APPENDIX C: ANALYSIS

Bicycle Suitability Index

The Bicycle Suitability Index (BSI) model utilizes existing infrastructure (in a Geographic Information System (GIS) form) to develop composite demand side (where resident trips would typically originate from and travel to) and supply side (what physical infrastructure exists) models of Greeley. Objective tools such as this are utilized during the planning process to complement the more subjective input received during public input sessions and through survey and online mapping exercises, as both are critical components to developing a well-rounded data and input-driven plan.

Following is a description of the methods and results of Bicycle Demand Analysis (demand side) and the Bicycle Level of Traffic Stress Analysis (supply side). The analytical methods within provide an objective, data-driven process of identifying network gaps as potential projects and identifying areas of high existing or potential bicycle and pedestrian activity. The resulting Supply and Demand Typologies Model presents an array of potential bicycle and improvement opportunities for Greeley.

Table 1: Sources of Model Inputs

Model Input	Source	Notes
Posted Speed Limit	Greeley	GIS data
Number of Travel Lanes	Greeley	GIS data
Bicycle Facilities	Greeley	GIS data + spot field verification
Demographic Data	US Census	2010 Census Block Level Data
School Enrollment	Greeley-Evans School District	
Transit Service	Greeley Evans Transit	GIS data

Data Sources

A number of data inputs were incorporated into the analysis. Table 1 displays each variable, its source, and notes on assumptions that were made.

Bicycle Demand Analysis (BDA)

Background, Overview of BDA, and Use Considerations

Models serve as an effective means to understand how factors in a complex system interact by providing a simplified version of the system for study. However, by definition, models are representations of reality and are constrained by the quality of available data and the complexity of the system under consideration. Throughout the modelling process, significant effort was made to collect the best data possible for input to the model and field verify data as necessary and possible.

BSI provides a general understanding of expected activity in the pedestrian environment by combining categories representative of where people live, work, play, access public transit and go to school into a composite sketch of demand.

Generally speaking, the scoring method is a function of density and proximity. Scores reflect relative impact on walking or bicycling to and from census block corners that are located adjacent to the features used in the analysis. As such, scores are represented as density patterns of census block corners within a ¼ mile of each other. Subsequently, the scores are effectively a result of two complementing forces: *distance decay* – the effect of distance on spatial interactions yields lower scores for features over ¼ mile away from other features; and *spatial density* – the effect of closely clustered features yields higher scores. Scores will increase in high feature density areas and if those features are close together. Scores will decrease in low feature density areas and if features are further apart. In essence, the score is the intersection of distance and density. Thus, on the maps shown in the following figures, the highest density/usage/activity locations (shown in red) do not represent specific physical facilities, but rather represent relative higher use zones as calculated previously.

Categories are scored on a scale of 1 – 5 based on density and proximity and then assigned weighted multipliers to reflect the relative influence categories have on pedestrian activity. The feature weighting method is discussed in the following section.

Where people live includes 2010 census block level population density information. These locations represent potential trip origin locations. More trips can be made in areas with higher population density. "Live" trip hot spots include areas around UNC, Aims CC, Bittersweet Park, neighborhoods east of US 85, and many other residential areas throughout Greeley.

