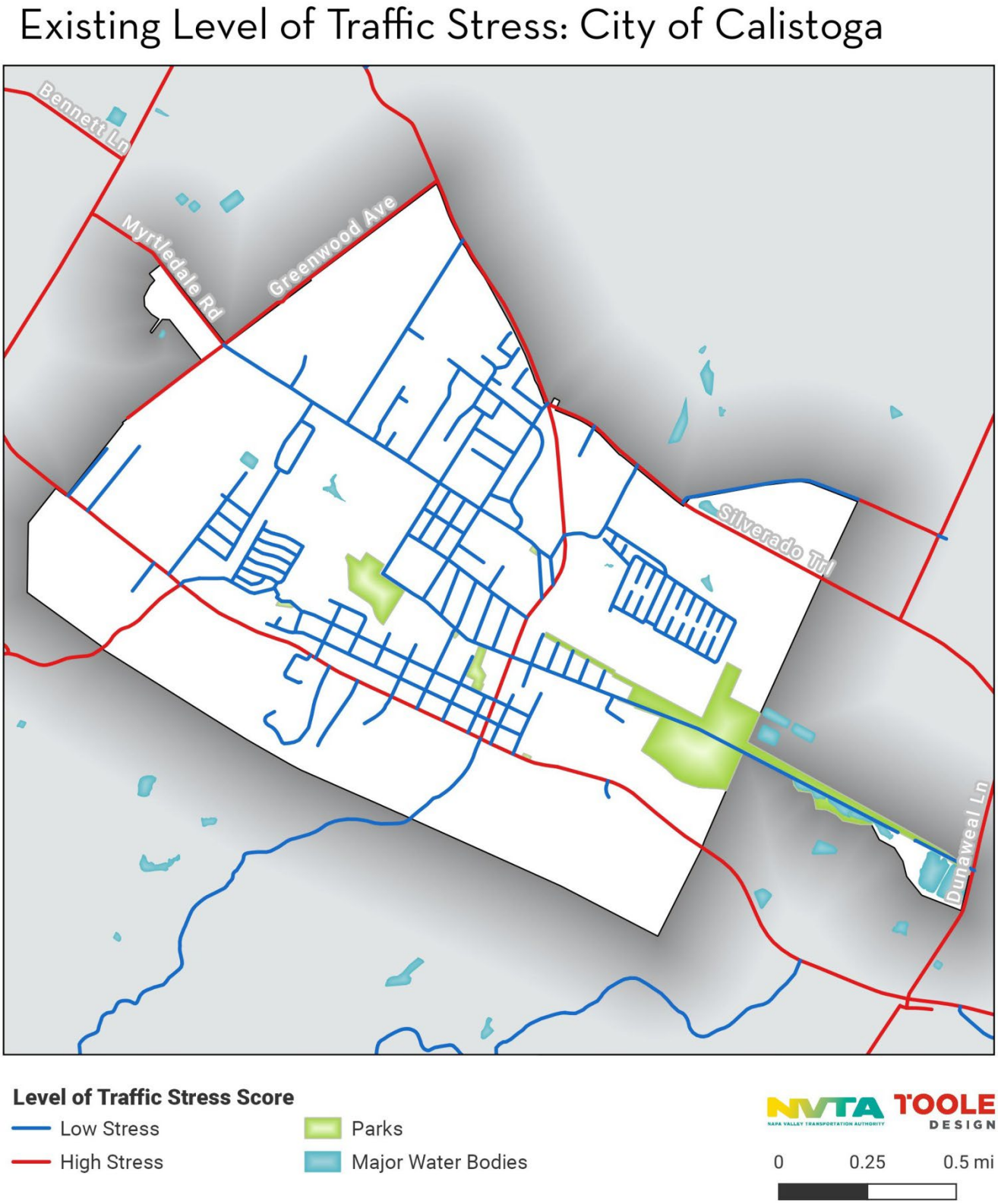


Figure C.4. Existing Level of Traffic Stress of Streets and Trails

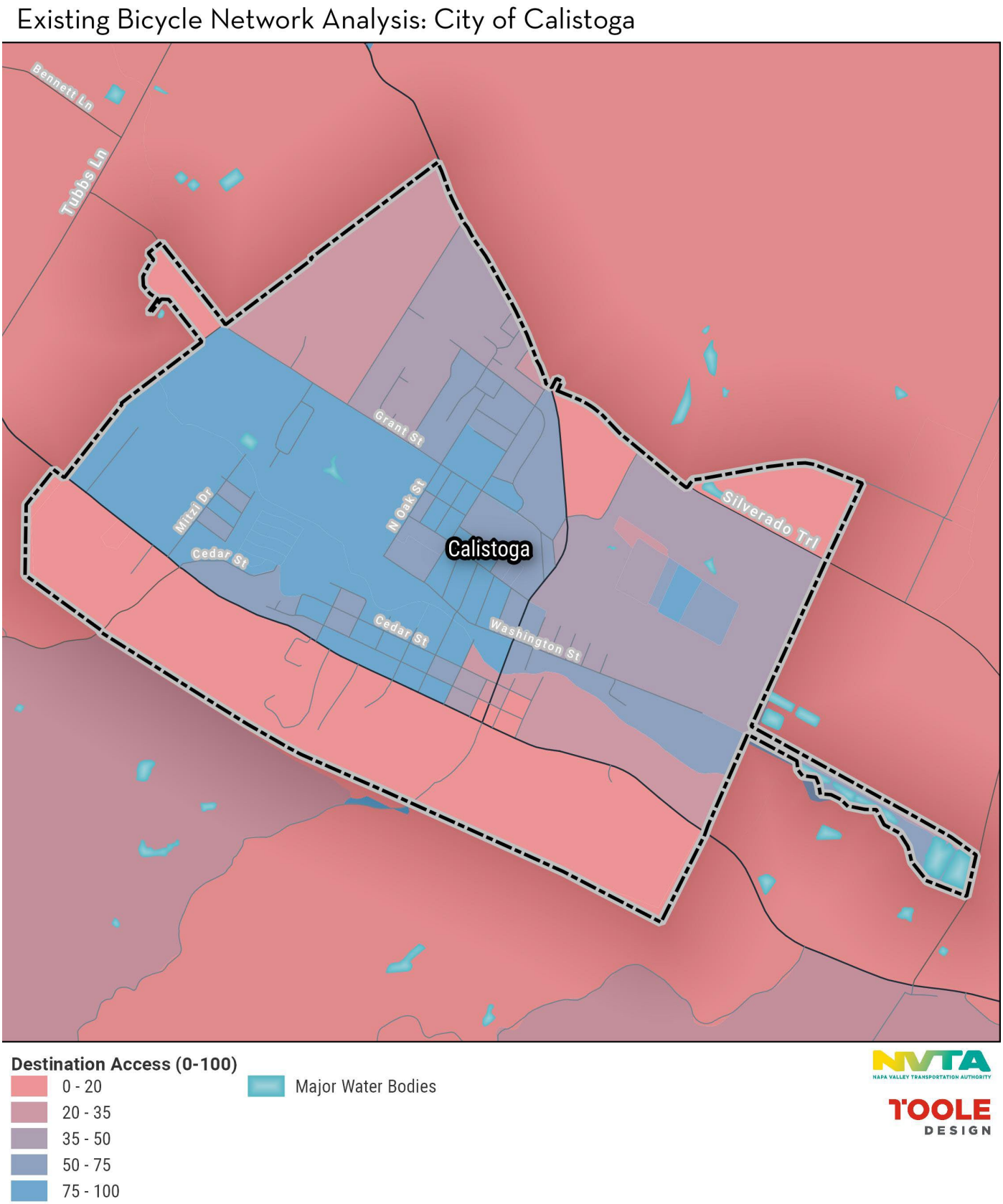


Figure C.5. Bicycle Network Analysis Results for Existing Network

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures C.8 and C.9, implementation of these relatively low-cost on-street facilities creates a visible improvement in connectivity within the City of Calistoga. The areas surrounding Lincoln Avenue downtown in particular benefit from implementation of bike lanes there.

When the recommended Class I facilities are added in to the implementation network, connectivity improves further. The third map following (Figure C.10) shows the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I). The impact of the Napa River Trail construction is clear within the southern portions of Calistoga. That is understood to be a large, long-term capital investment, however, so implementation of on-street facilities in the meantime will provide benefits to the city.

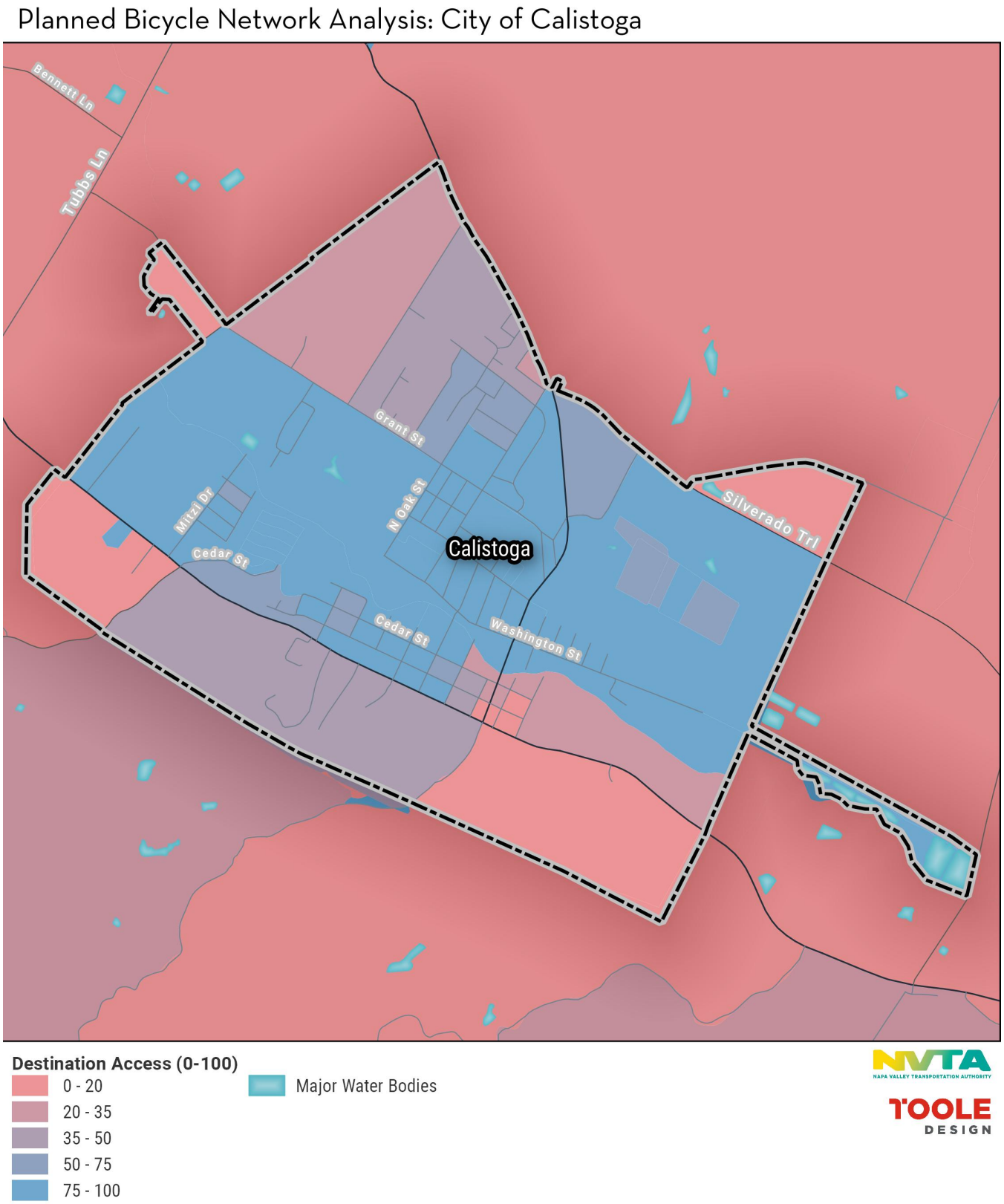


Figure C.8. BNA Results from On-Street Facility Implementation

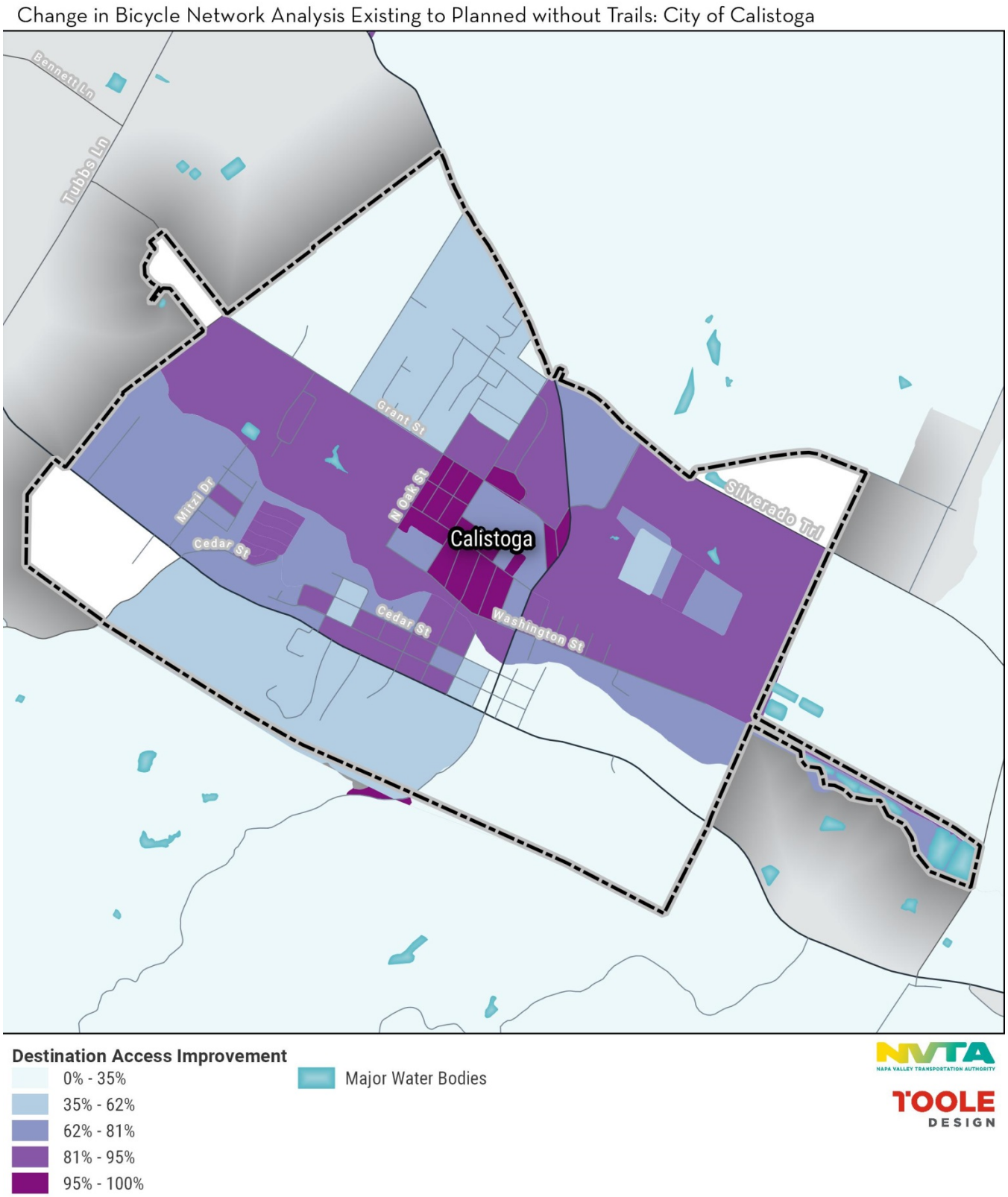


Figure C.9. Improvement in BNA Score from On-Street Facility Implementation

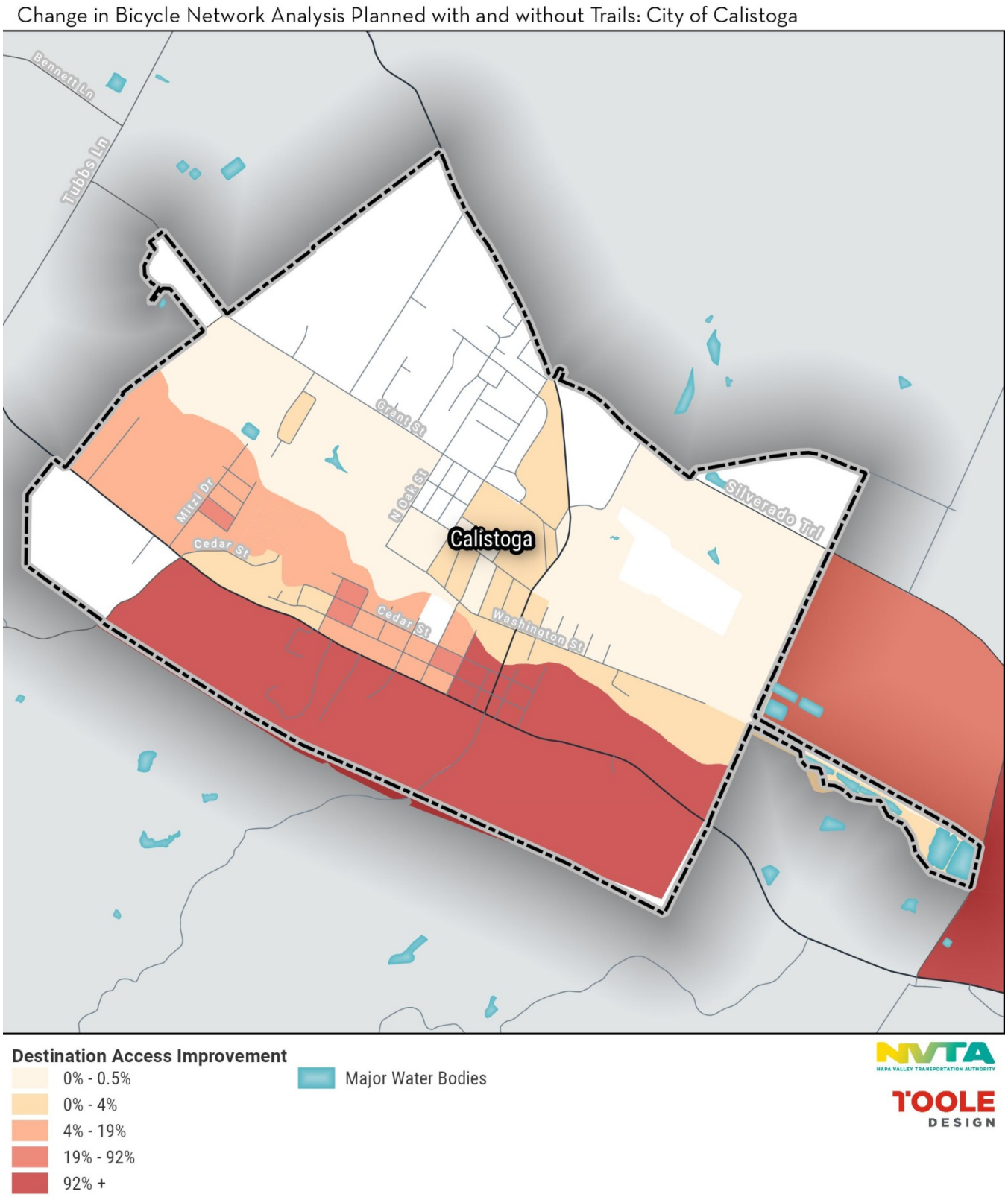


Figure C.10. Improvement in BNA Score from Shared Use Path Implementation

Level of Comfort and Bicycle Network Analysis

This plan assessed Napa's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[6]

[6] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

Many streets, about 77 percent, in Napa today can be considered comfortable for most people riding a bike (see Figures N.7-10). Local streets connect to one another and to nearby existing trails within neighborhoods, but the remaining 23 percent of the network is high-stress streets that divide the city. Some of these high-stress streets have bike lanes (Class II) today that, while providing space for bicyclists on the roadway, do not improve the level of comfort enough for many existing or potential riders. These bike lanes are adjacent to higher volume, higher speed traffic which is stressful for Interested but Concerned riders. These riders may still need to access destinations on these streets, however, and may be more likely to ride on a sidewalk in situations where they do not feel comfortable.