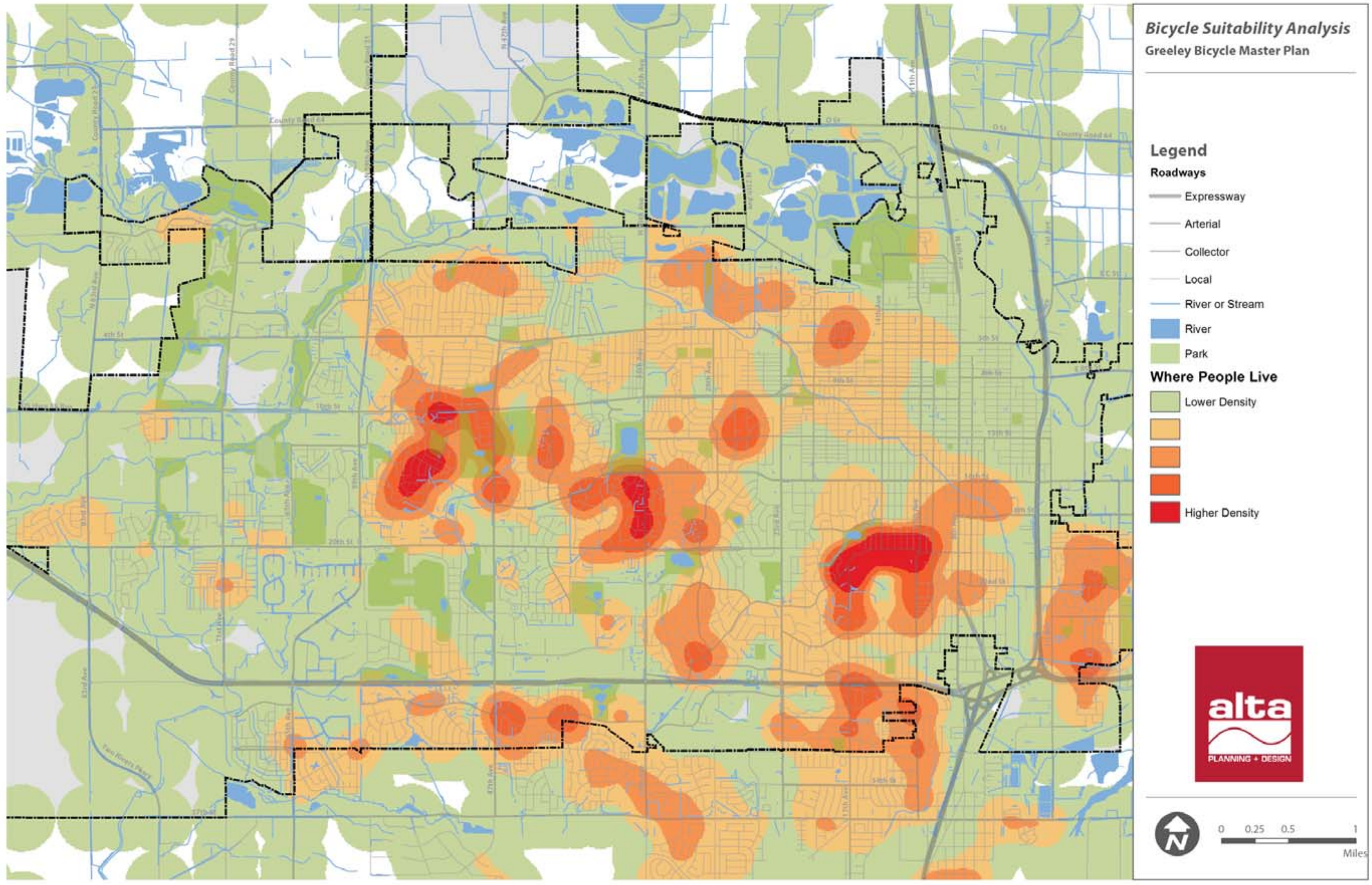

Figure 1: Greeley "Live" BDA map

Where people work mainly represents trip ends, for people working in Greeley regardless of residency. Its basis is 2010 total employment by census block. Depending on the type of job, this category can represent both trip attractors (i.e., retail stores or cafes) and trip generators (i.e., office parks and office buildings) in terms of base employment population. It is therefore also used in the where people play category by overlaying with specific job types, such as retail. Hot spots for the "work" analysis include the areas around North Colorado Medical Center, Aims CC, UNC, Weld County offices, and downtown, as well as retail areas along US 34.

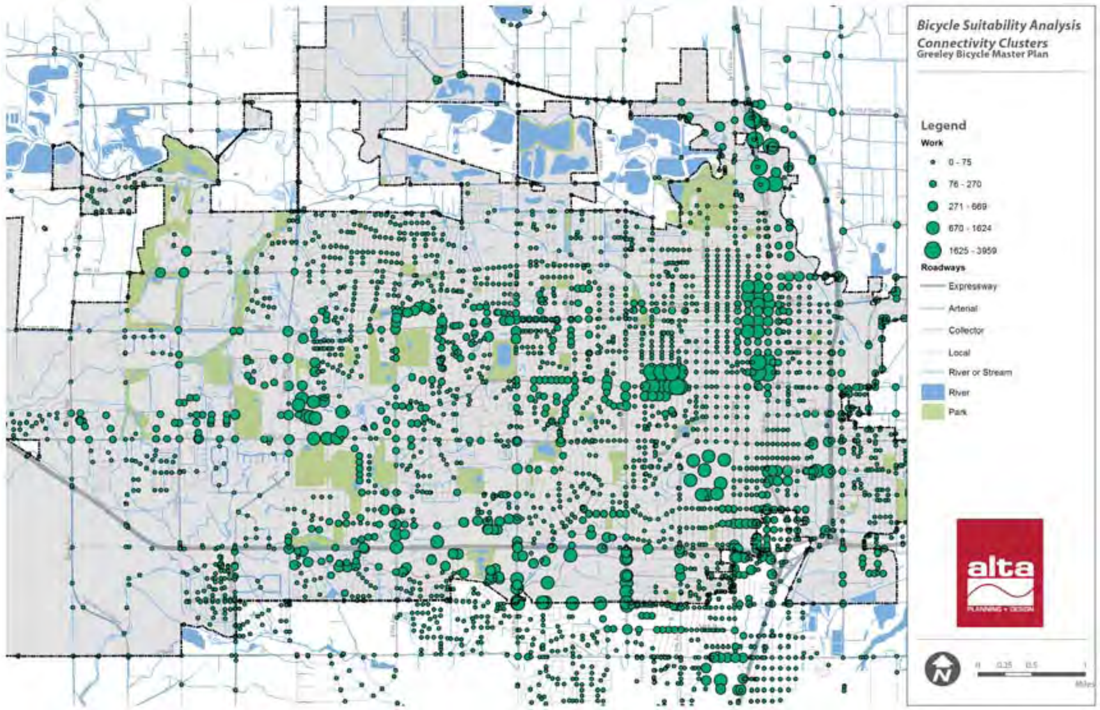

Figure 2: Employment data (for reference)

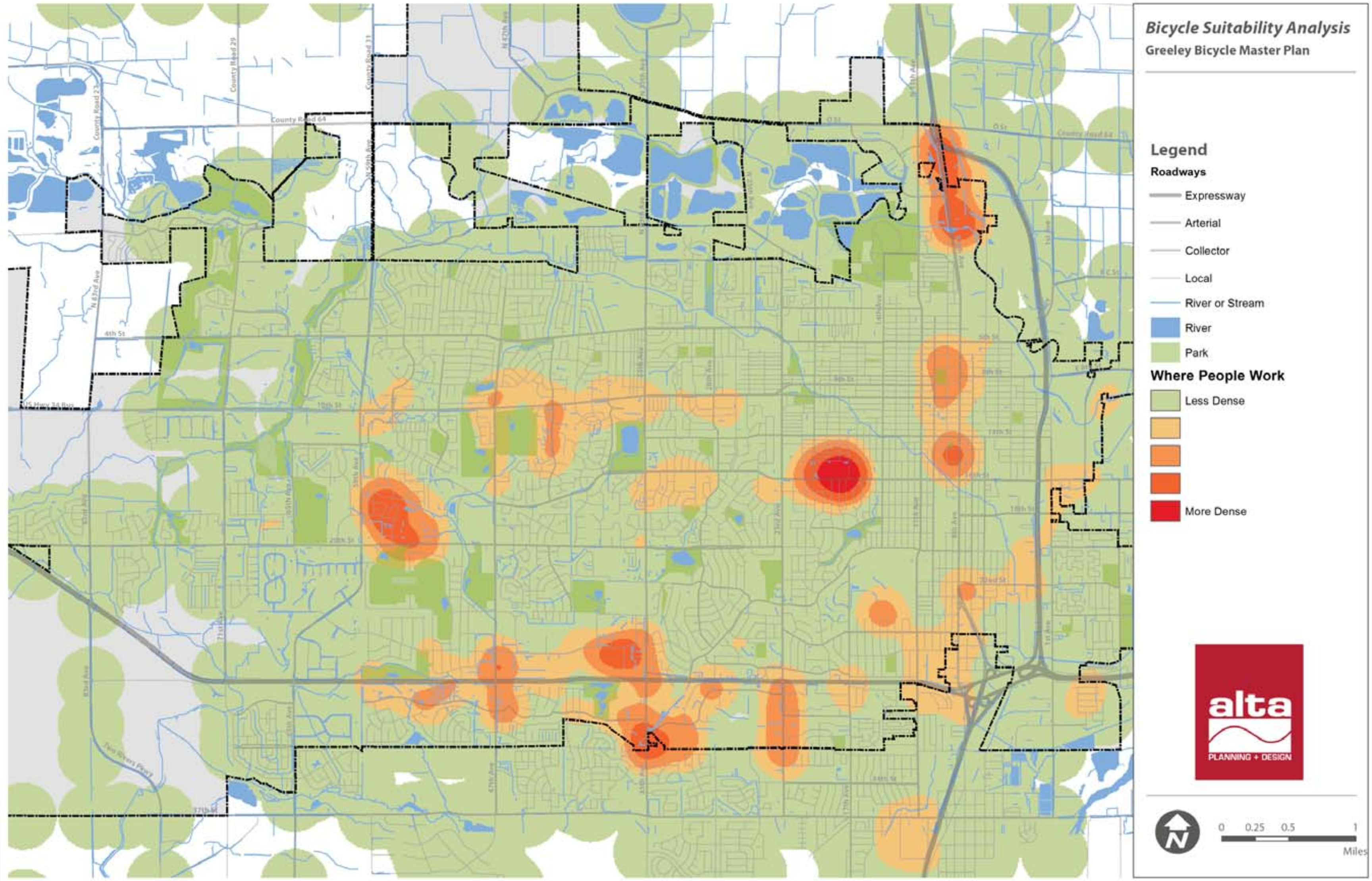

Figure 3: Greeley "Work" BDA map

Where people learn represents where students K-12, at community college, or at university go to school. Its basis is enrollment data from the Greeley-Evans School District, Aims Community College, and University of Northern Colorado (UNC). This becomes the student-age resident equivalent of a work trip generator. University and K-12 models were split to allow for K-12 visual clarity due to relatively large enrollment at the university and community college.