The stress level of streets and crossings impacts people's ability to access destinations throughout Napa which is represented in the following BNA maps (Figures N.11-14). Overall, connectivity within the city decent with a weighted average score of 35. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 - 35 = Fair Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

Small segments of high-stress streets, such as the bike lane gap on the east side of the 3rd Street bridge, create an impact on connectivity. The scores for blocks served by that street can be seen to be lower than those served by the 1st Street bridge, which rates as a low-stress street in this assessment. The benefits of a well-connected, small-block street grid can be seen in downtown and the neighborhood to its north. While Main Street is considered high stress and is not a recommended bicycle route, there are adjacent streets, like Brown Street, that can provide access through this area as alternatives. In neighborhoods that surrounded by high-stress streets, connectivity to destinations is not as good.

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

Existing Level of Traffic Stress: City of Napa - Downtown

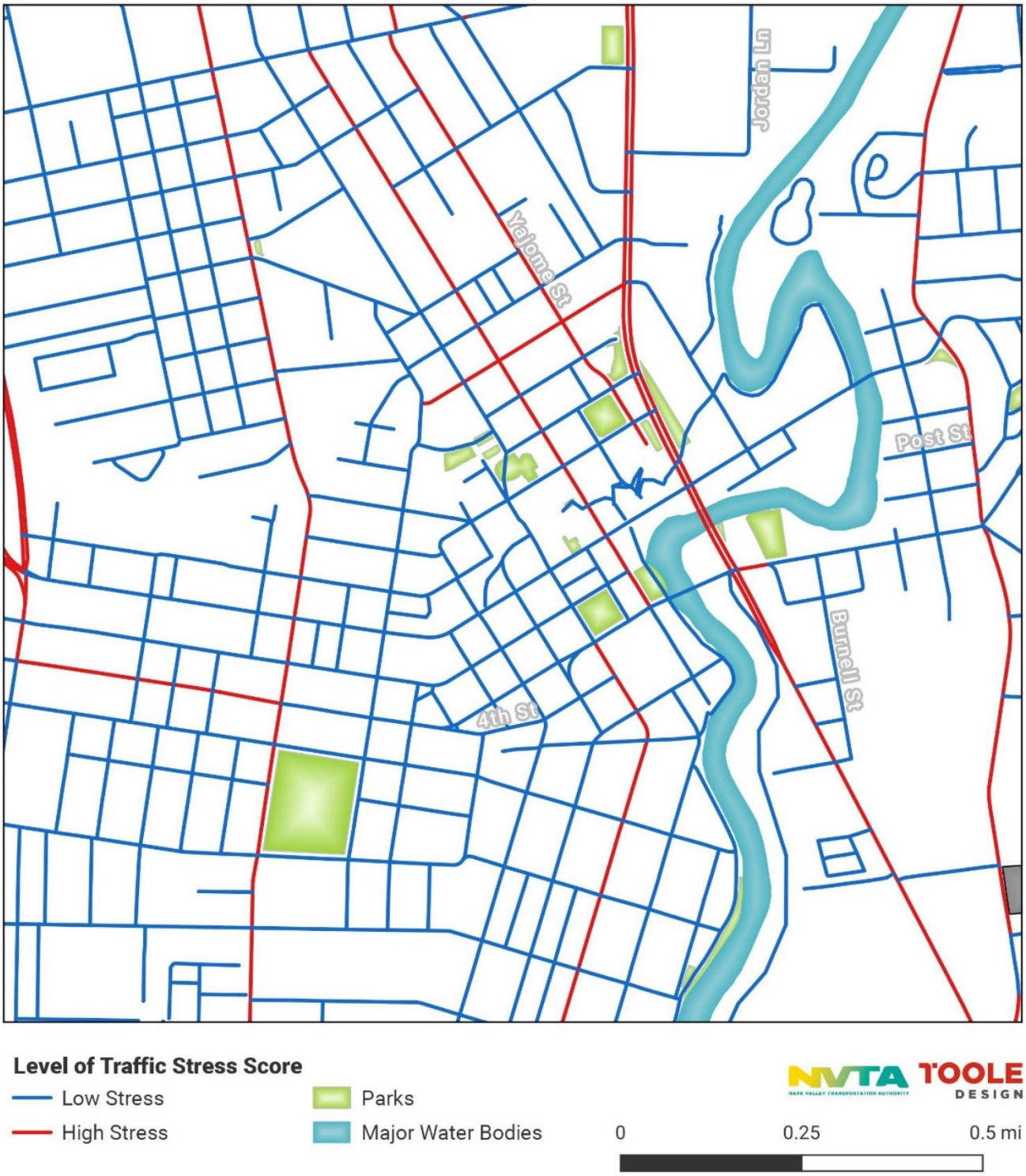


Figure N.7. Existing Level of Traffic Stress of Streets and Trails – Downtown

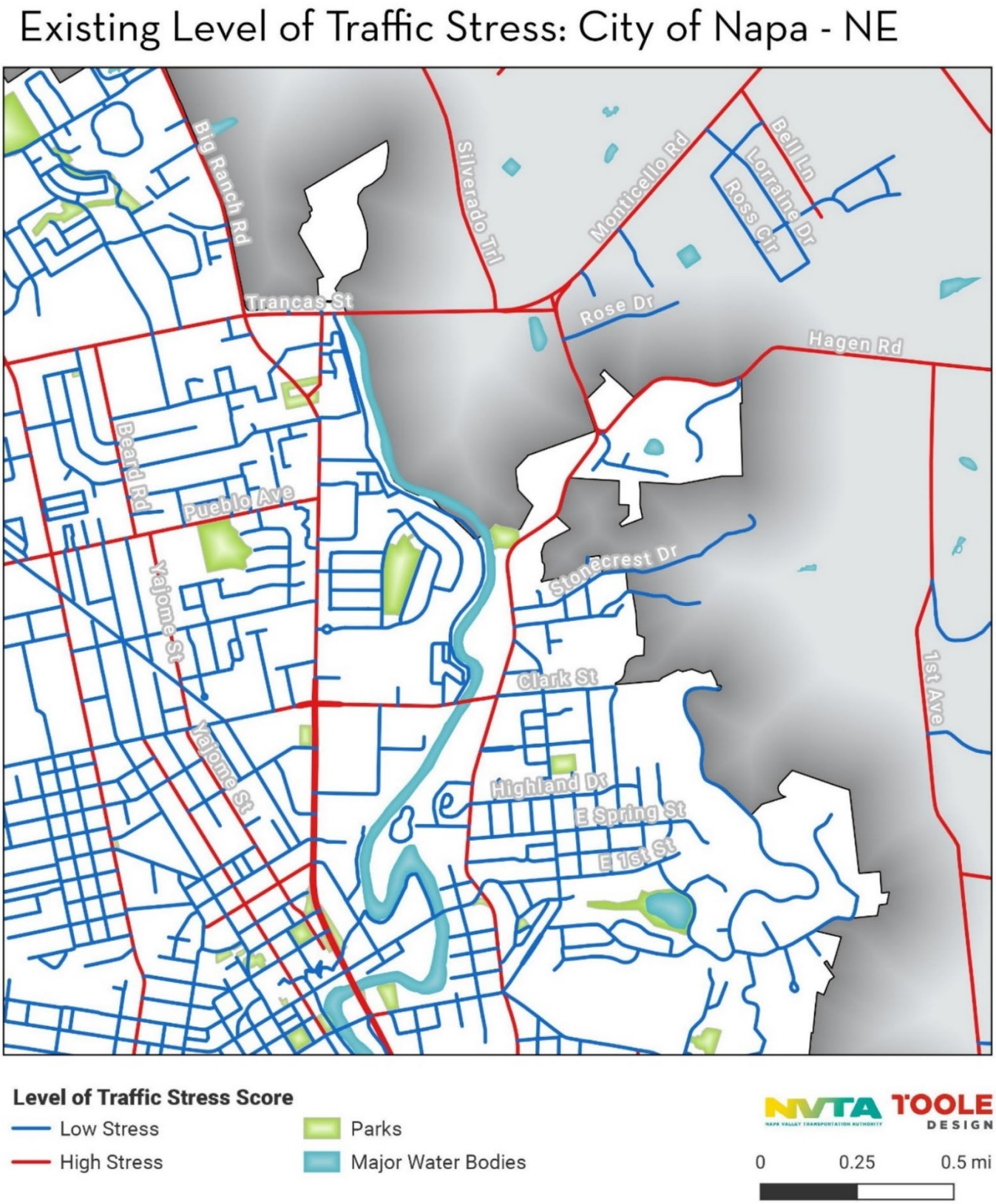


Figure N.8. Existing Level of Traffic Stress of Streets and Trails – Northeast

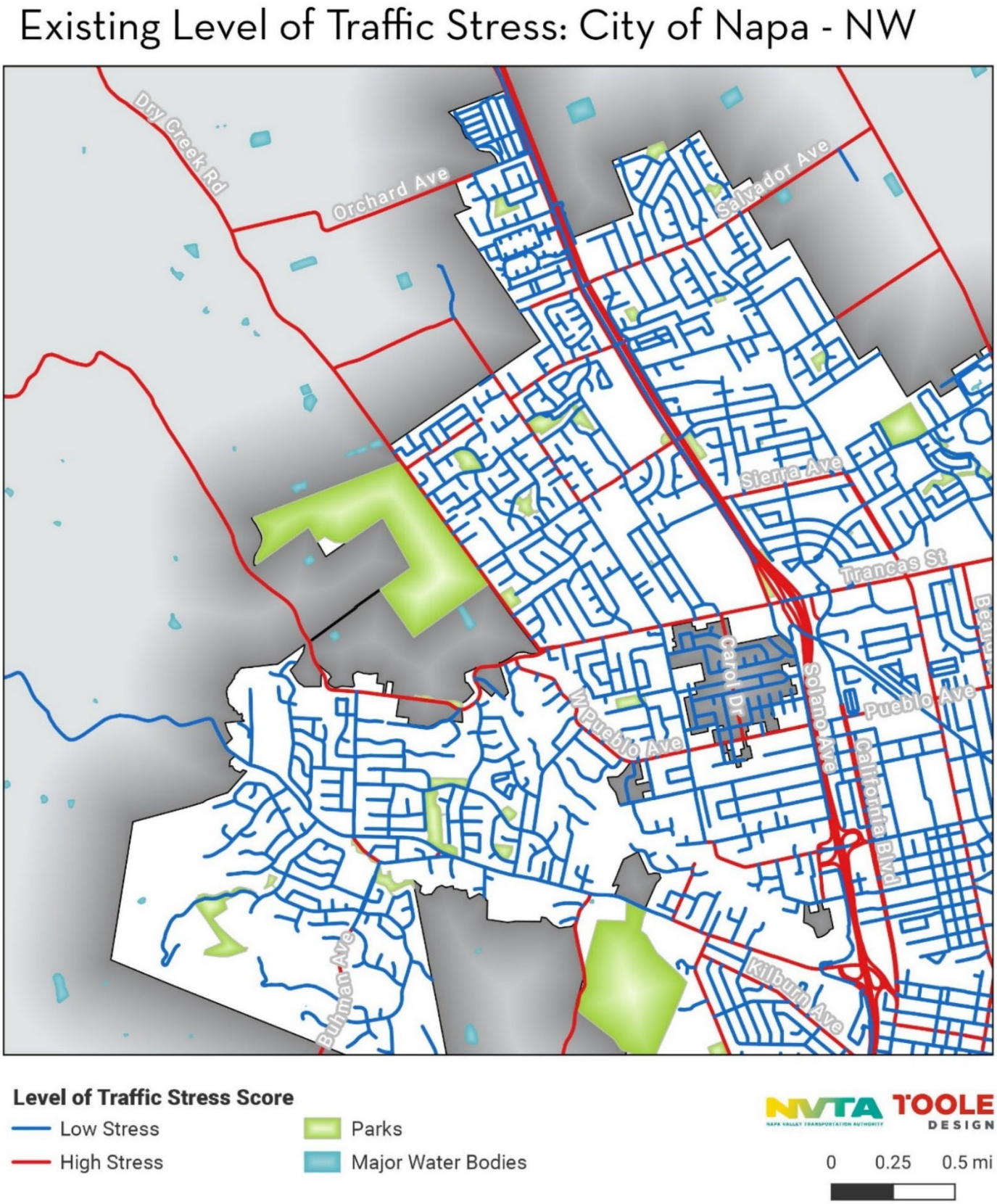


Figure N.9. Existing Level of Traffic Stress of Streets and Trails – Northwest

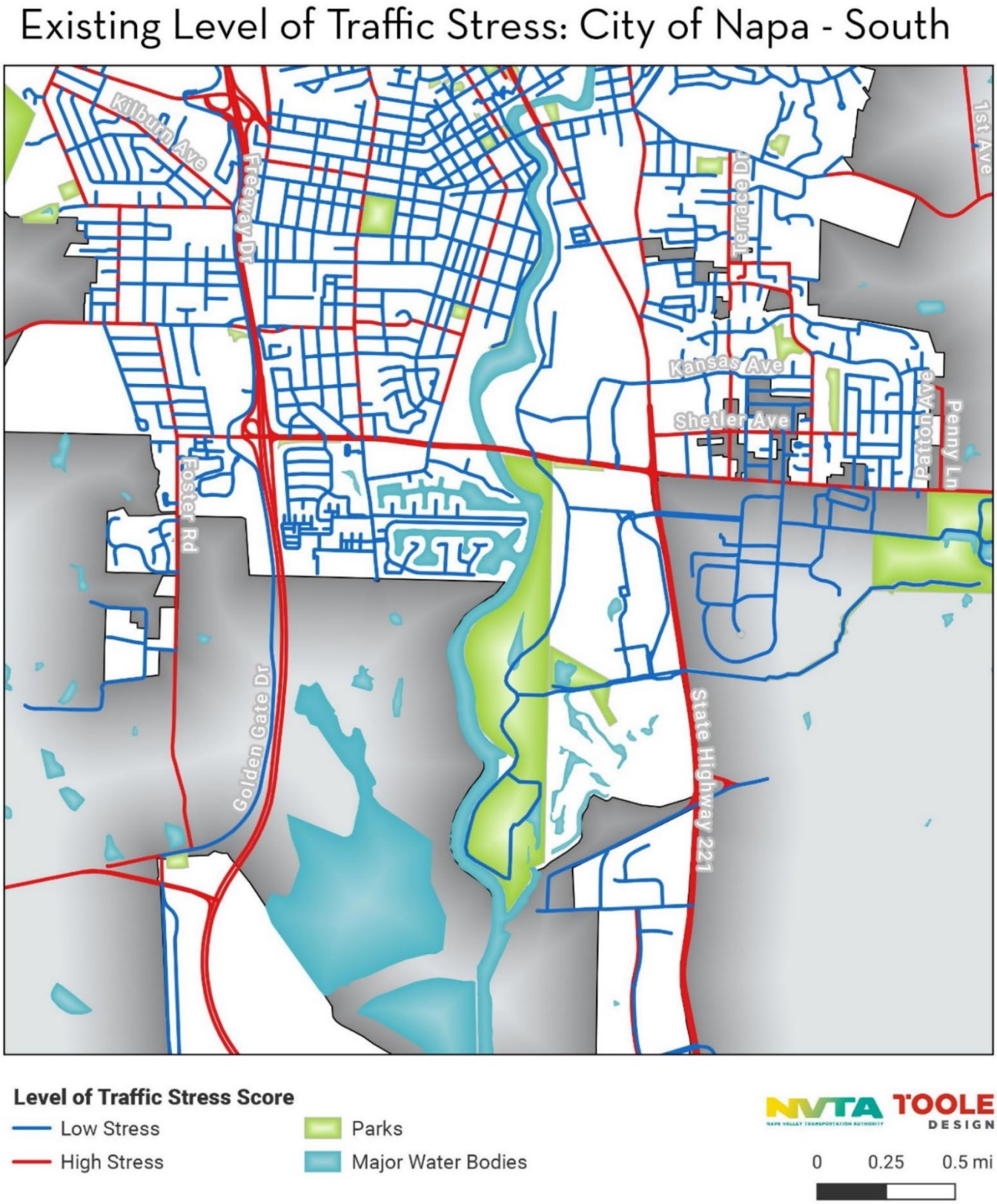


Figure N.10. Existing Level of Traffic Stress of Streets and Trails – South

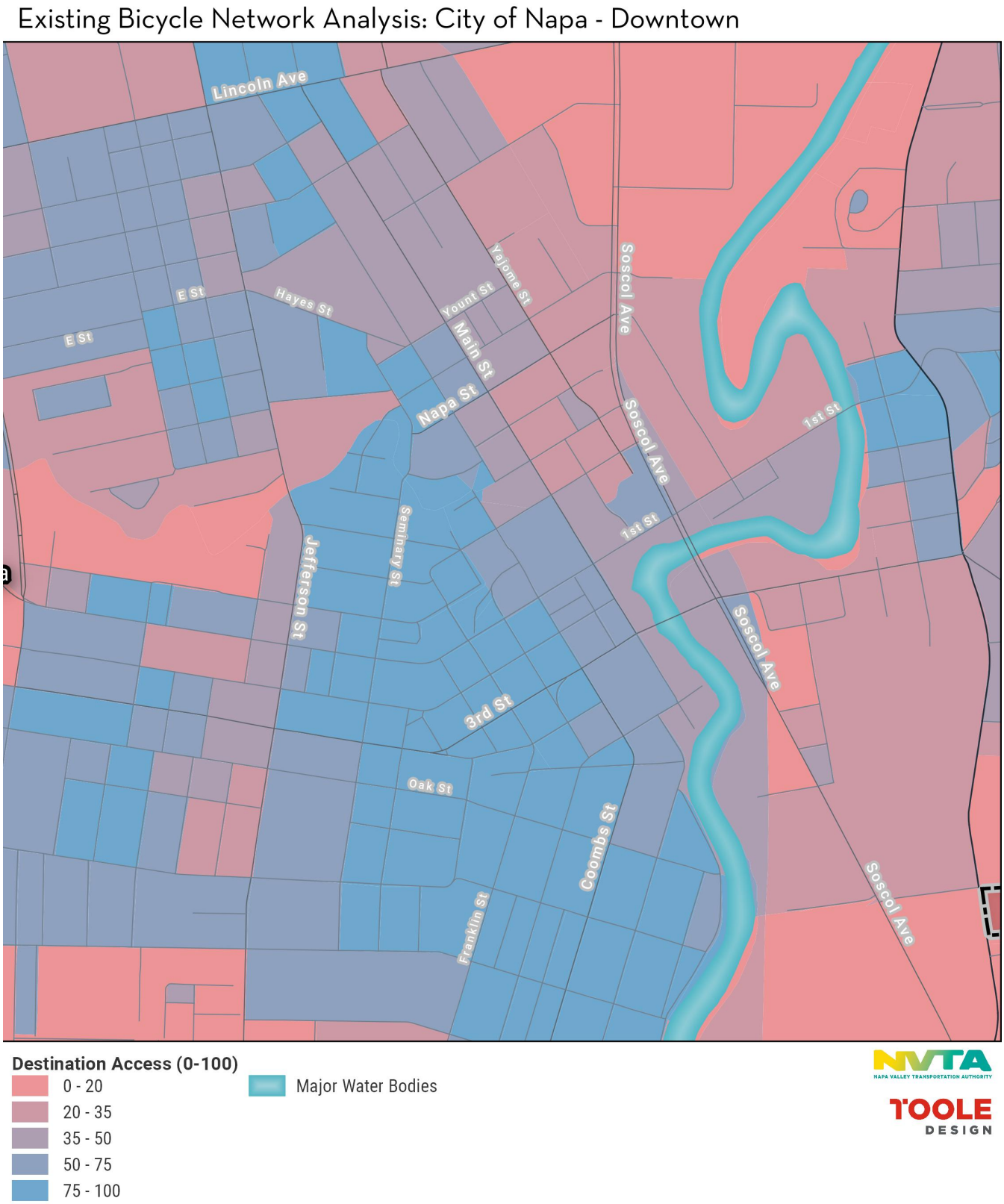


Figure N.11. Bicycle Network Analysis Results for Existing Network – Downtown