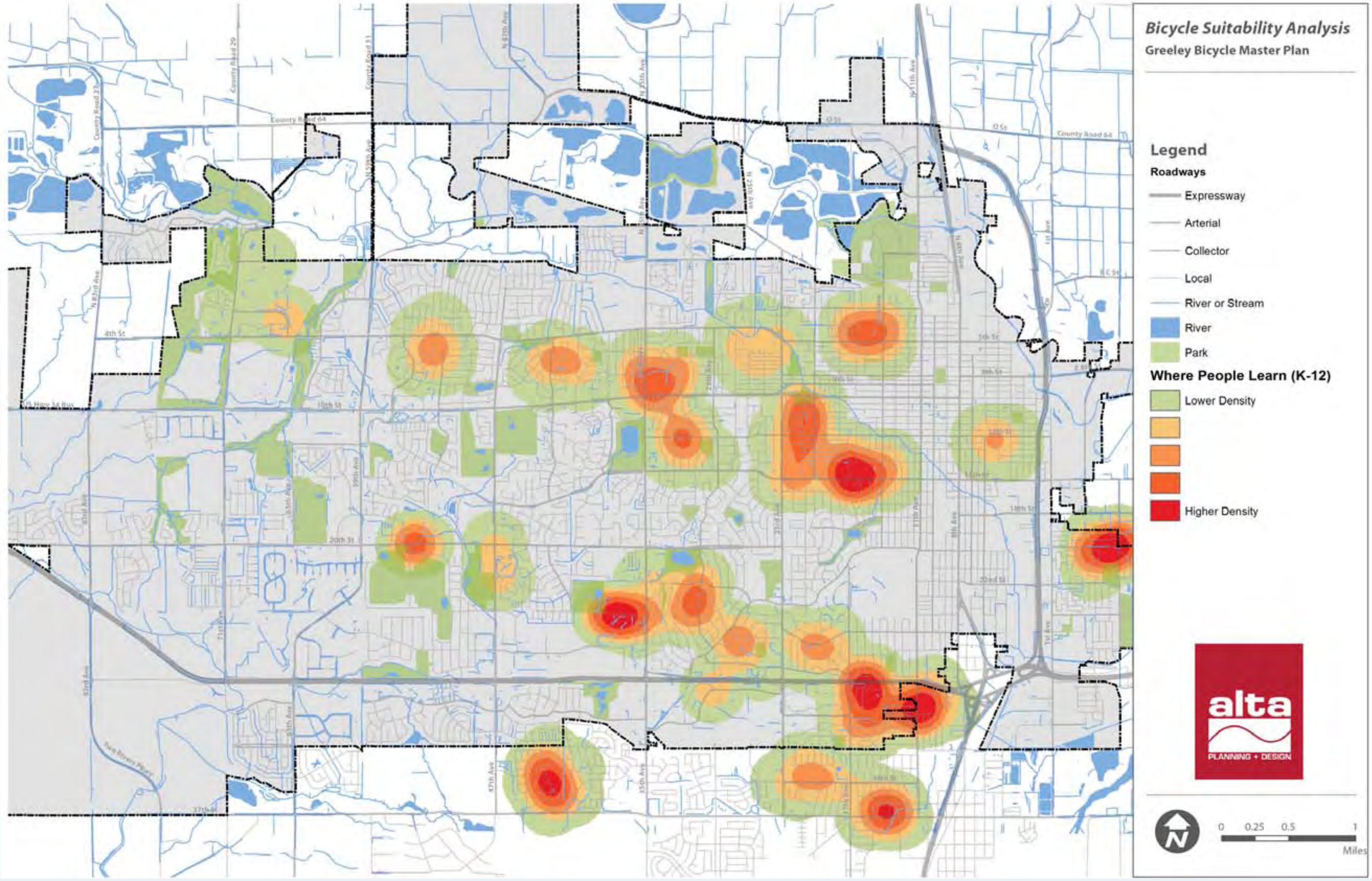

Figure 4: Greeley "Learn - K-12" BDA map

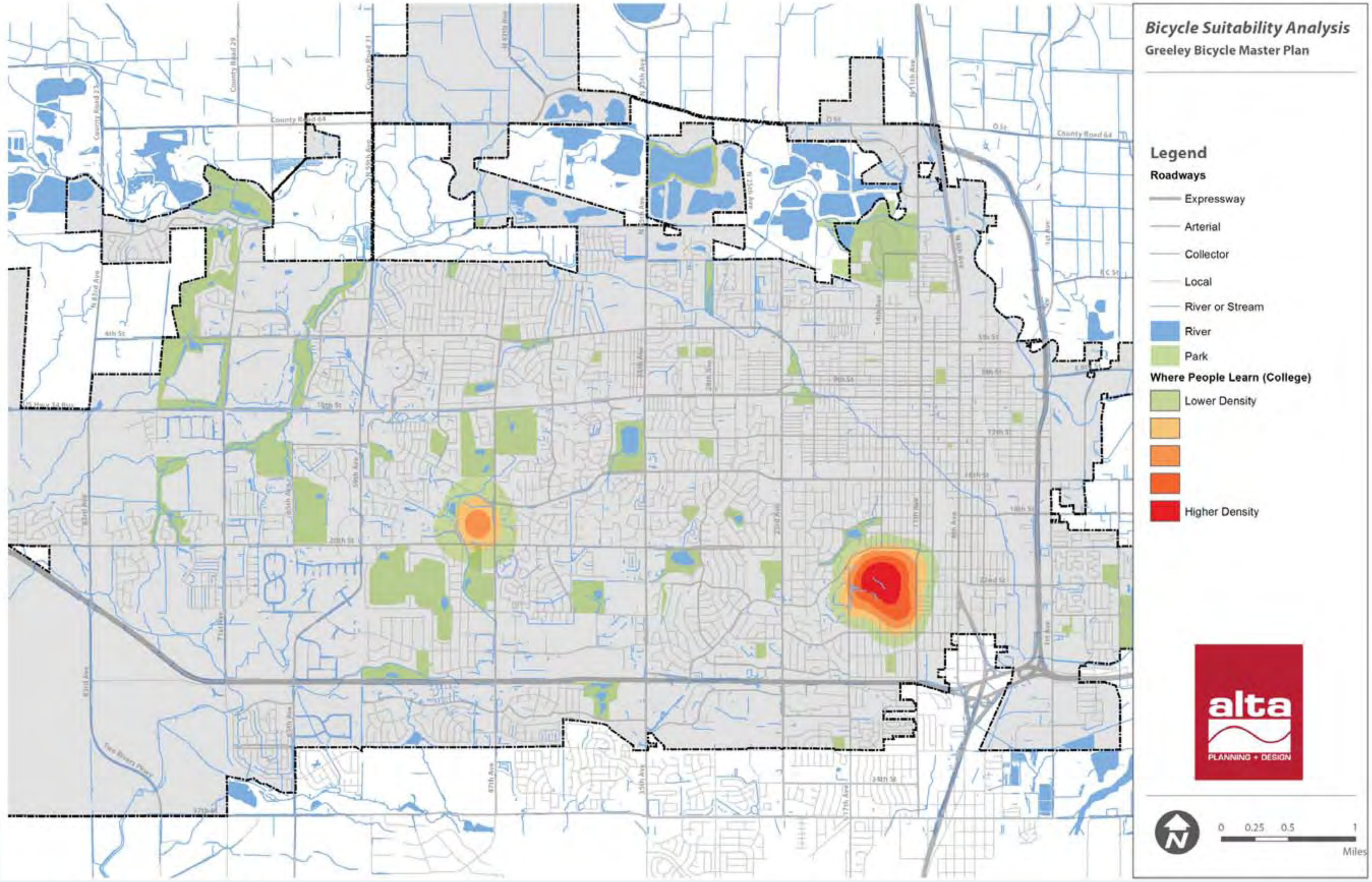

Figure 5: Greeley "Learn - College" BDA map

Where people play is a combination of varied land use types and destinations. Overlays such as retail destinations and parks contribute to this category. Trailheads that are in a Greeley park are included this analysis, but trailheads that are not considered a Greeley park were not analyzed, but are strongly considered in the network recommendations due to public emphasis on trail connections. While all destinations are not exactly where one would expect to "play," these civic amenities are still destinations of importance reflected in this category due to the temporary nature of the visit. "Play" hotspots identified in this analysis include retail along the US 34 corridor, parks and retail along the 10th Street corridor including the area around Walmart and Bittersweet park, and areas in the downtown core including the trail and civic areas around Lincoln Park.

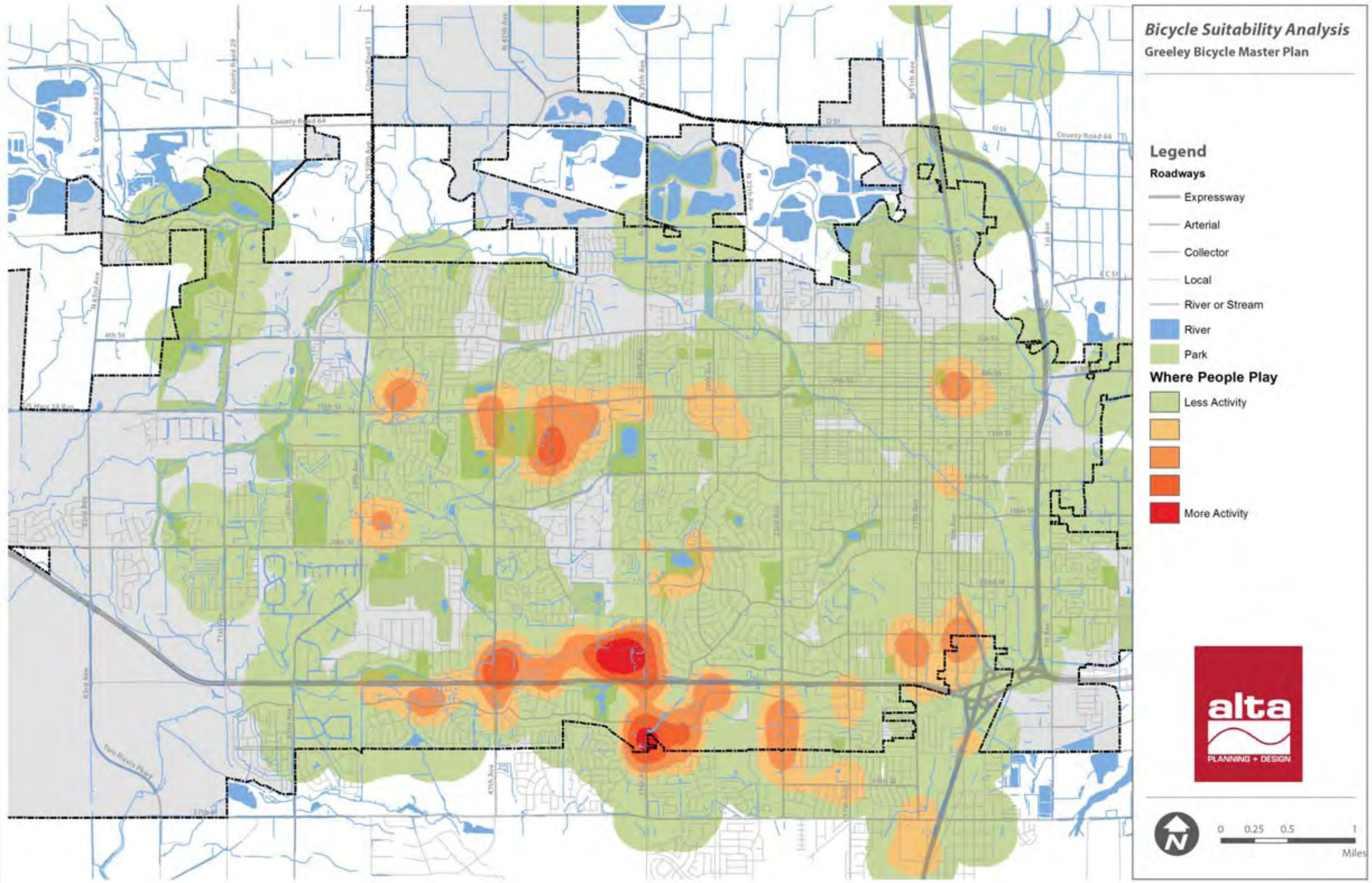

Figure 6: Greeley "Play" BDA map

Where people access transit assessed by location of bus stops. This category accounts for the transit stops within a 1/4 mile of each other. Transit stops with greater observed activity were weighted more heavily utilizing boarding data from Greeley Evans Transit (GET). It is important to understand that, because potential bicycle destinations consider adjacencies and density of destinations (in this case, locations such as bus stops), this analysis considers not only the relative use (boarding data) for each stop, but analyzes each stop's proximity to other stops and other lines, creating hot spots based on both proximity and use. In this case, the downtown core, the Weld County offices, the UNC area, and portions of the US 34 retail corridor as well as smaller areas along 10th Street and to the east of US 85 are identified as "hot spots."