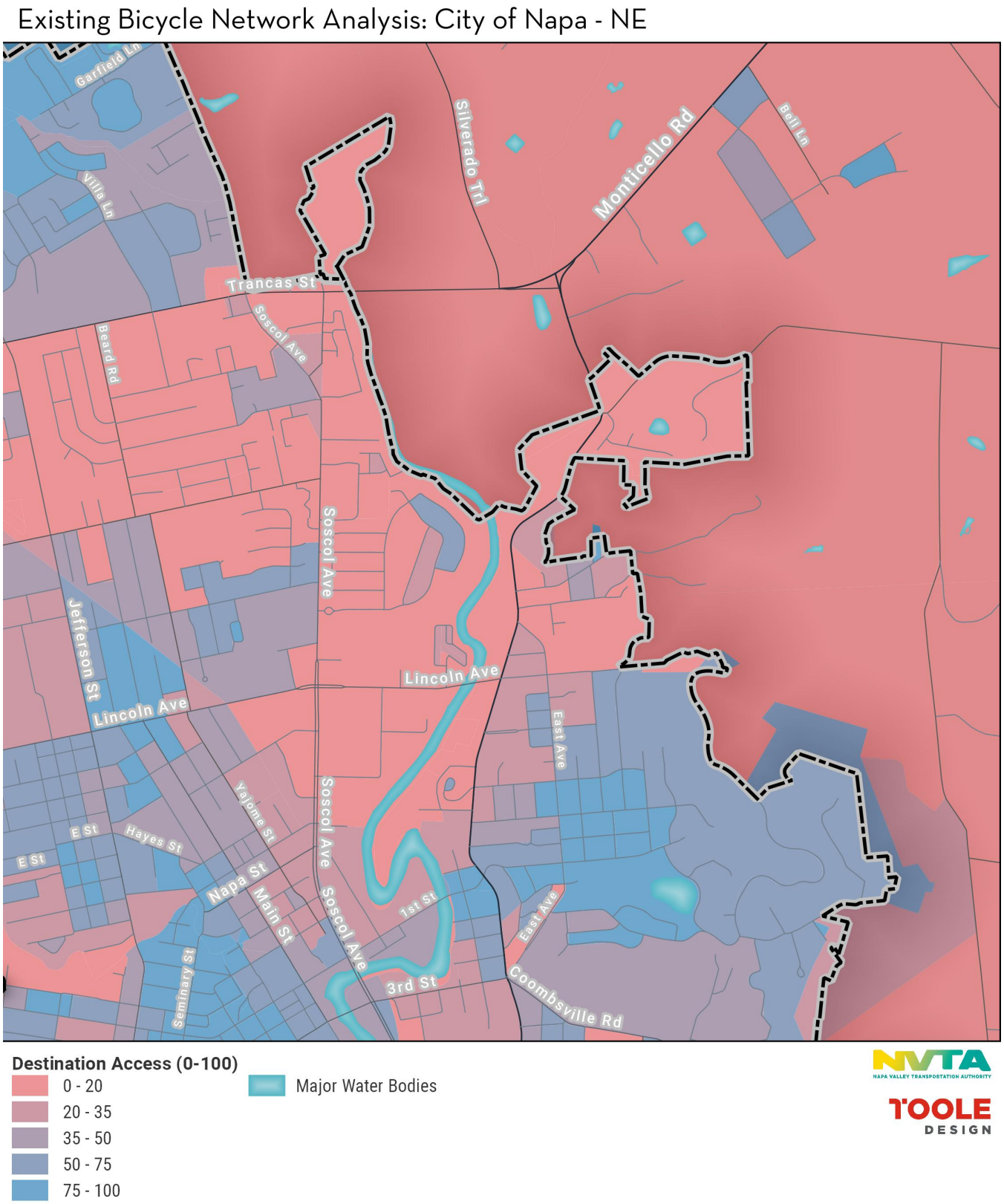


Figure N.12. Bicycle Network Analysis Results for Existing Network – Northeast

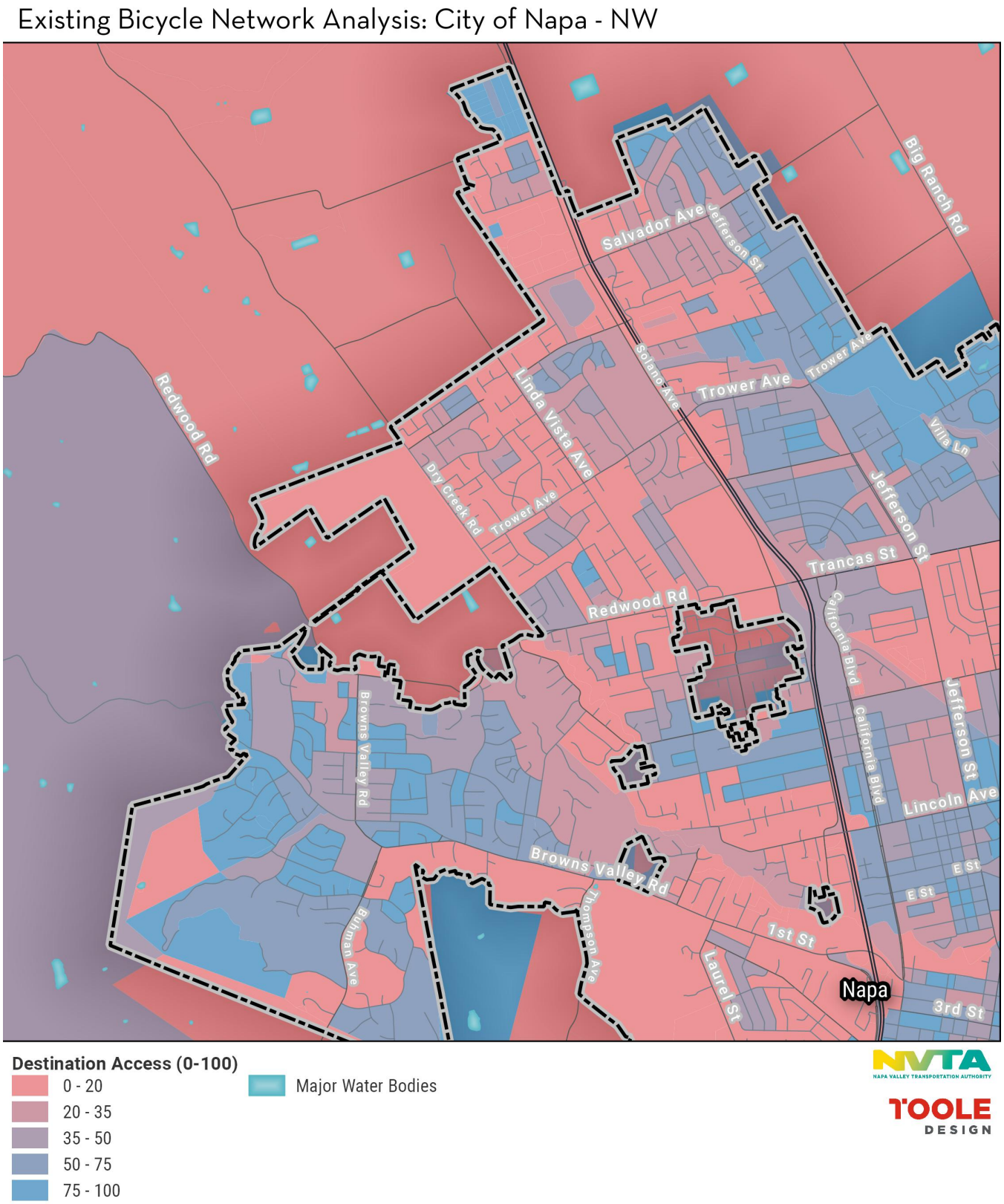


Figure N.13. Bicycle Network Analysis Results for Existing Network – Northwest

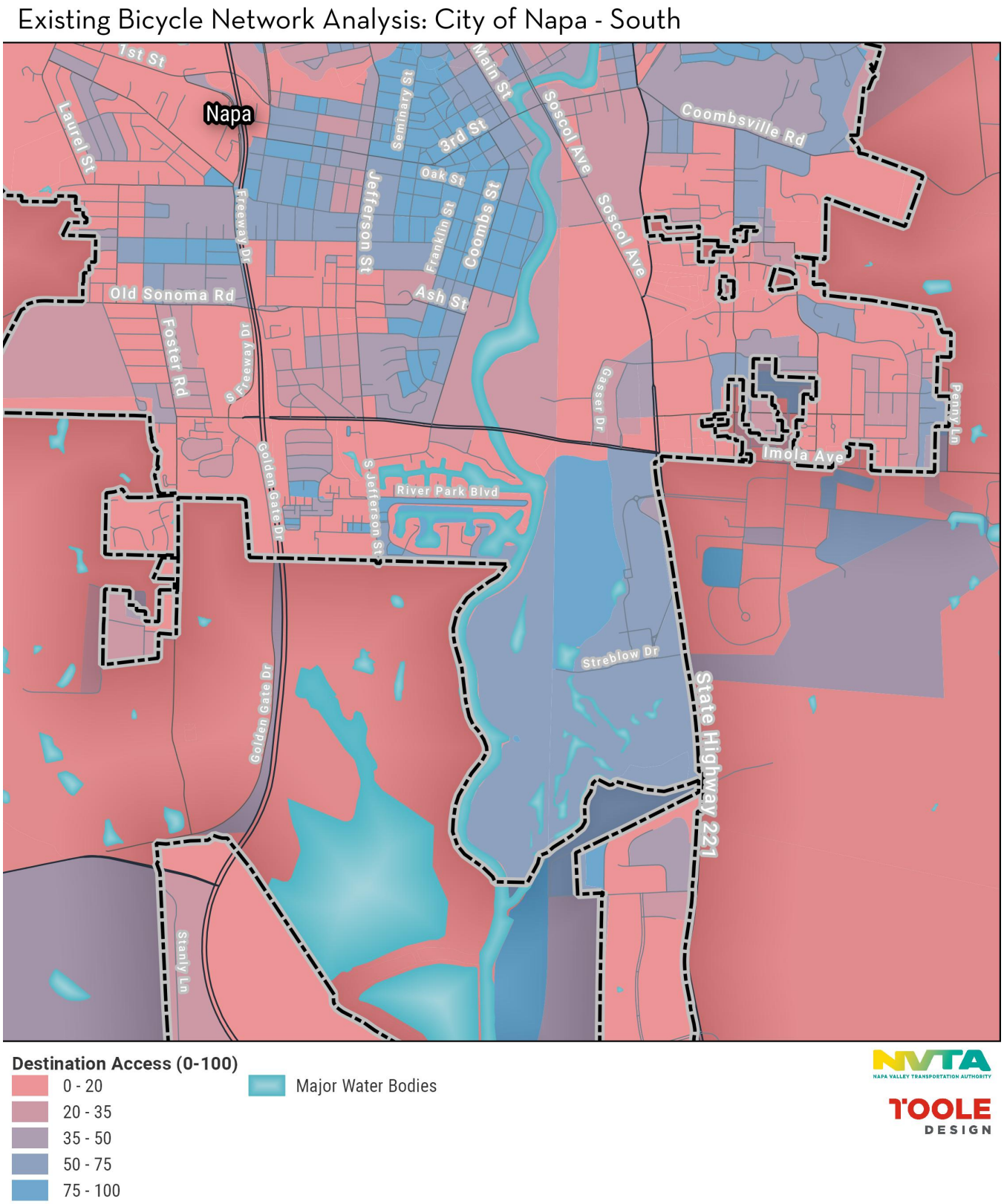


Figure N.14. Bicycle Network Analysis Results for Existing Network – South

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures N.23-26 and Figures N.27-30, implementation of these relatively low-cost on-street facilities creates a visible improvement on connectivity within the City of Napa. Implementation of on-street bike facilities improves the city's average BNA score from 33 to 54, an improvement of 65 percent. Significant improvements are seen in downtown's already good connectivity as a result of new bike lanes on the northern end of Coombs Street, filling in the gap on 3rd Street east of the bridge, and a bicycle boulevard treatment on 3rd Street west of downtown. Improvements are also seen in connectivity in outlying neighborhoods as a result of bicycle boulevard and bike lane projects.

When the recommended Class I facilities are added in to the implementation network, connectivity improves further. The third set of maps following (Figures C.31-34) show the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I). Downtown again benefits significantly from implementation of these facilities. Filling of the Soscol Gap on the Vine Trail and construction of a shared use path along the Parkway Mall connecting Pearl Street to 2nd Street, as well as extensions of paths along the riverfront account for the difference. These are acknowledged to be large investments, however, so the benefits of on-street facilities outlined above will be tangible, shorter-term outcomes of phased implementation of the bike network.