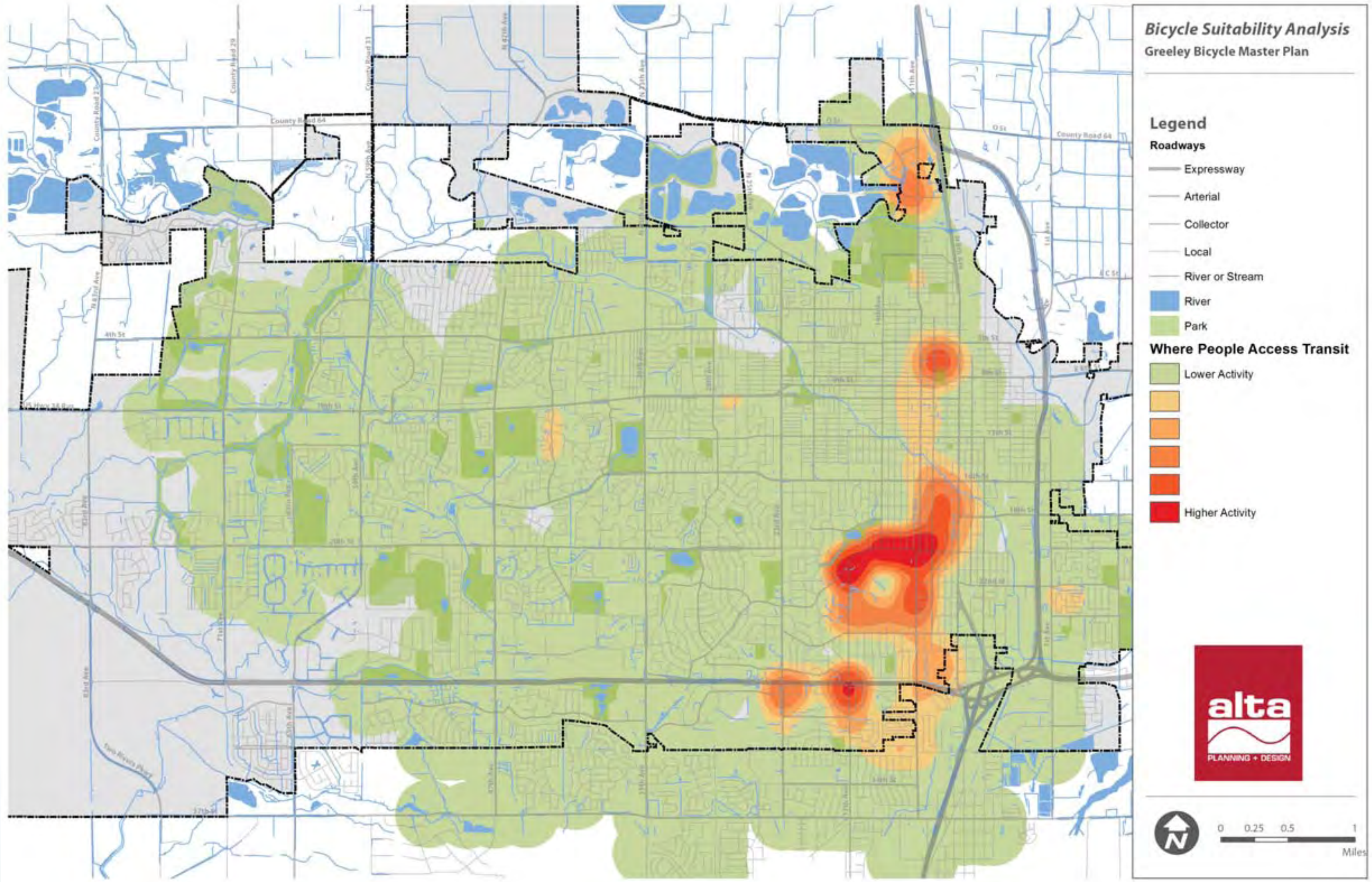

Figure 7: Greeley "Access Transit" BDA map

Composite Demand. Figure 8 shows the composite demand analysis for Greeley, which was developed by overlaying the factor maps and applying standard weights to each factor. This analysis shows that the highest potential for bicycle travel demand are near the UNC Campus, the North Colorado Medical Center, Aims CC, the Weld County offices, neighborhoods east of US 85, downtown, and along major commercial corridors such as US 34 (north and south sides) and 10th Street. See "Bicycle Suitability Index Conclusion" for additional conclusions.

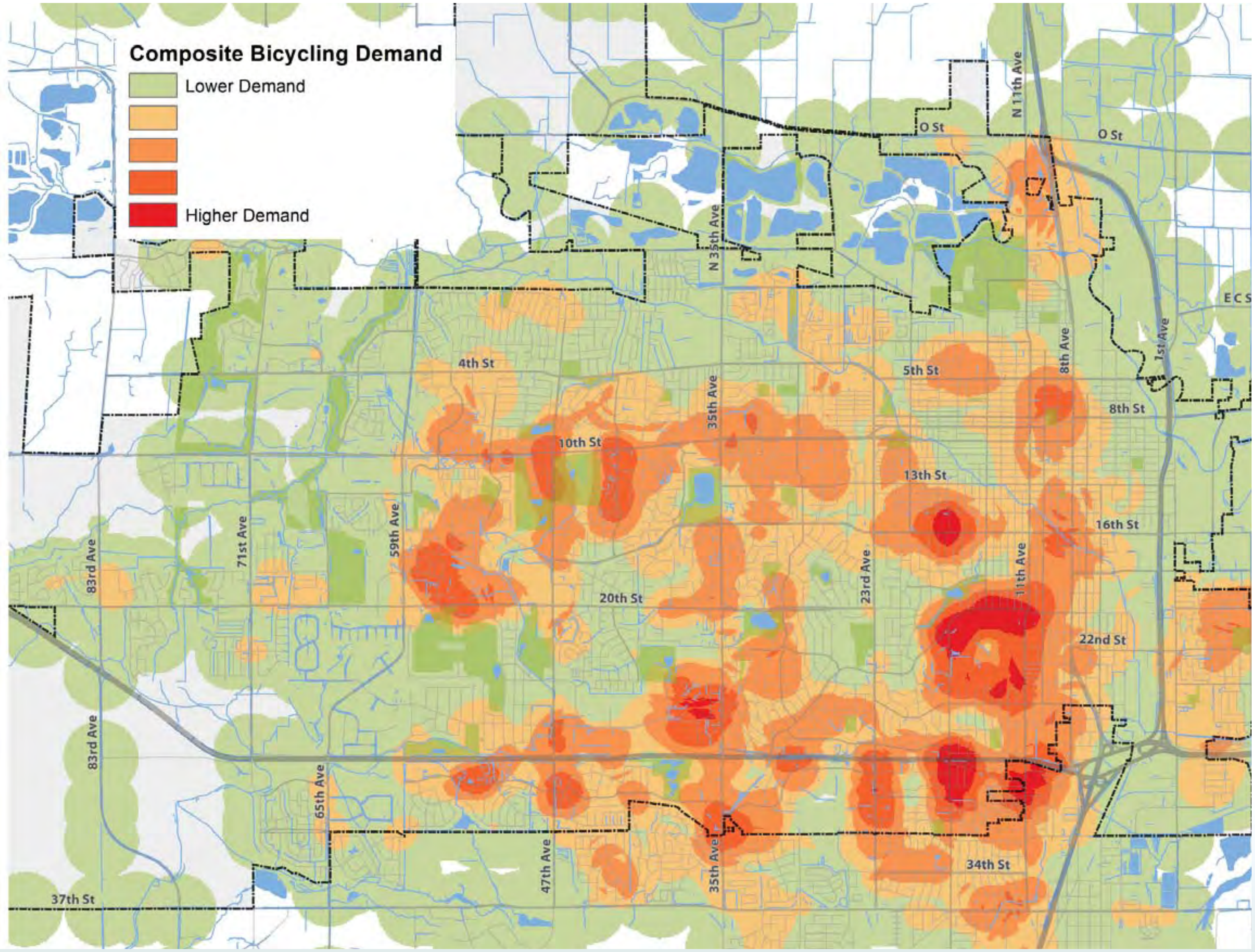

Figure 8: Greeley Composite Demand BDA analysis

Bicycle Conditions - Level of Traffic Stress Analysis

Introduction to Level of Traffic Stress

The methods used for the Level of Traffic Stress Analysis were adapted from the 2012 Mineta Transportation Institute (MTI) Report 11-19: Low-Stress Bicycling and Network Connectivity. The approach outlined uses roadway network data, including posted speed limit, number of travel lanes, and presence and character of bicycle lanes, as a proxy for bicyclist comfort level. Road segments are classified into one of four levels of traffic stress (LTS) based on these factors. The lowest level of traffic stress, LTS 1, is assigned to roads that would be tolerable for most children to ride, and could also be applied to multi-use paths that are separated from motorized traffic (not shown in this analysis); LTS 2 roads are those that could be comfortably ridden by the mainstream adult population; LTS 3 is the level assigned to roads that would be acceptable to current "enthused and confident" cyclists; and LTS 4 is assigned to segments that are only acceptable to "strong and fearless" bicyclists, who will tolerate riding on roadways with higher motorized traffic volumes and speeds. The definitions for each level of traffic stress are shown Table 2.