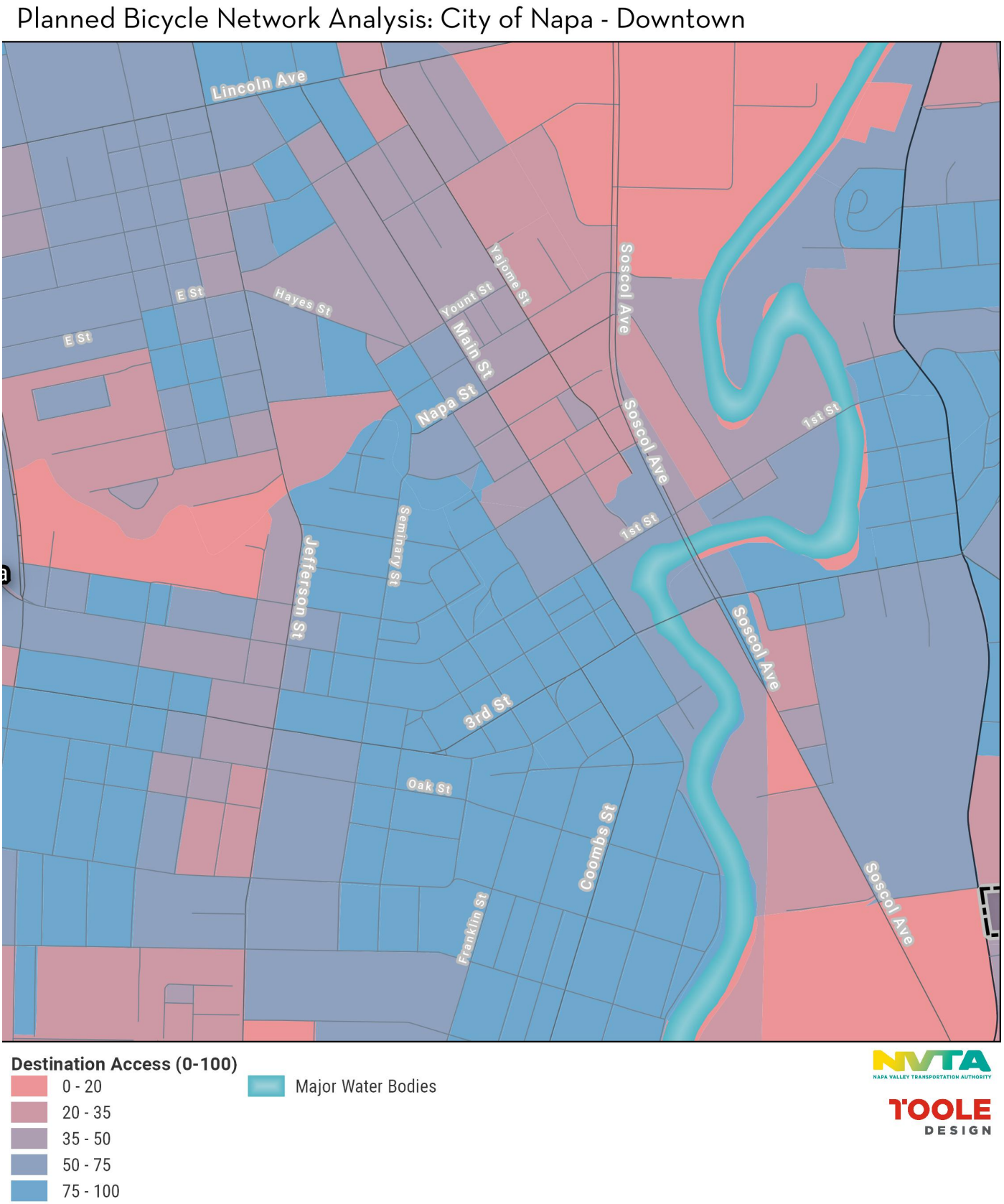


Figure N.23. BNA Results from On-Street Facility Implementation – Downtown

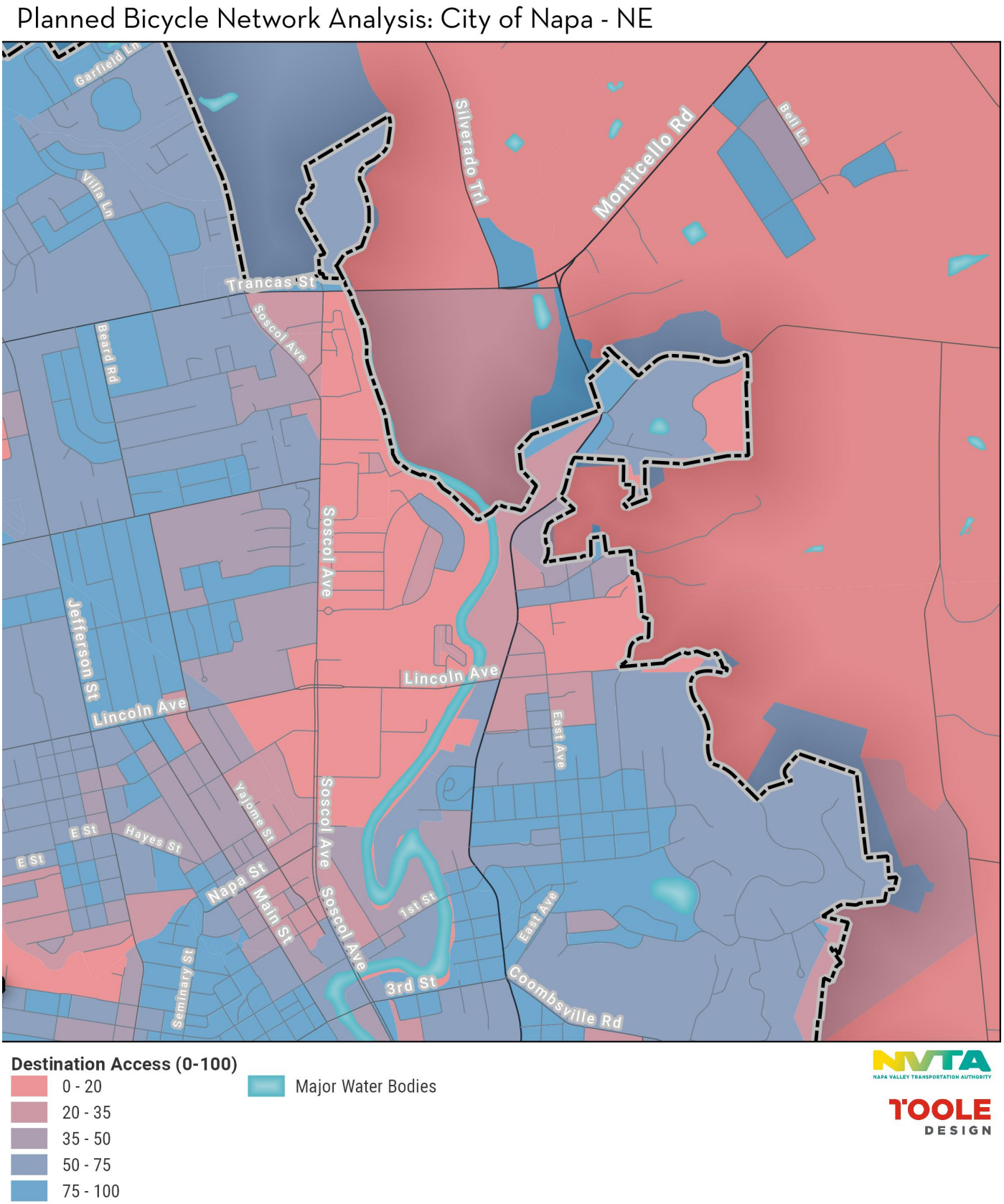


Figure N.24. BNA Results from On-Street Facility Implementation – Northeast

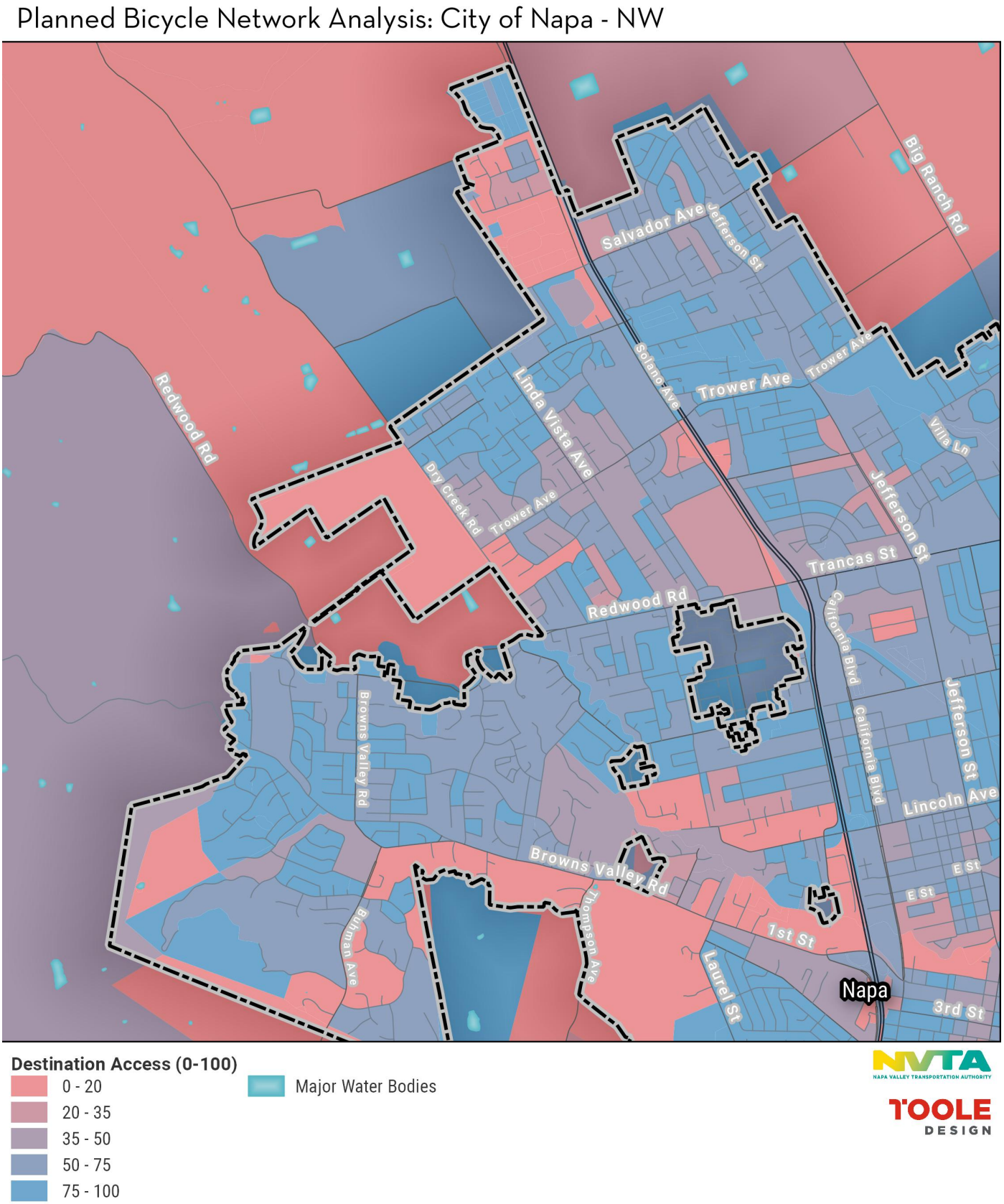


Figure N.25. BNA Results from On-Street Facility Implementation – Northwest

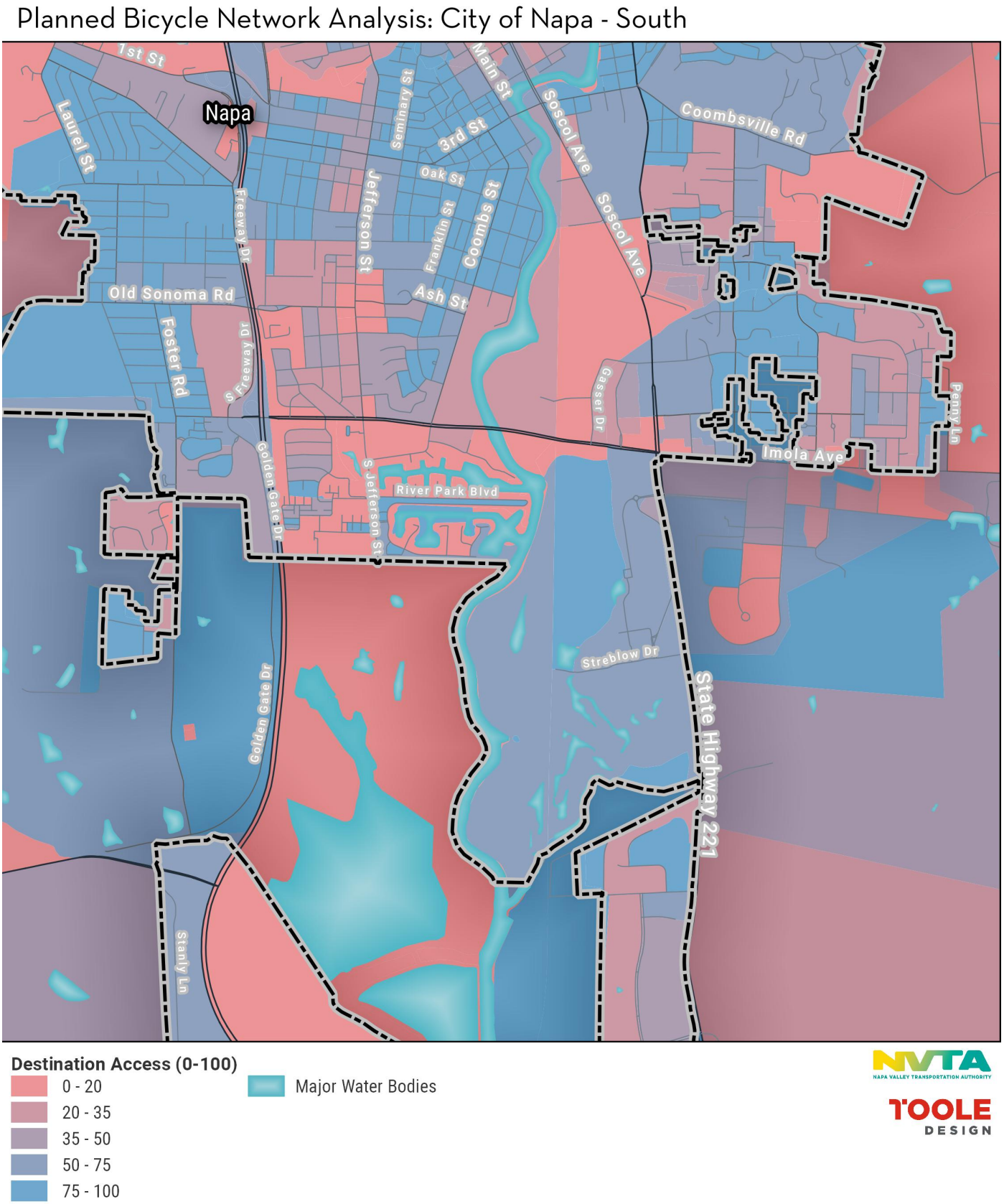


Figure N.26. BNA Results from On-Street Facility Implementation – South

Change in Bicycle Network Analysis Existing to Planned without Trails: City of Napa - Downtown

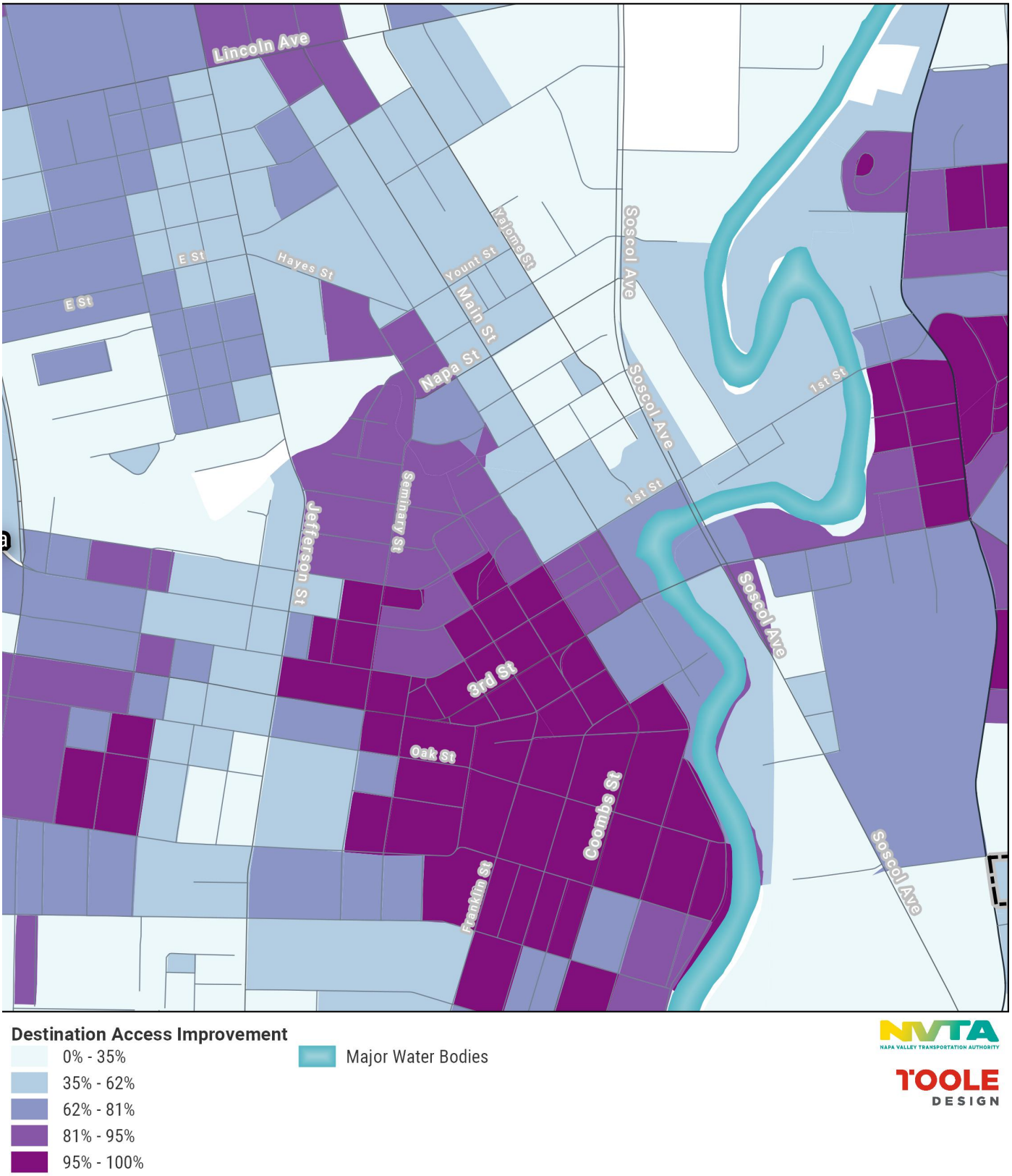
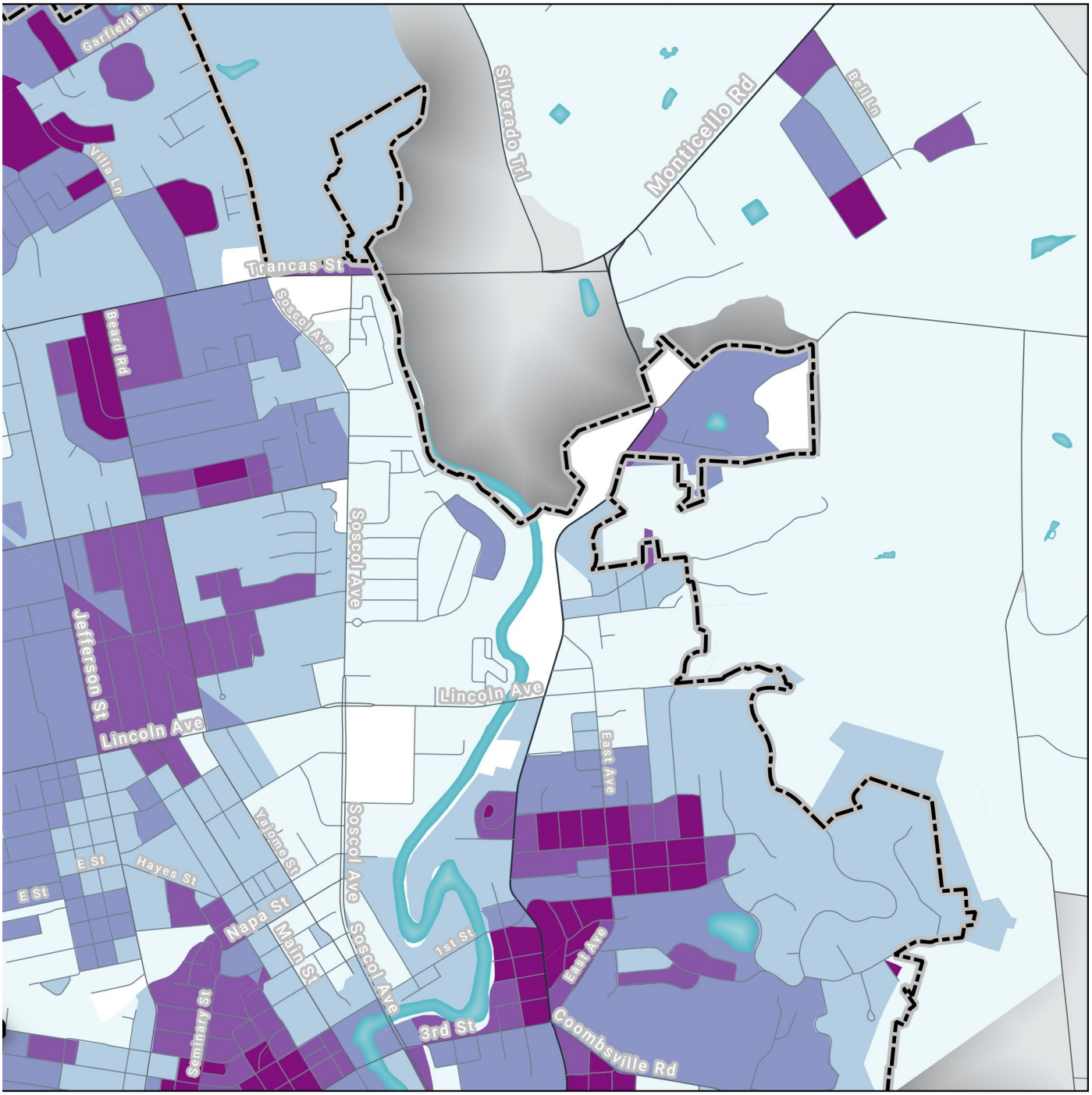


Figure N.27. Improvement in BNA Score from On-Street Facility Implementation – Downtown

Change in Bicycle Network Analysis Existing to Planned without Trails: City of Napa - NE



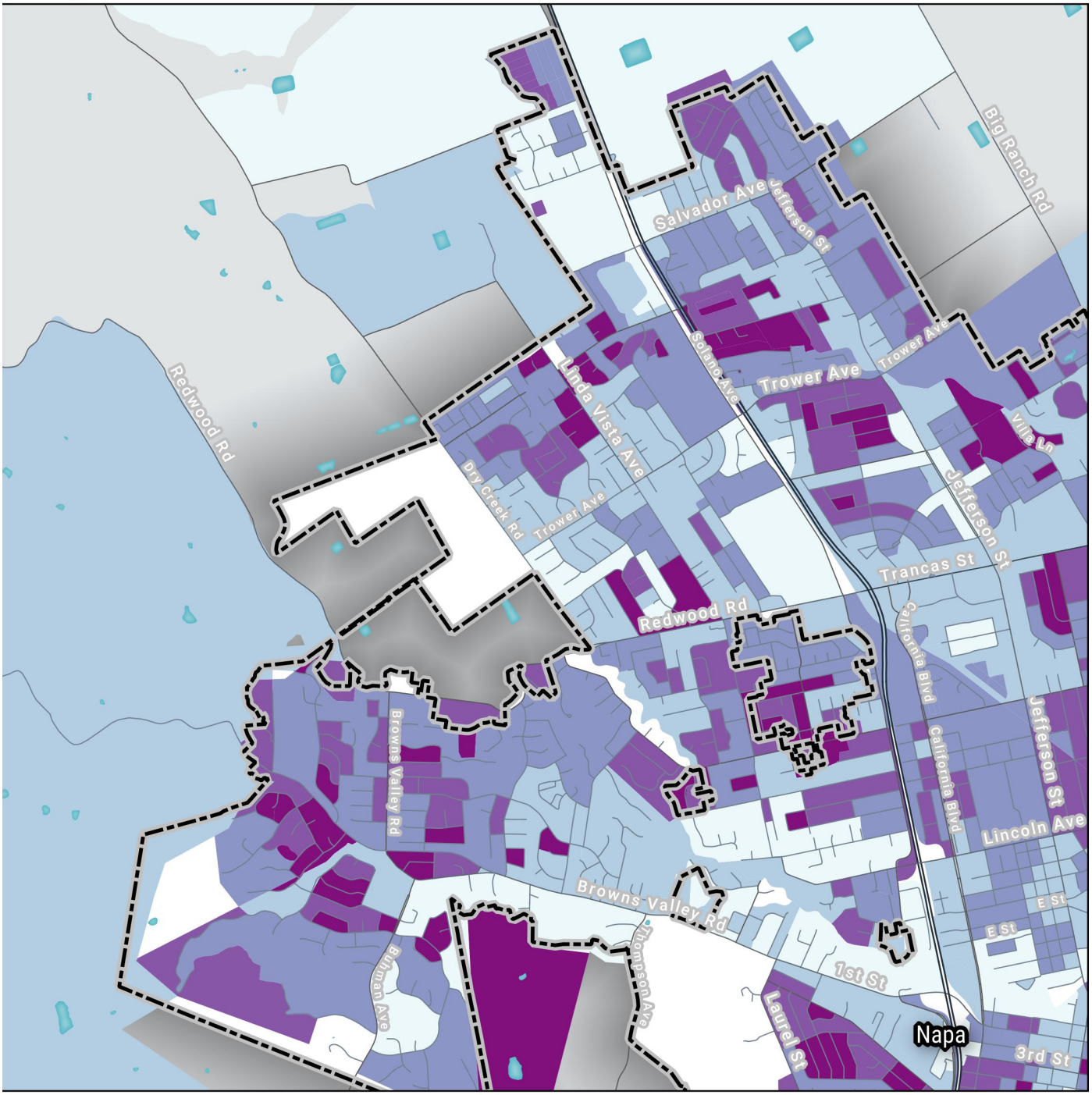
Destination Access Improvement

- 0% - 35%
- 35% - 62%
- 62% - 81%
- 81% - 95%
- 95% - 100%

Major Water Bodies

Figure N.28. Improvement in BNA Score from On-Street Facility Implementation – Northeast

Change in Bicycle Network Analysis Existing to Planned without Trails: City of Napa - NW