A bicycle network is likely to attract a large portion of the population if its fundamental attribute is low stress connectivity. In other words, a network should provide direct routes between origins and destinations that do not include links that exceed one's tolerance for traffic stress. The BSI is an objective, data-driven evaluation model which identifies high traffic stress links, bicycle network gaps and gaps between "low stress" links, and a score assessing the relative user comfort or level of stress a user may experience on each link is mapped. Each user is different and will tolerate different levels of stress in their journey so these maps should be used as a general guide rather than an absolute truth.

Table 2: Levels of Traffic Stress Definitions

LTS 1	Presenting little traffic stress and demanding little attention from cyclists, and attractive enough for a relaxing bike ride. Suitable for almost all cyclists, including children trained to safely cross intersections. On links, cyclists are either physically separated from traffic, or are in exclusive bicyclist zone next to a slow traffic stream with no more than one lane per direction, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where cyclists ride alongside a parking lane, they have ample operating space outside the zone into which car doors are opened. Intersections are easy to approach and cross.
LTS 2	Presenting little traffic stress and therefore suitable to most adult cyclists, but demanding more attention than might be expected from children. On links, cyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a well-confined traffic stream with adequate clearance from a parking lane, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where a bike lane lies between a through lane and a right-turn lane, it is configured to give cyclists unambiguous priority where cars cross the bike lane and to keep car speed in the right-turn lane comparable to bicyclist speeds. Crossing are not difficult for most adults.
LTS 3	More traffic stress than LTS 2, yet markedly less than the stress of integrating with multilane traffic, and therefore welcome to man people currently riding bike in American cities. Offering cyclists either an exclusive riding zone (lane) next to moderate-speed traffic or shared lanes on streets that are not multilane and have moderately low speed. Crossings may be longer or across higher-speed roads than allowed by LTS 2, but are still considered acceptably safe to most adult bicyclists.
LTS 4	A level of stress beyond LTS 3
Source: Mineta Transportation Institute Report 11-19	

Bicycle LTS Analysis Results

Segment Analysis

The results of the segment-based LTS are shown in Figure 9. Much of the network consists of disconnected clusters of low-stress (LTS 1 to 2) streets, shown in green and yellow. Individually, these islands of low-stress streets are comfortable to ride for most adults, but they are isolated from one another by larger roads with higher traffic speeds that disrupt bicycle mobility.