Destination Access Improvement

- 0% - 35%
- 35% - 62%
- 62% - 81%
- 81% - 95%
- 95% - 100%

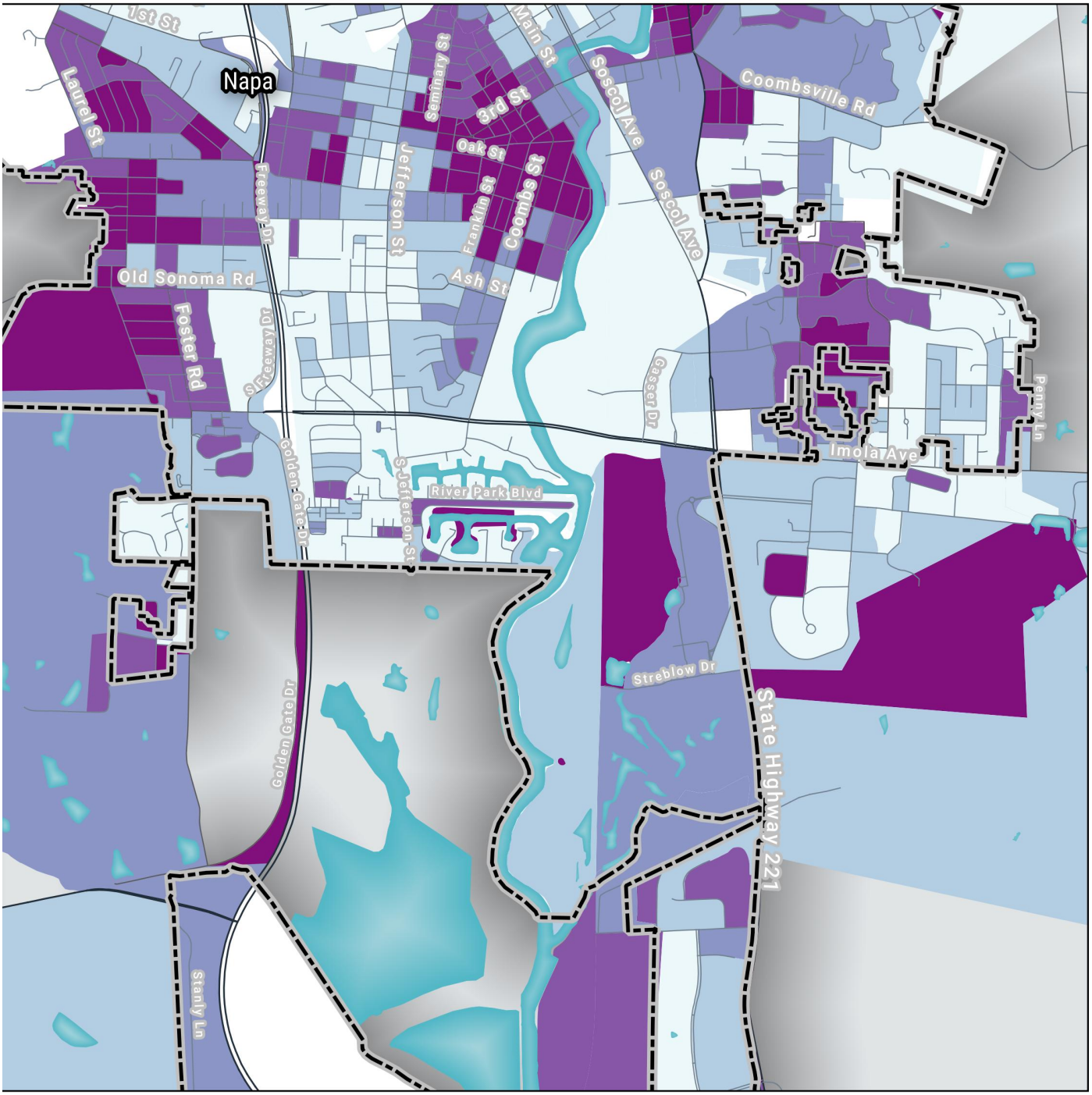
Major Water Bodies

NVTA NAPA VALLEY TRANSPORTATION AUTHORITY

TOOLE DESIGN

Figure N.29. Improvement in BNA Score from On-Street Facility Implementation – Northwest

Change in Bicycle Network Analysis Existing to Planned without Trails: City of Napa - South



Destination Access Improvement

- 0% - 35%
- 35% - 62%
- 62% - 81%
- 81% - 95%
- 95% - 100%

Major Water Bodies

Figure N.30. Improvement in BNA Score from On-Street Facility Implementation – South

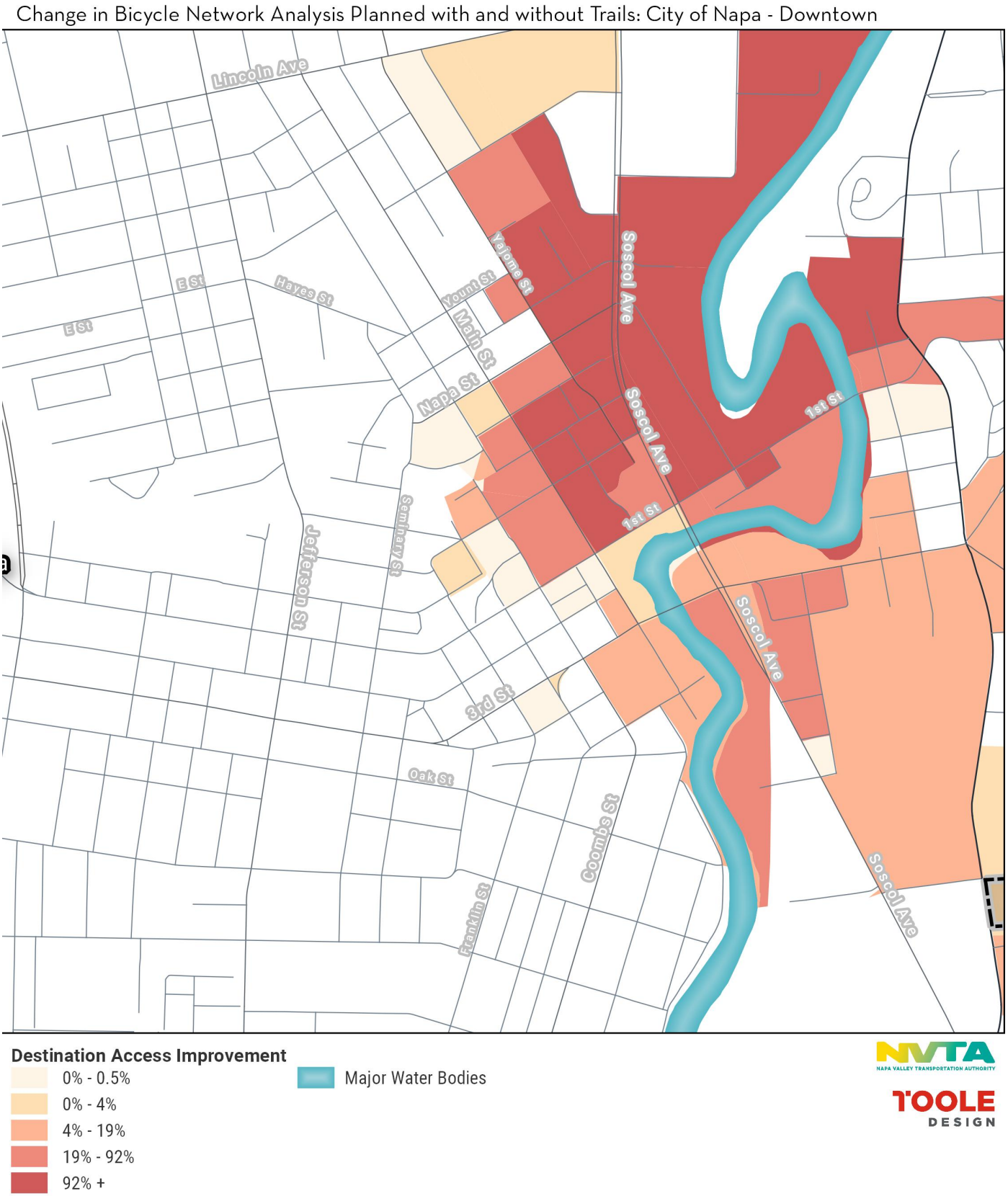


Figure N.31. Improvement in BNA Score from Shared Use Path Implementation – Downtown

Change in Bicycle Network Analysis Planned with and without Trails: City of Napa - NE

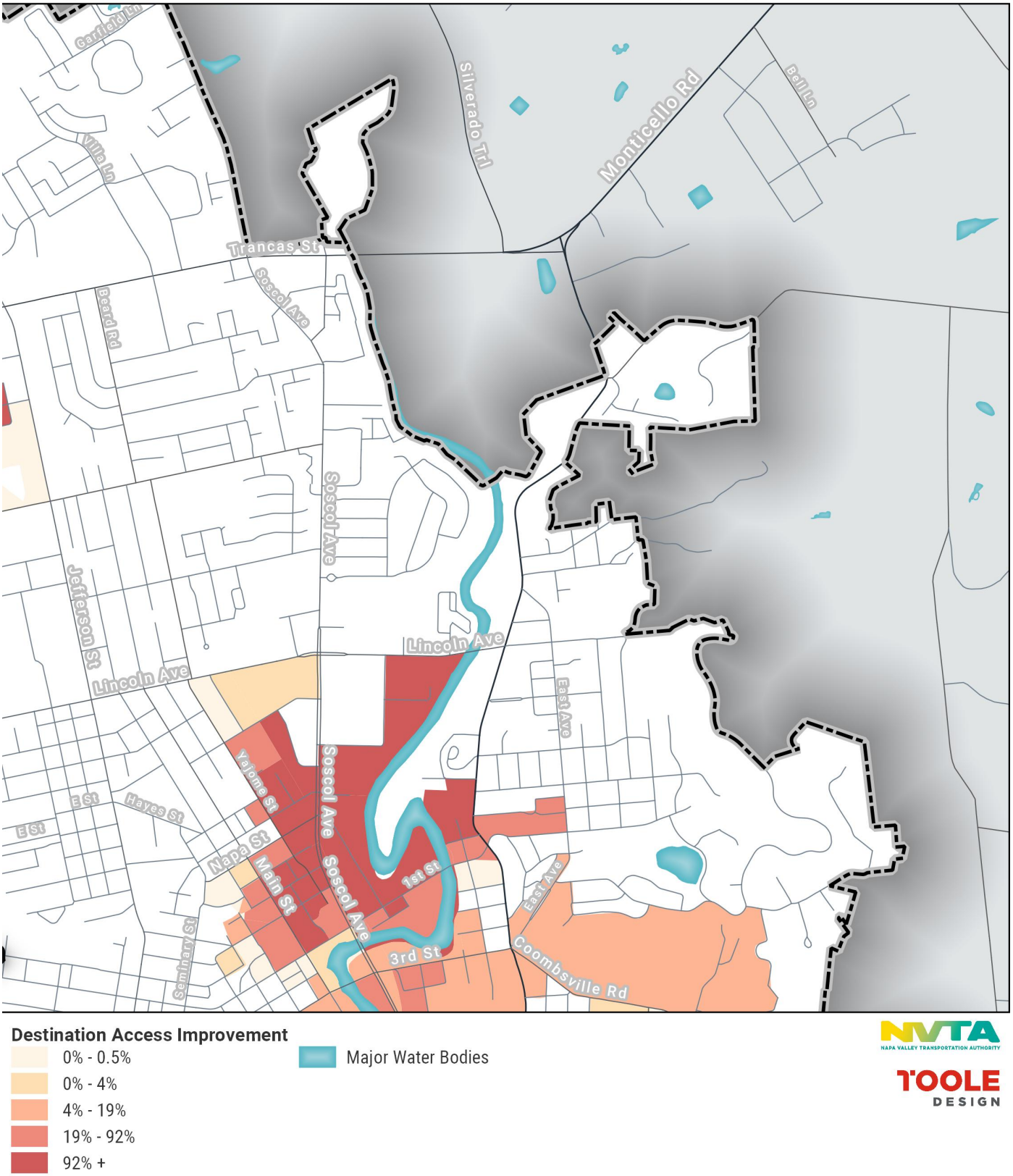


Figure N.32. Improvement in BNA Score from Shared Use Path Implementation – Northeast

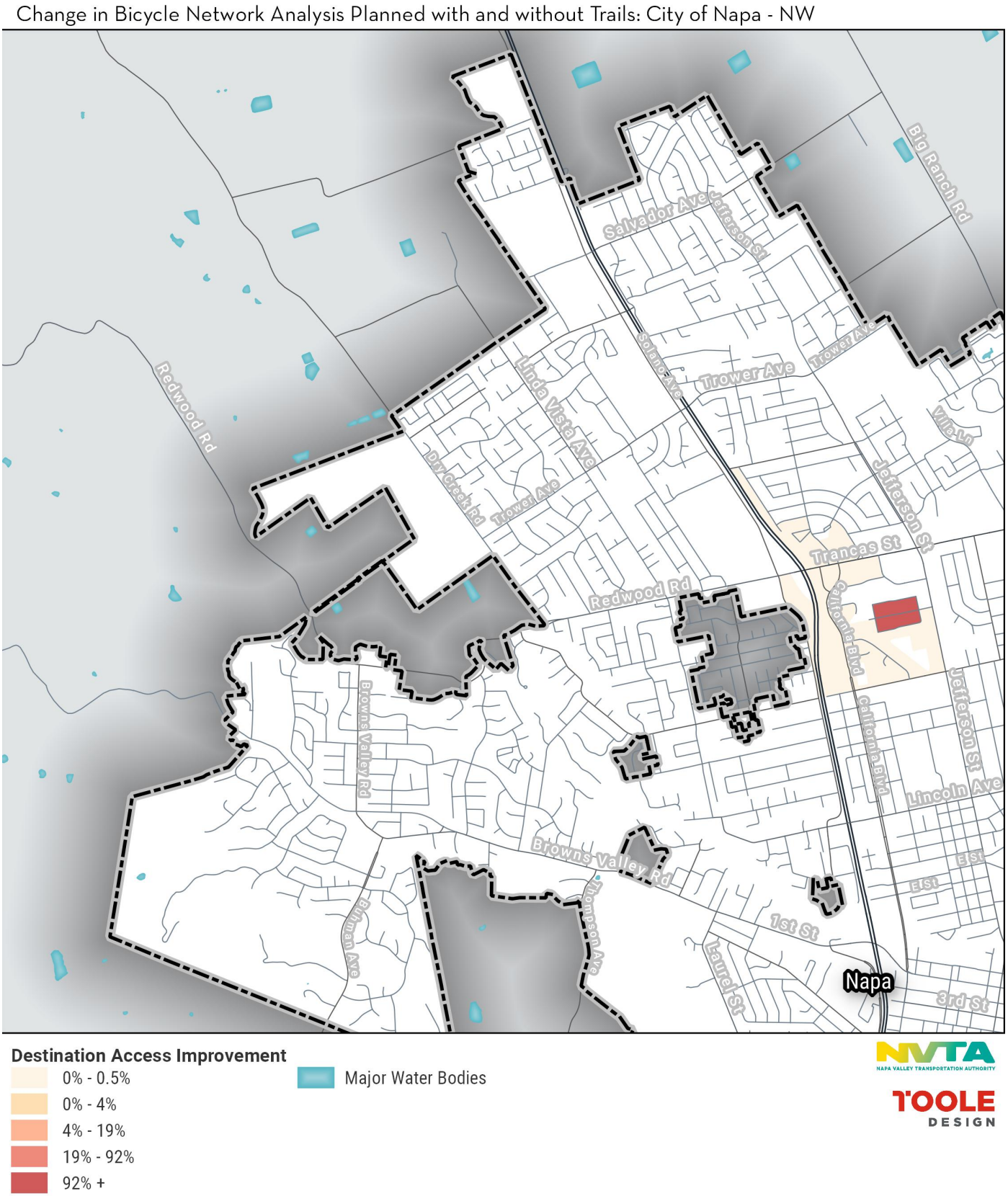


Figure N.33. Improvement in BNA Score from Shared Use Path Implementation – Northwest

Change in Bicycle Network Analysis Planned with and without Trails: City of Napa - South

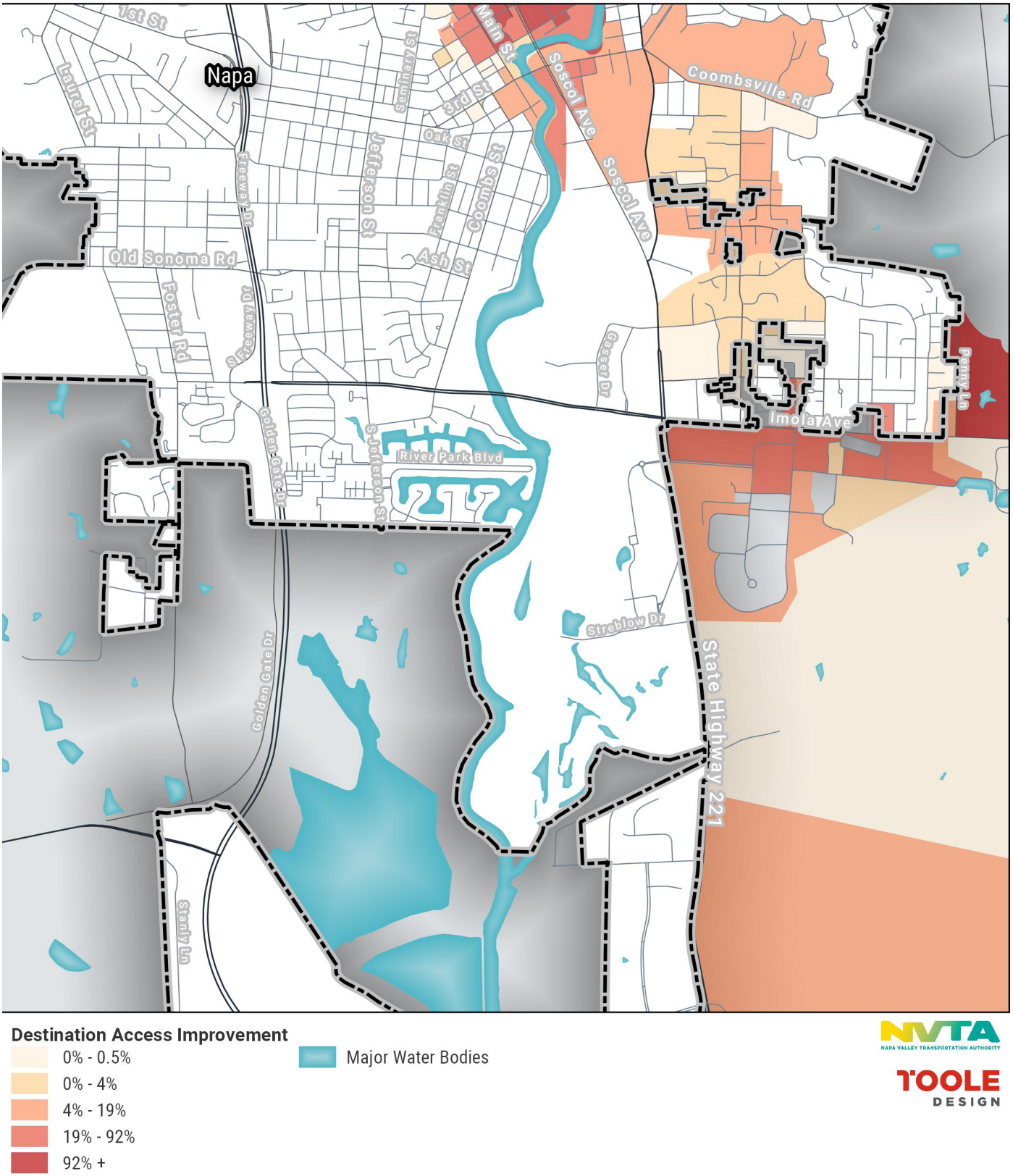


Figure N.34. Improvement in BNA Score from Shared Use Path Implementation – South

Level of Comfort and Bicycle Network Analysis

This plan assessed St. Helena's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[7]

[7] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

Many streets, about 61 percent, in St. Helena today can be considered comfortable for most people riding a bike (see Figure SH.4). Local streets connect to one another within some neighborhoods, but the remaining 31 percent of the network is high-stress streets that divide the city and make a continuous low-stress route difficult to link together. Main Street and several streets that intersect it are rated as high-stress for bicycling because of their roadway classification. Data were not available about all street characteristics that are considered within the LTS and BNA analyses, so assumptions are made based on classification, that is, if a street is classified by the City as local, collector or arterial. Some of these streets may not present a high-stress environment, however, so results should be viewed through this lens.

The stress level of streets and crossings impacts people's ability to access destinations throughout St. Helena which is represented in the following BNA map (Figure SH.5). Overall, connectivity within the city is quite limited at an average score of 14, though the connectivity benefits of the Pope Street bike lanes are evident in the areas near that existing facility. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = OK Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

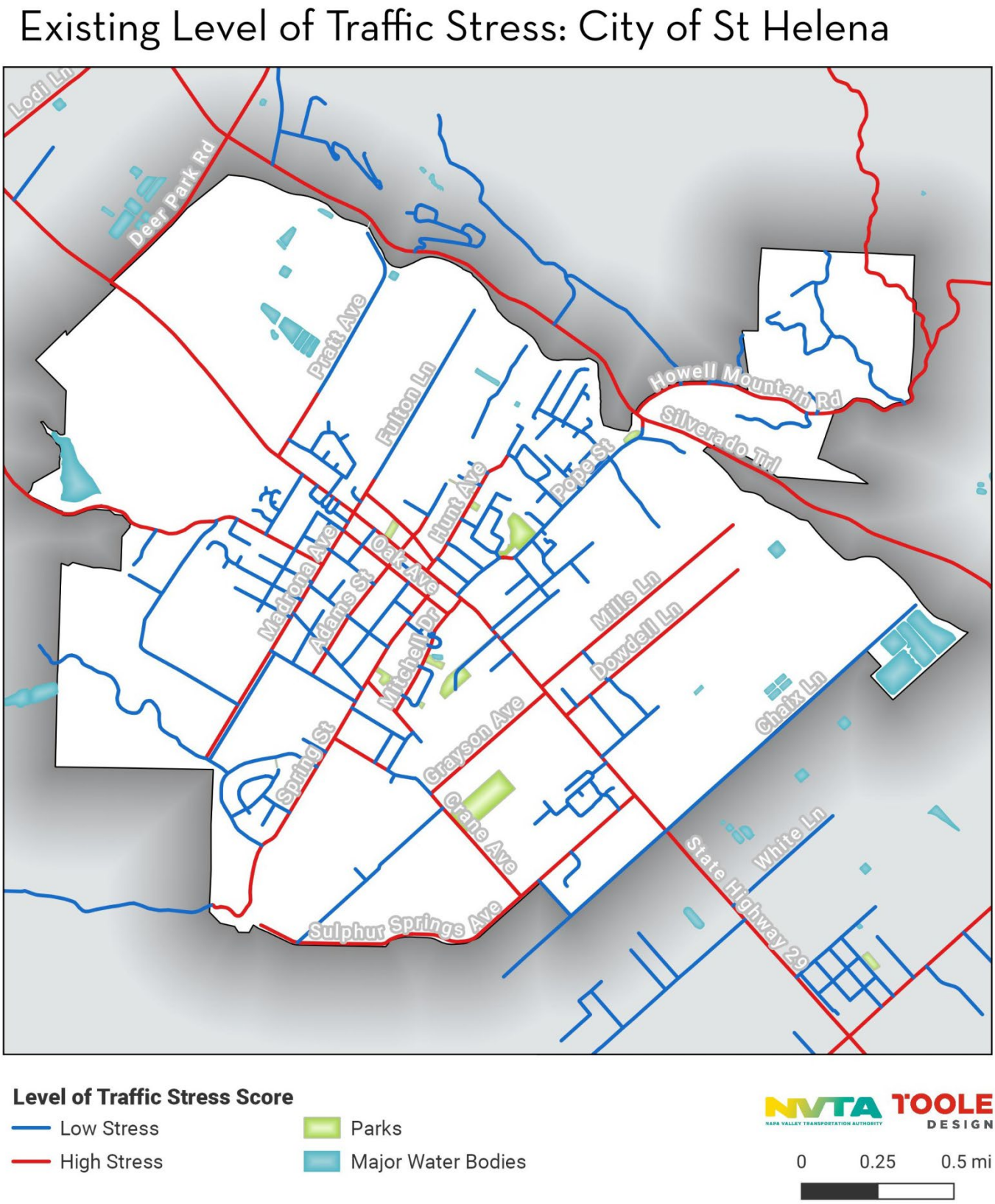


Figure SH.4. Existing Level of Traffic Stress of Streets and Trails

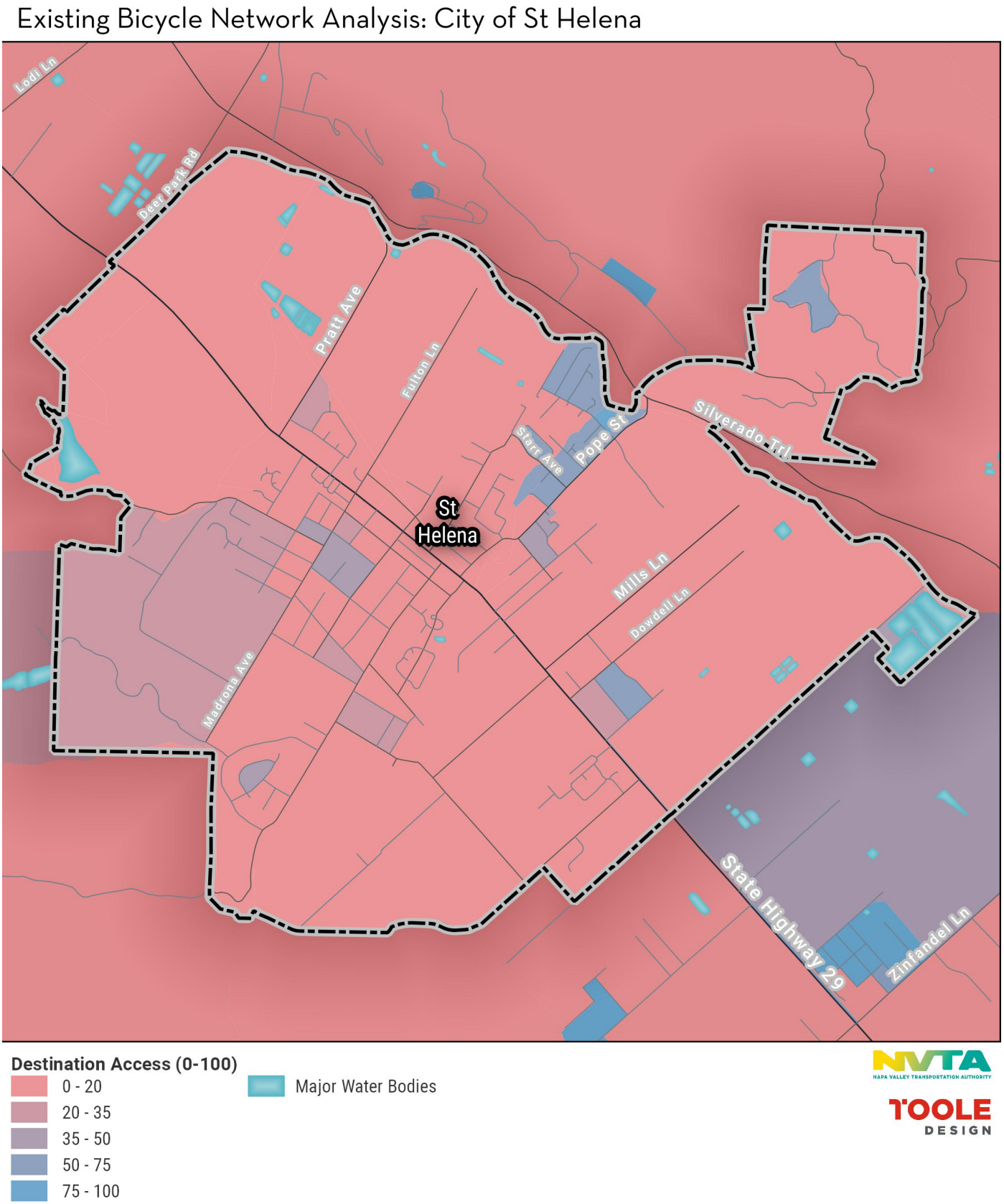


Figure SH.5. Bicycle Network Analysis Results for Existing Network

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures SH.9 and SH.10, implementation of these relatively low-cost on-street facilities creates a major improvement in connectivity within the City of St. Helena. The overall BNA score for the city improves from 14 to 70, putting it squarely within the "Very Good Connectivity" range. St. Helena has great opportunity for improvement because its underlying street network is well connected in a grid pattern south of Main Street, and the small block size north of Main Street also aids connectivity.

When the recommended Class I facilities are added in to the implementation network, connectivity improves further. The third map following (Figure SH.11) shows the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I). The impact of the Napa River Trail and Vine Trail is clear within the northwestern part of St. Helena. These are understood to be a large, long-term capital investments, however, so implementation of on-street facilities in the meantime will provide great benefits to the city.

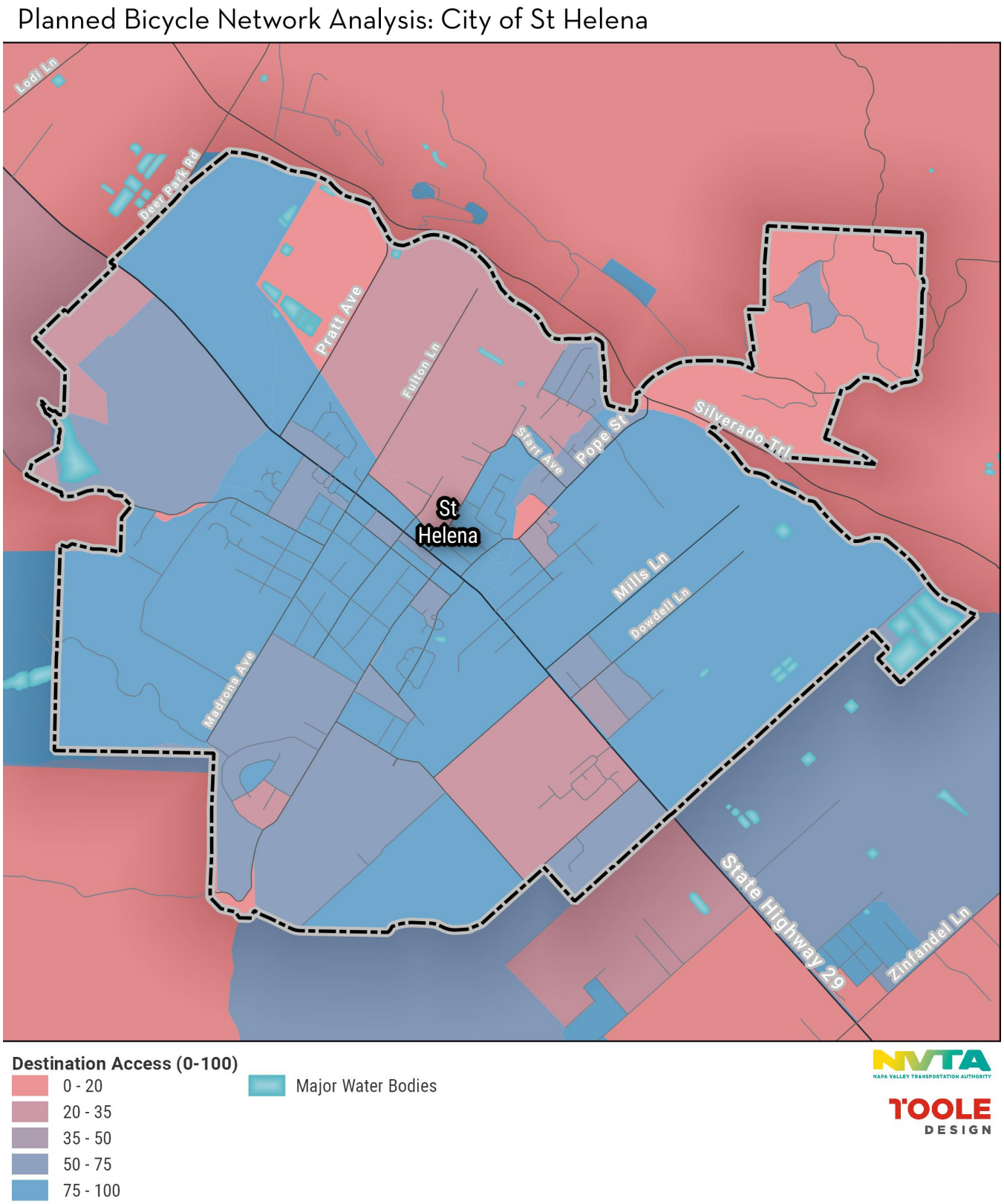


Figure SH.9. BNA Results from On-Street Facility Implementation

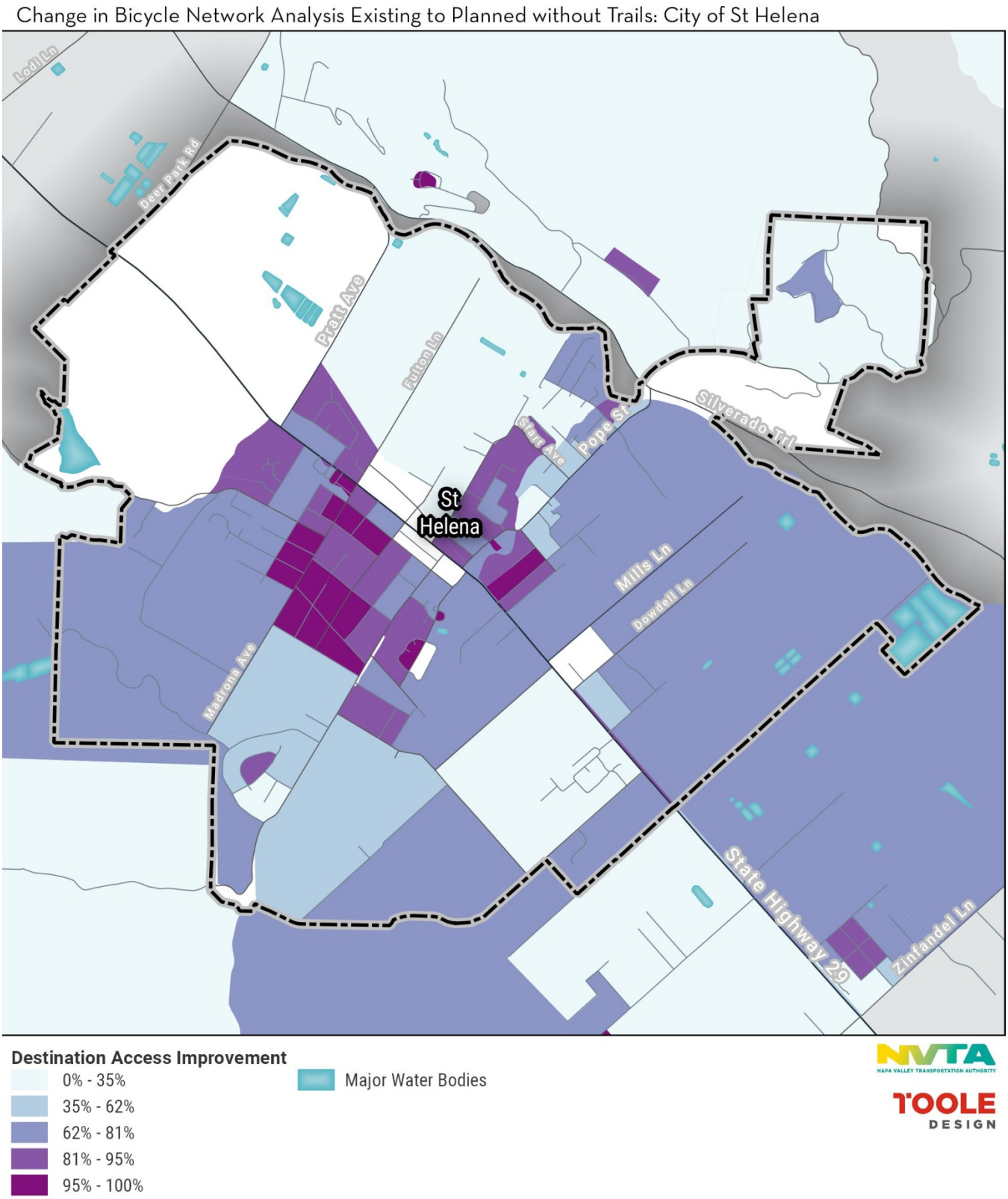


Figure SH.10. Improvement in BNA Score from On-Street Facility Implementation

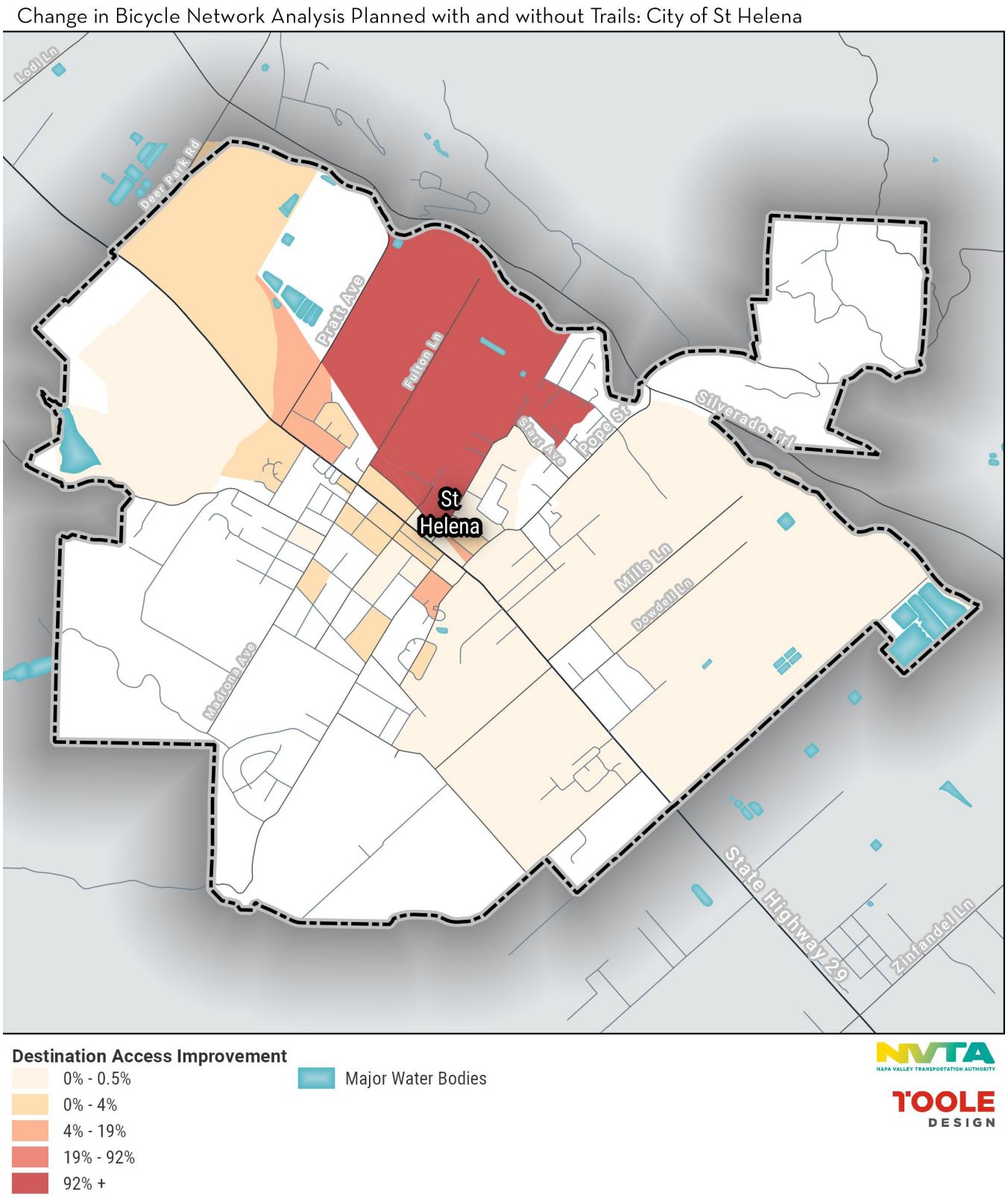


Figure SH.11. Improvement in BNA Score from Shared Use Path Implementation

UNINCORPORATED NAPA COUNTY

Level of Comfort and Bicycle Network Analysis

This plan assessed Napa County's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[8]

[8] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

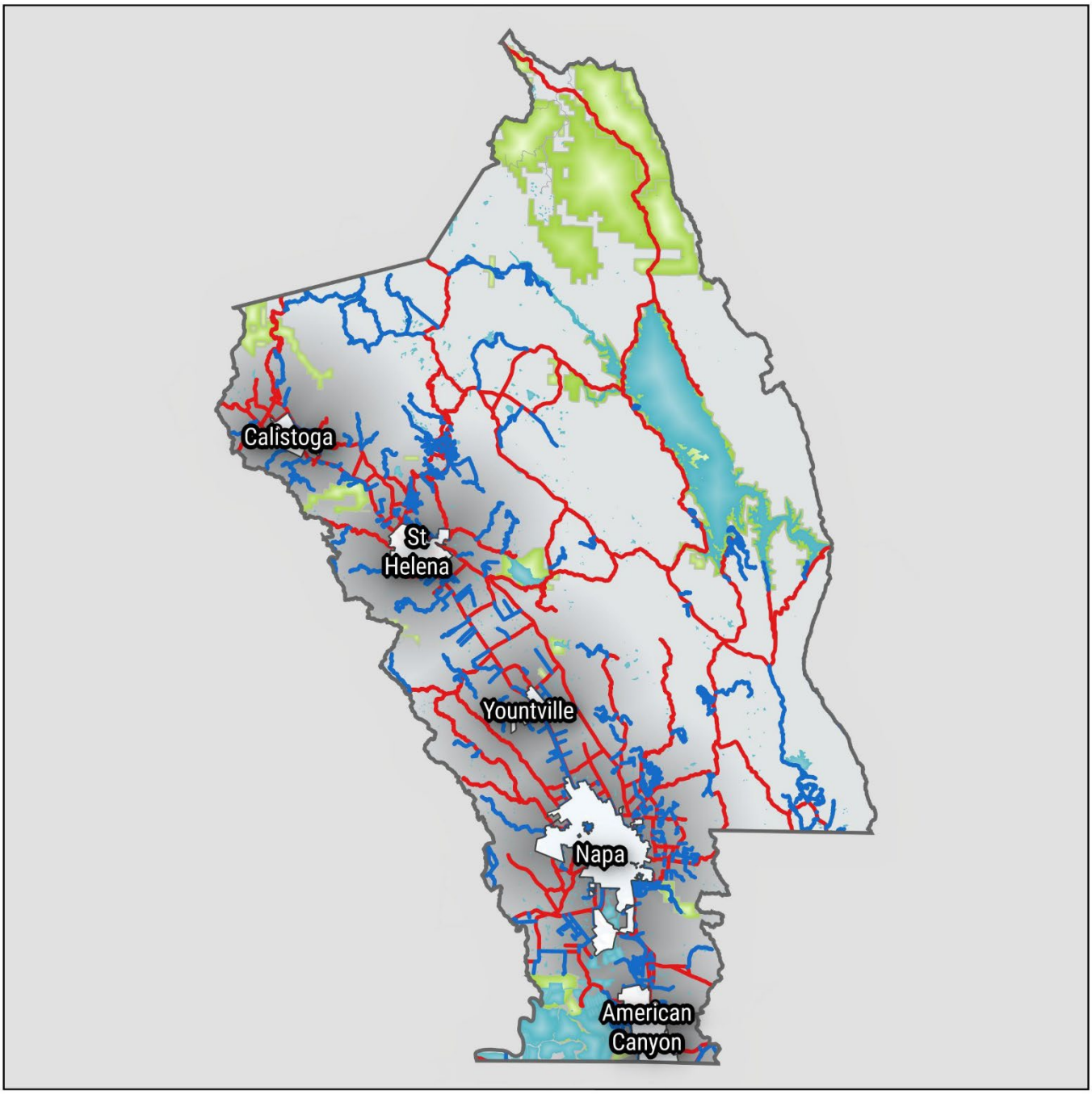
Within the unincorporated areas of the county, about half (46 percent) of streets rate as low-stress for bicycling (see Figure UNC.4). This rating takes into account the comfort level of an Interested but Concerned rider, not an experienced recreational rider who may find high-speed, low-volume rural roads comfortable as well. There are low-stress streets in some of the developed parts of the unincorporated areas (Angwin, areas adjacent to incorporated cities), but they are largely disconnected from one another by high-stress streets or by the underlying disconnected nature of the road network.

The stress level of streets and crossings impacts people's ability to access destinations throughout the County which is represented in the following BNA map (Figure UNC.5). Connectivity within the County as a whole currently scores a 33 since although streets may present a low-stress riding environment, they do not connect to a destination, or they only connect to a very low-density area. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = OK Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

Existing Level of Traffic Stress: Countywide



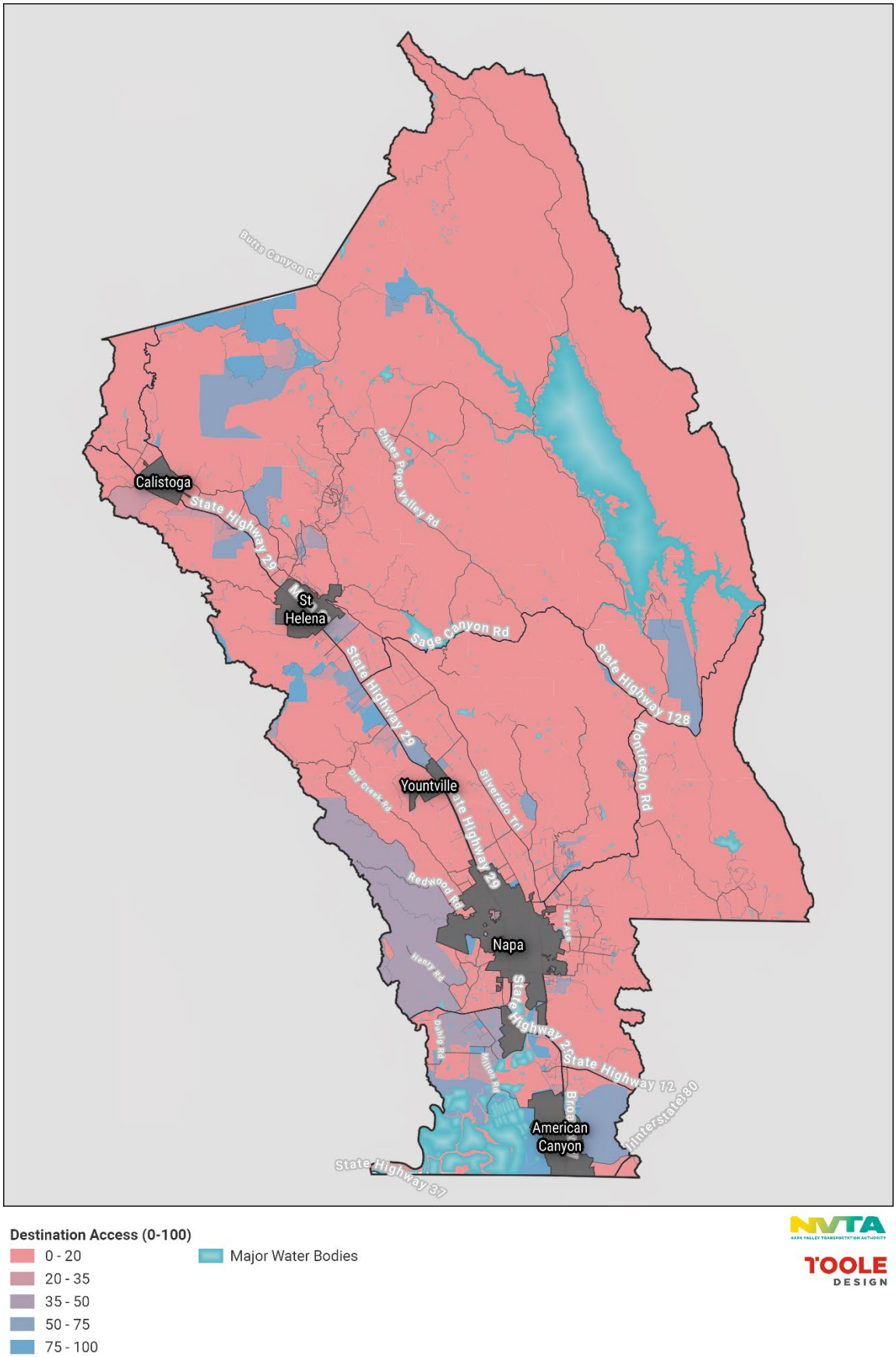
Level of Traffic Stress Score

- Low Stress
- High Stress
- Parks
- Major Water Bodies

0 4 8 mi

Figure UNC.4. Existing Level of Traffic Stress of Streets and Trails

Figure UNC.5 Existing Bicycle Network Analysis: Napa County



Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures UNC.10 and UNC.11, implementation of these relatively low-cost on-street facilities creates a visible improvement in connectivity in some portions of the County. This analysis takes into account all changes to the network, so improvements to on-street facilities within the incorporated areas can also provide benefit in the unincorporated areas. The existing BNA scores in the outlying parts of the County see a sizable percentage increase in part because they are starting from a low baseline.

When recommended Class I facilities are added in to the implementation network, connectivity improves further. The third map following (Figure UNC.12) shows the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I). Improvements in connectivity in the unincorporated areas are centered along the Vine Trail alignment which is to be expected as it will be the major off-street connector through these areas.

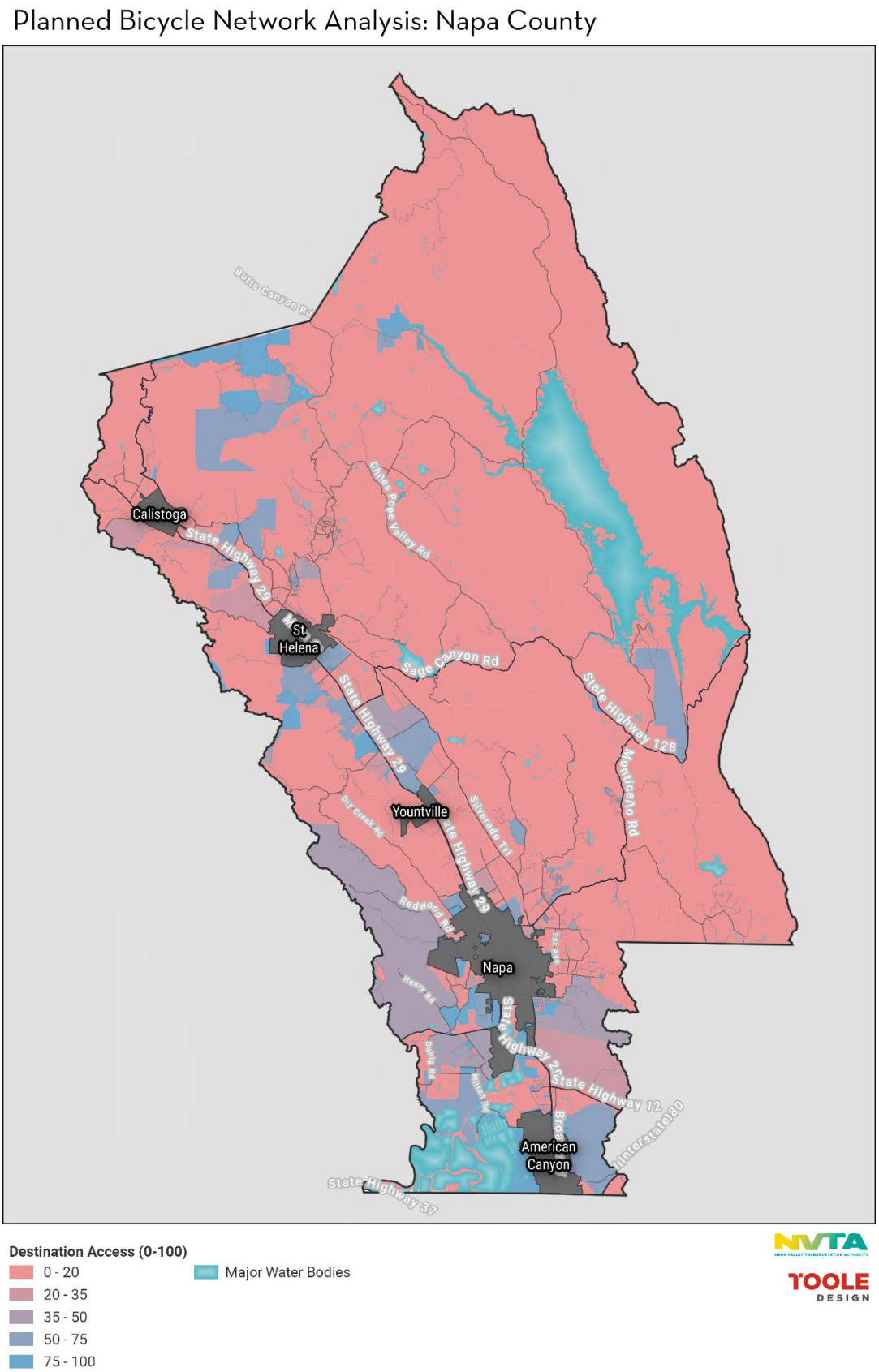


Figure UNC.10. BNA Results from On-Street Facility Implementation

Change in Bicycle Network Analysis Existing to Planned without Trails: Napa County

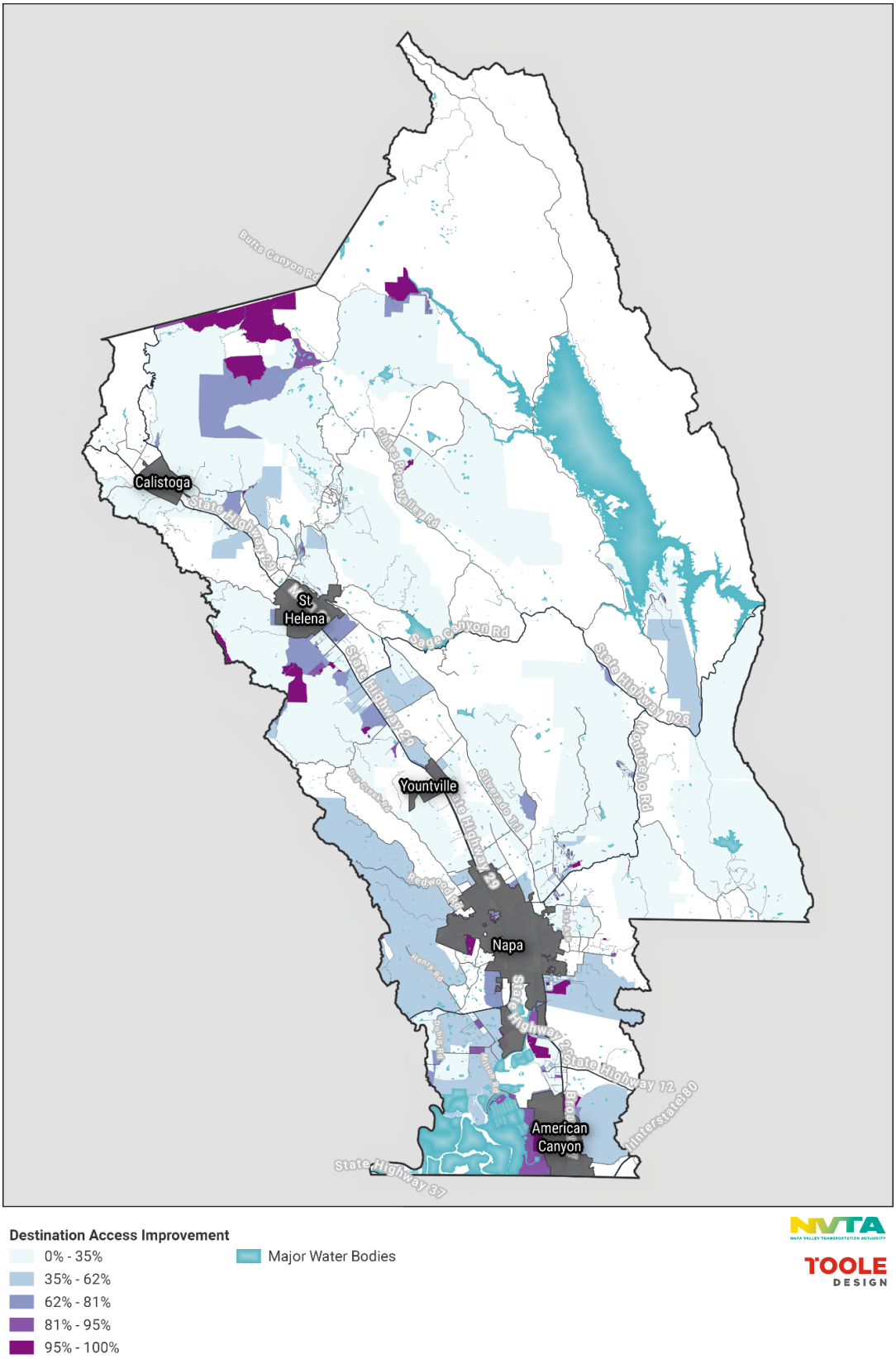


Figure UNC.11. Improvement in BNA Score from On-Street Facility Implementation

Change in Bicycle Network Analysis Planned with and without Trails: Napa County

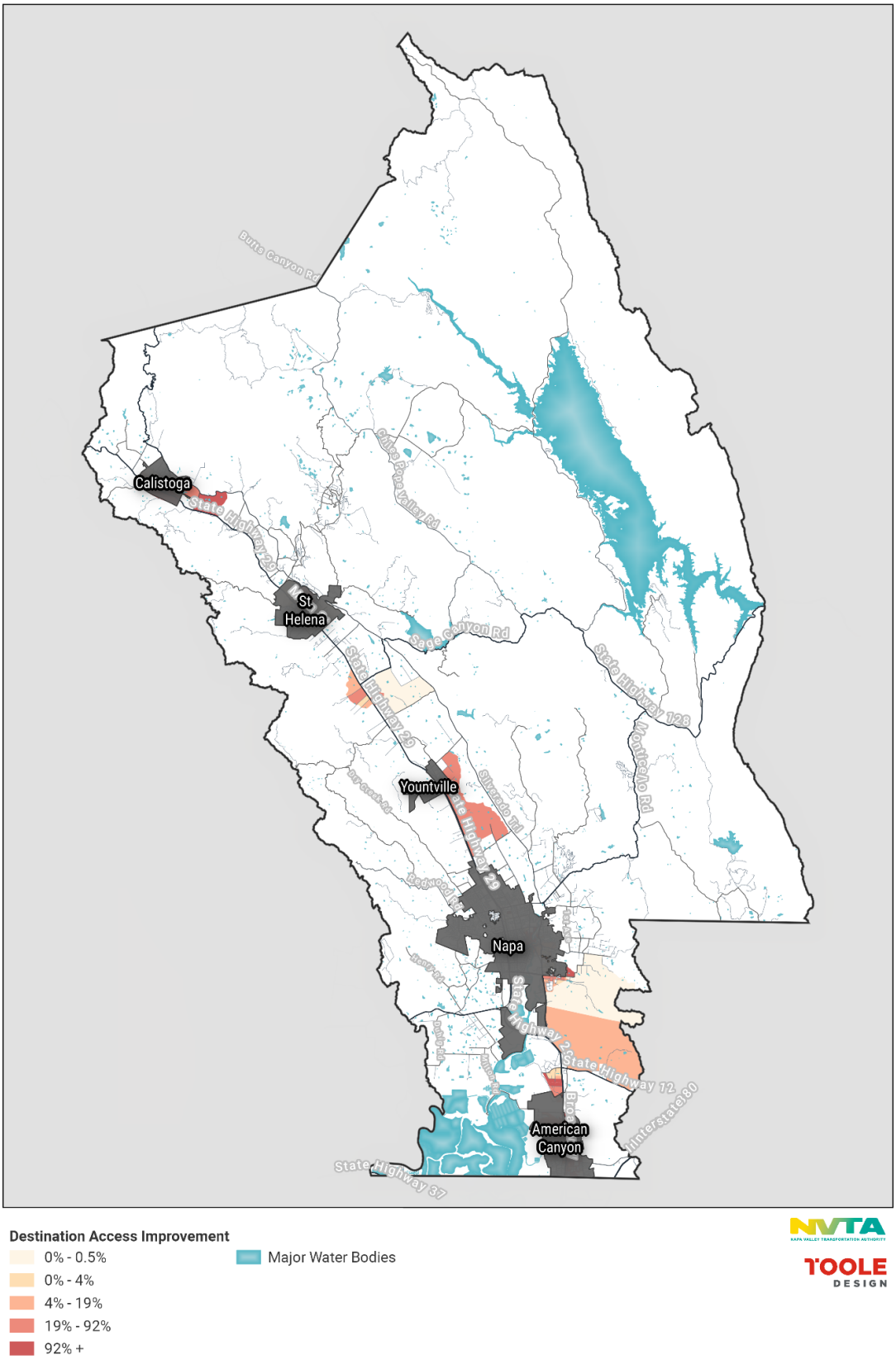


Figure UNC.12. Improvement in BNA Score from Shared Use Path Implementation

TOWN OF YOUNTVILLE

Level of Comfort and Bicycle Network Analysis

This plan assessed Yountville's street and trail network for Level of Traffic Stress (LTS) to understand where the network serves Interested but Concerned riders well, and where additional facilities are needed. LTS measures how people feel when they are bicycling. The proximity, volume, and speed of traffic can impact how people feel while riding, and these are the variables included when measuring LTS for street and trail segments. For instance, two streets both with standard bike lanes (Class II) have differing stress levels because of differing traffic characteristics: a street with two lanes, no parking, and a speed limit of greater than 30 mph will be high stress, while a street with two lanes, no parking, and a speed limit of 25 mph will be low stress. Further detail is available in Appendix H: Connectivity Analysis Methodology.

Intersections can also create stressful riding environments, so they are assessed by reviewing the characteristics of the cross street (traffic speed and number of lanes), as well as the traffic control provided. Signalized intersections give the bicyclist the opportunity to cross when traffic is stopped, creating a lower-stress experience. A high-stress intersection interrupts a rider's low-stress route and can make them more likely to choose not to bike. Understanding the stress level of streets and intersections alone is only part of the picture, however.

Level of Traffic Stress is calculated not only to assess the comfort of specific streets and intersections but also to determine how much of a given jurisdiction is accessible by bike to the Interested but Concerned population. This assessment is done with the Bicycle Network Analysis (BNA) approach. The BNA allows planners to understand where there is good low-stress connectivity in the bicycle network, and where there are challenges. The BNA evaluates connectivity of Census blocks within biking distance (3.1 miles, approximately a 30-minute ride) of one another, and then assesses the number and types of destinations available within each of those blocks. Since Yountville is only one mile long, the BNA evaluates Census blocks within the town, as well as in adjacent Napa Valley. Blocks are only considered connected if there is an unbroken low-stress connection between them. In other words, even a short stretch of stressful biking or a single intersection can negate a potential connection. Last, the BNA considers detour: if a low-stress route goes more than 25 percent out of the way compared to a direct route, that low-stress route is not considered available.

The BNA gives each block a score based on the proportion of destinations accessible on the low-stress network. For instance, if there are five schools in biking distance, but only two are on a low-stress network, the block scores worse than if all five were connected. The total scores shown are the sum of scores across different types of destinations, and a higher overall score means the area is more connected on the low-stress bicycle network. For this Plan, destinations used included schools and

colleges, retail, parks, libraries, post offices, major transit stops, trailheads, restaurants, and hotels, plus general connectivity to jobs and population based on Census data.[9]

Many streets, about 76 percent, in Yountville today can be considered comfortable for most people riding a bike (see Figure Y.4). Local streets connect to one another and to nearby existing trails within neighborhoods, but the remaining 24 percent of the network is high-stress major connecting streets. In particular, Washington Street, one of the main streets in Yountville that houses many retail and restaurant locations, currently presents a high-stress environment for Interested but Concerned riders. Due to limited right-of-way on Washington Street, bicyclists are currently encouraged to ride on the parallel Hopper Creek Pathway and the Vine Trail.

The stress level of streets and crossings impacts people's ability to access destinations throughout Yountville which is represented in the following BNA map (Figure Y.5). Overall, connectivity within the town itself is good at an average score of 48. Based on scoring across multiple uses of the BNA so far in the U.S., the scores on the map below can be interpreted using the following ranges:

- 0 - 20 = Poor Connectivity
- 20 -35 = Fair Connectivity
- 35 - 50 = Good Connectivity
- 50 and above = Very Good Connectivity

In addition to showing the existing connectivity of the bicycle network, the BNA can help visualize the impact of planned bicycle improvements both on streets and the addition of new shared use paths. Maps showing these changes in connectivity are included in the implementation section.

[9] Major transit stops include the Soscol Gateway Transit Center, Redwood Park & Ride, and other timed stops for the longer NVTA routes: 10, 11, 21, 29.

Figure Y.4. Existing Level of Traffic Stress of Streets and Trails

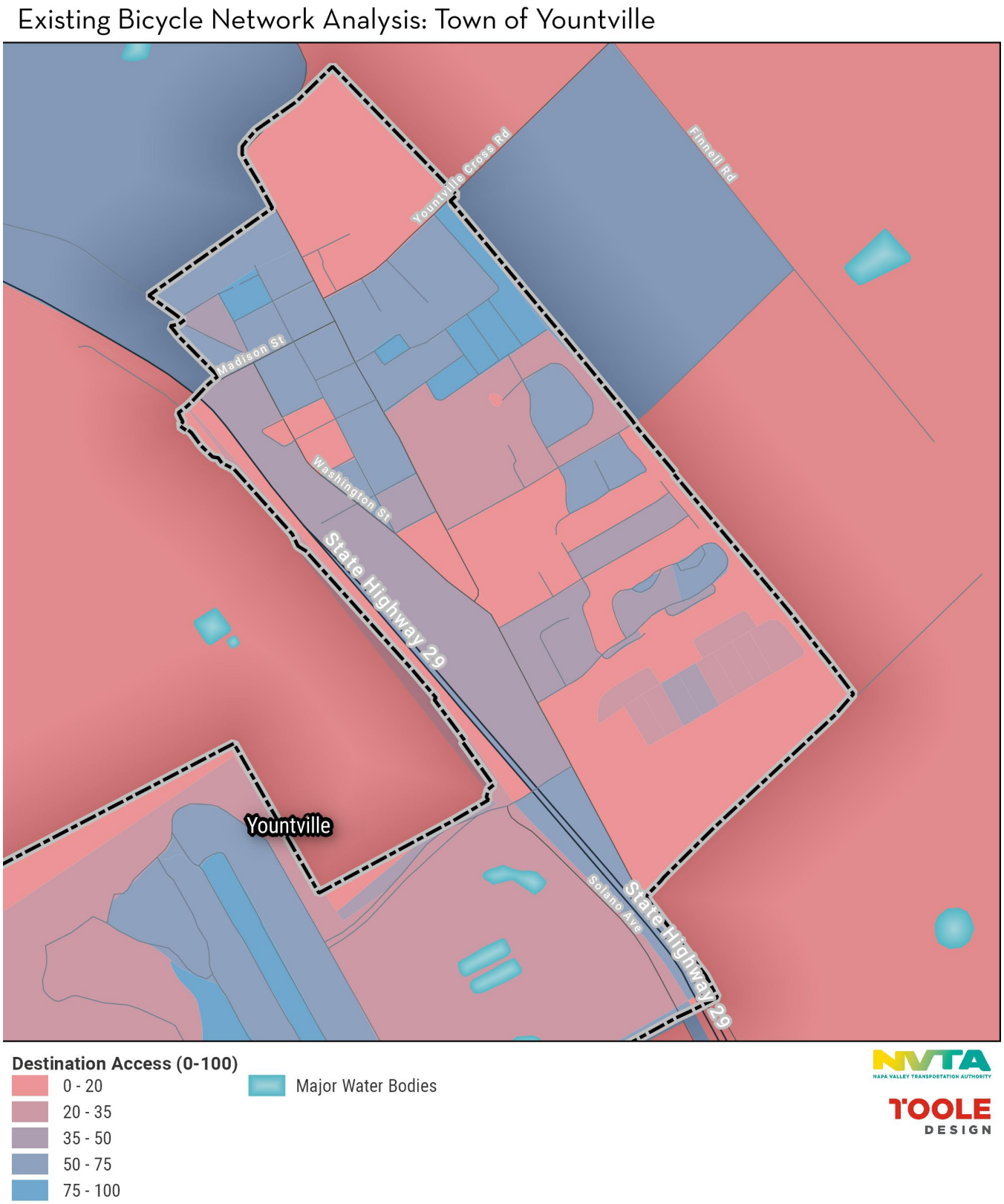


Figure Y.5. Bicycle Network Analysis Results for Existing Network

Connectivity Improvements from Phased Implementation

The Bicycle Network Analysis (BNA) was conducted for planned scenarios as well as existing to understand the impact of the recommended network on low-stress connectivity. When evaluating the stress of future bike facilities, all planned bike boulevards, urban and suburban bike lanes, and separated bike lanes were assumed to be low-stress facilities. The analysis also assumes that all crossings for bike boulevards that would facilitate a low-stress experience are also implemented. Existing high-stress bike lanes that are not recommended to be upgraded were still included as high-stress facilities. As can be seen below in Figures Y.8 and Y.9, implementation of these relatively low-cost on-street facilities creates a visible improvement in connectivity within the Town of Yountville. The northern part of the town benefits from implementation of a bicycle boulevard on Webber Avenue which provides a connection to the Vine Trail which is a long-distance, low-stress facility.

When the recommended Class I facilities are added in to the implementation network, connectivity improves further in select areas. The third map following (Figure Y.10) shows the percentage change increase in BNA score between the planned network with only on-street facilities implemented, versus the score when *all* facilities are implemented, including shared use paths (Class I). The only recommended shared use path in Yountville is south of Mulberry St which connects the planned bicycle boulevard on that street to the network of private streets within the Rancho de Napa community.[10] This path is a longer-term capital investment; however, implementation of on-street facilities will provide benefits to the town in the meantime.

[10] This Plan recommends connections to private streets, but not along private streets. This path in particular provides a low-stress alternative to Washington Street for the Rancho de Napa and Bella Vista residents.

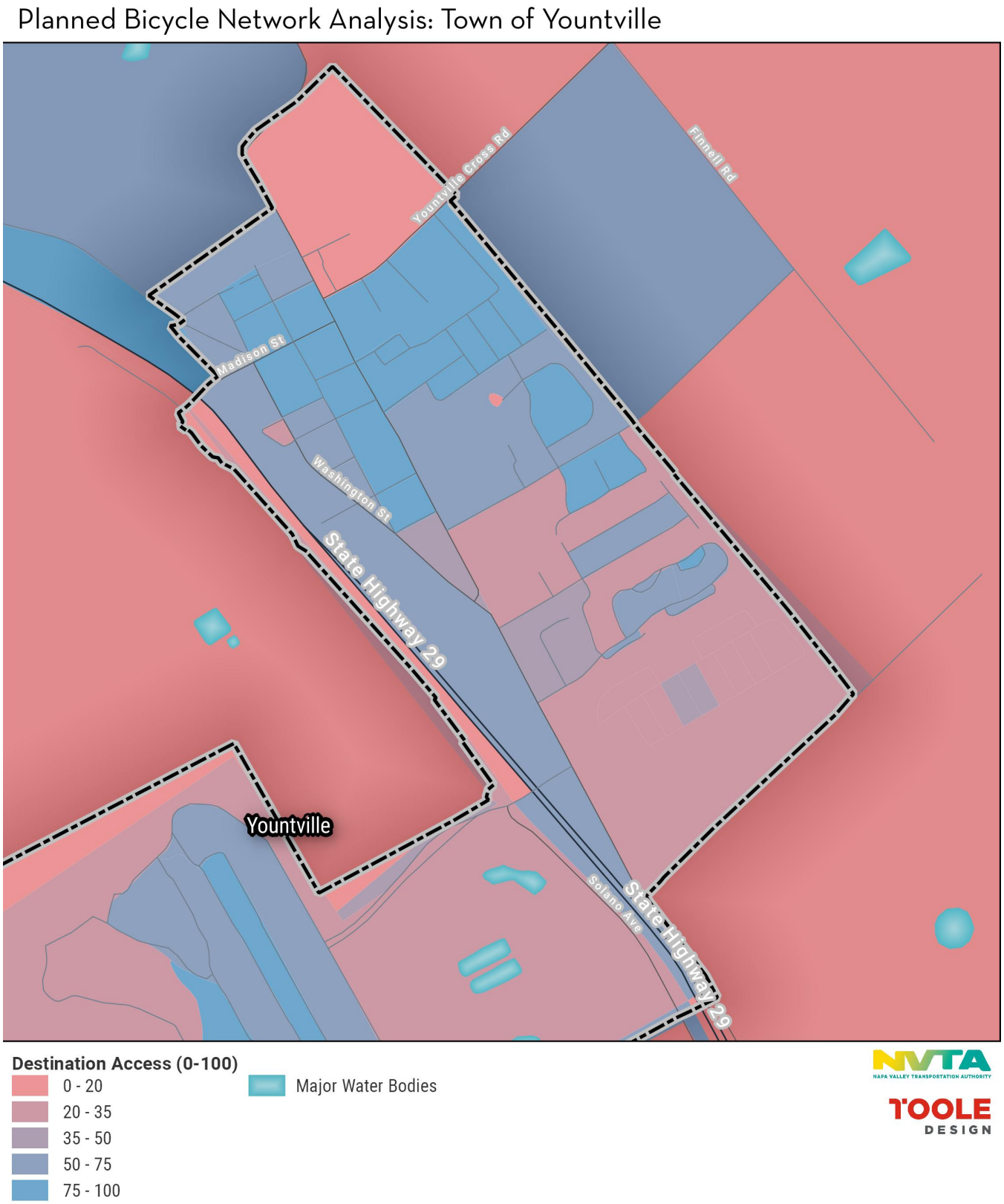


Figure Y.8. BNA Results from On-Street Facility Implementation

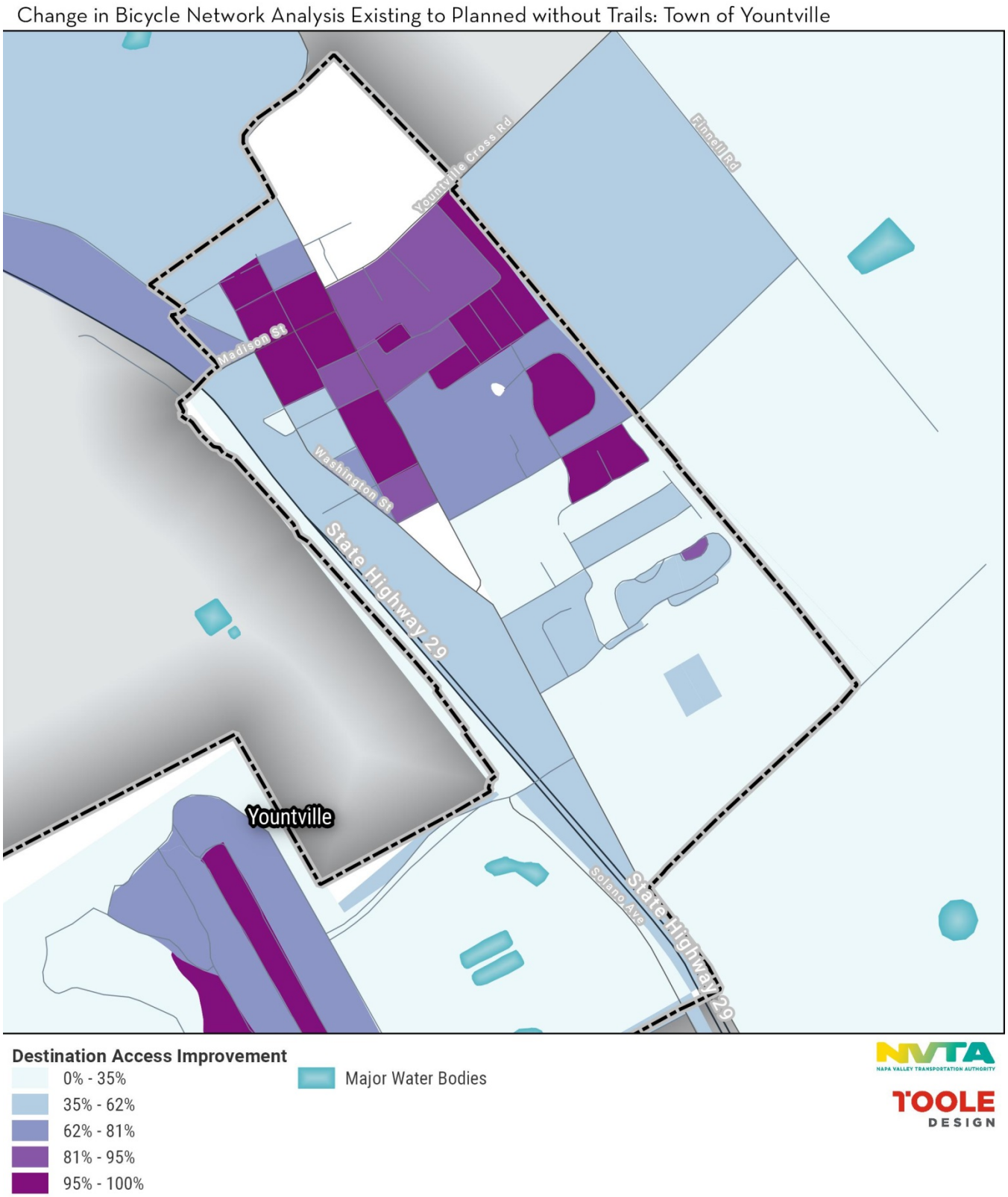


Figure Y.9. Improvement in BNA Score from On-Street Facility Implementation

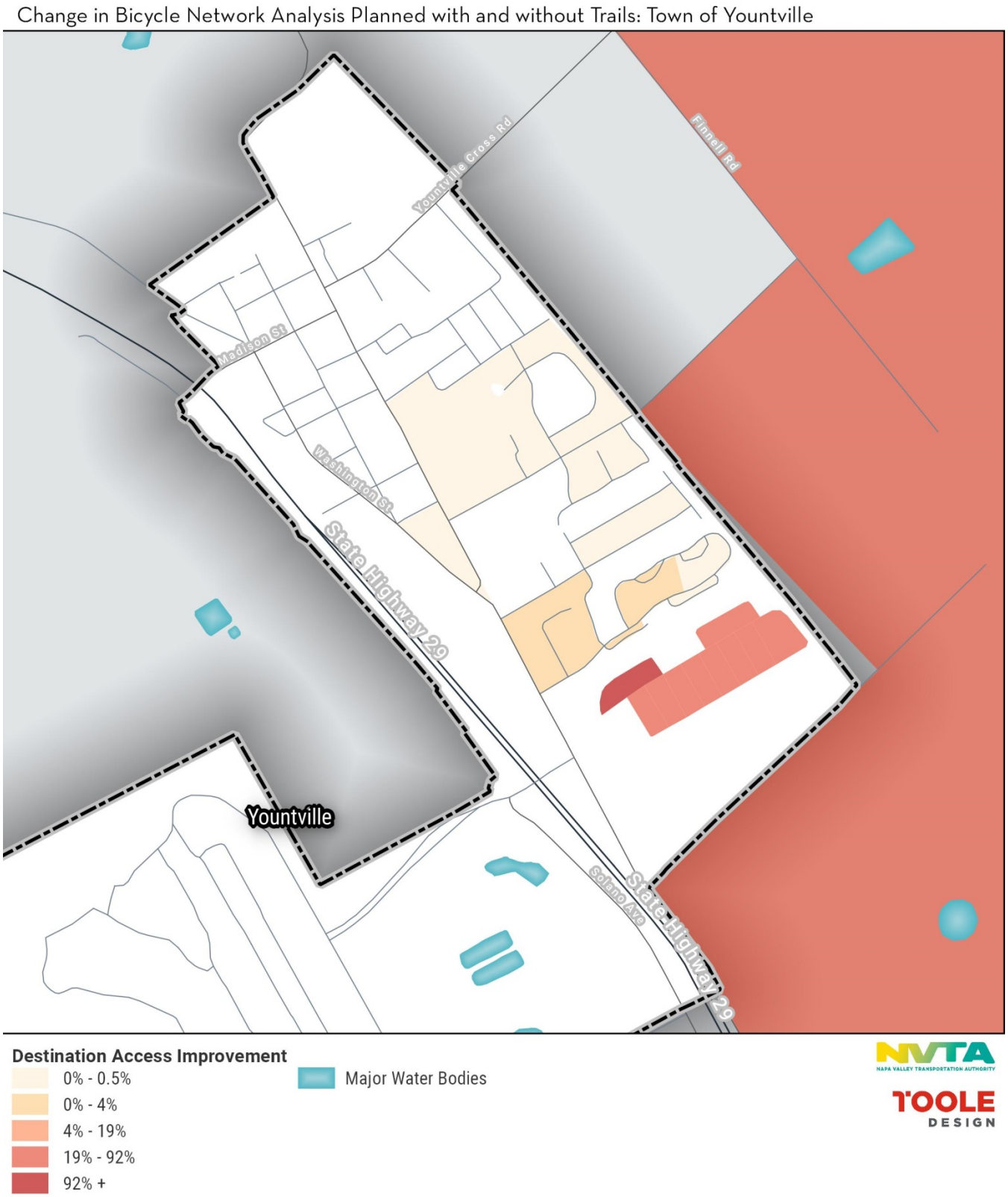


Figure Y.10. Improvement in BNA Score from Shared Use Path Implementation