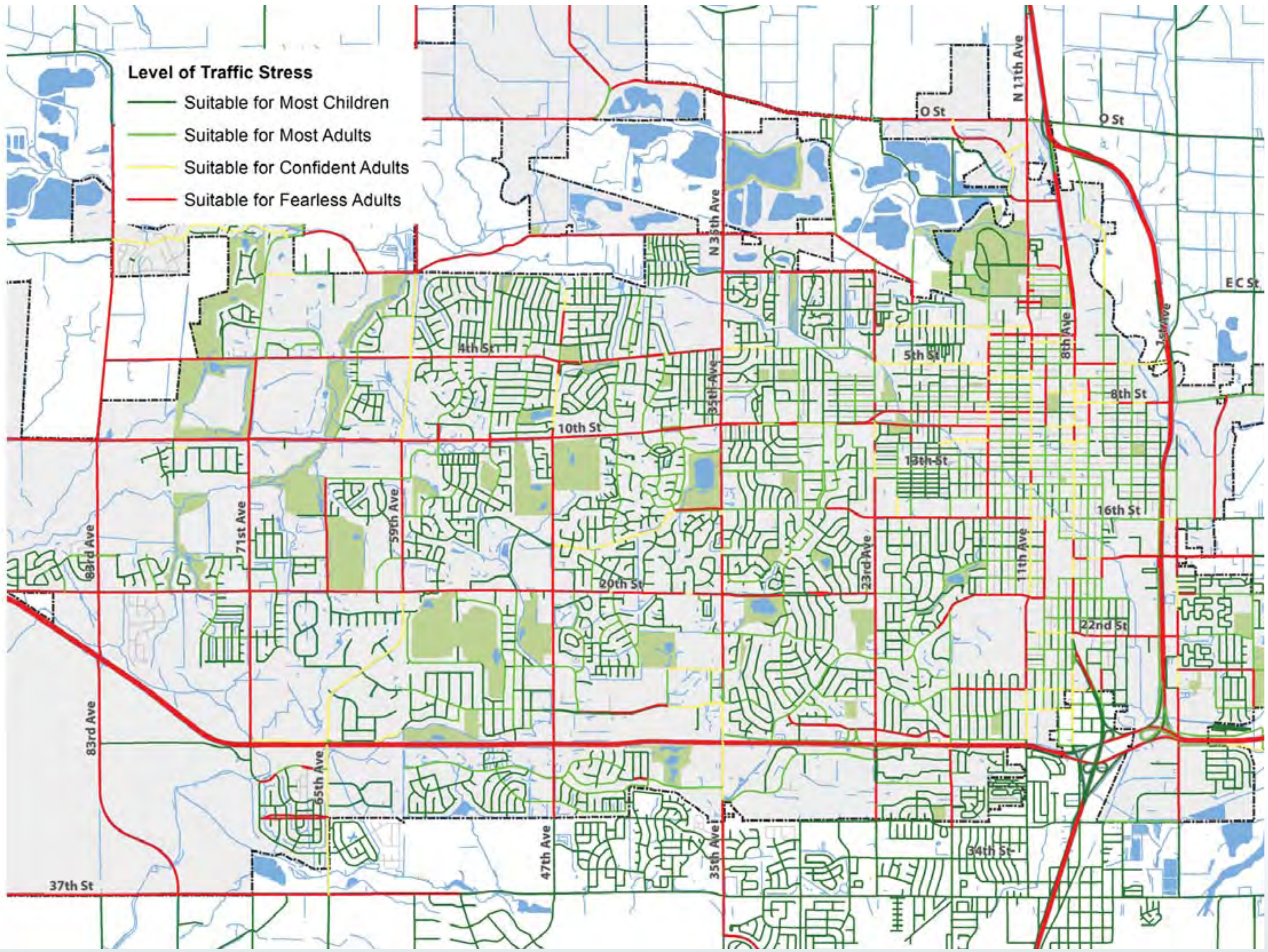

Figure 9: Bicycle Level of Traffic Stress segment analysis results

Connectivity Analysis

While major roadways act as barriers along the roadways and at unsignalized crossings, signals provide a connection for cyclists to move between low-stress neighborhood roadways. Figure 10 displays connected clusters of roadways (shown as one color) that can be travelled without using any link or crossing with a level of stress higher than LTS 2. In downtown Greeley and surrounding neighborhoods where the road network was built in a grid pattern, a large low-stress network is accessible. Outside of this central core, however, low–stress roads have been built without connectivity across major roadways, making travel between neighborhoods inaccessible to most adults. This display makes apparent the gaps in the bicycle network that could be targeted for improvements to create connected bicycling routes that are comfortable for the mainstream adult population. Along with improvements along high-stress corridors, safe crossing opportunities across those corridors will greatly increase bicycling mobility.

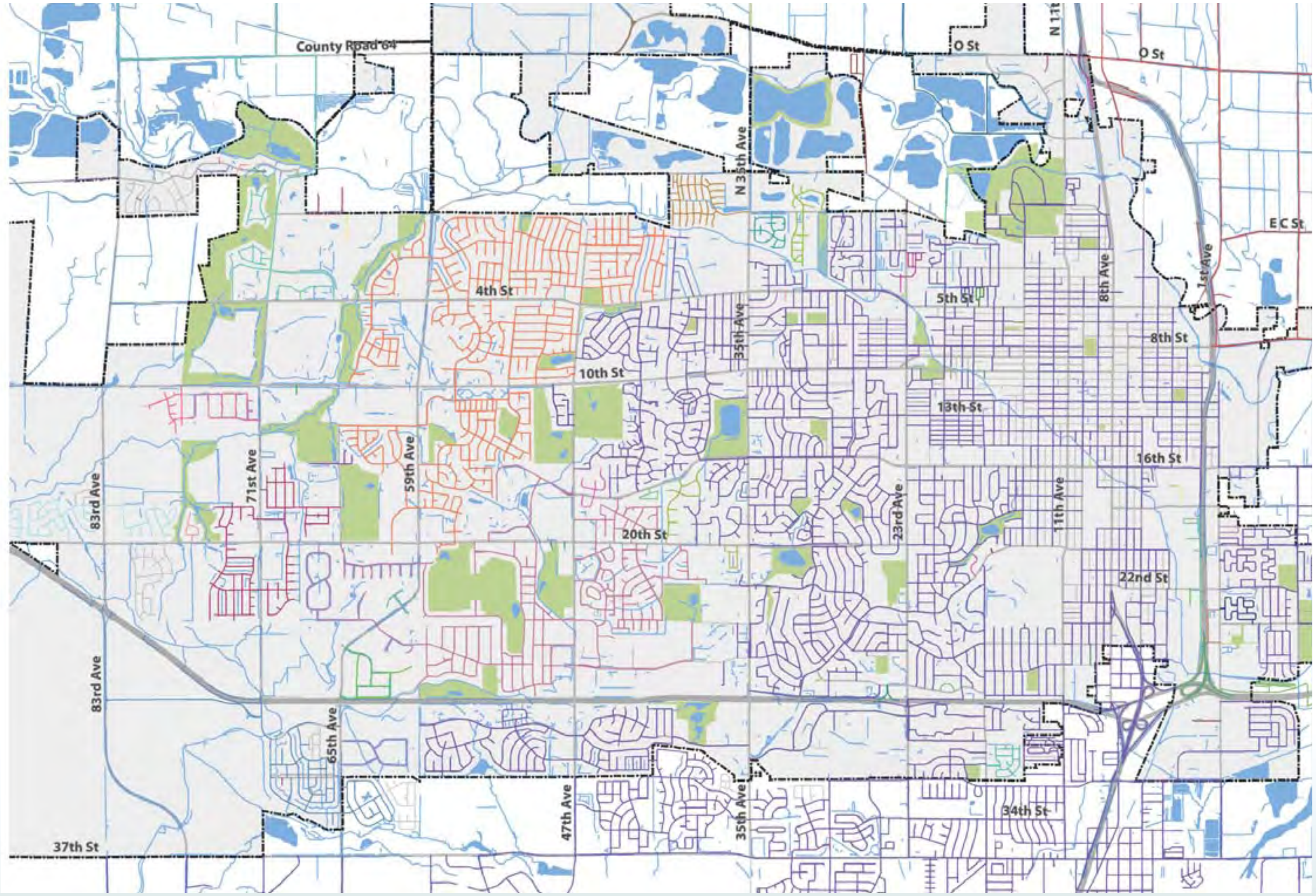

Figure 10: Bicycle Level of Traffic Stress 1 & 2 Connectivity Clusters

Bicycle Suitability Index Conclusions

BSI provided a picture of several phenomena:

1. Geographic variation in demand - potential activity levels at different Census block corners
2. Geographic variation in supply - the quality of the physical pedestrian and bicycle network

Variation in demand and supply are combined into the Composite BSI models. A list of possible bicycle and improvement options includes:

- Areas with high demand for bicycling and high supply of suitable infrastructure can benefit from innovative programs and capital projects that further support bicycling, closure of key gaps, and should be considered showcase areas where best practices can be modeled for the region. These areas provide cost-effective opportunities for improvements and should be high priority for investment.
- Areas with high demand and low supply of suitable infrastructure can benefit from infrastructure improvements to improve bicycling conditions. These areas may require bicycle facilities or intersection improvements to accommodate high level of demand. They should also be high priority for investment.
- Areas with low demand for bicycling and high supply of suitable infrastructure can benefit from programs to encourage bicycling and land use changes or development to increase the density of attractors and generators. These areas should be medium priority for investment.
- Areas with low demand for bicycling and low supply of suitable infrastructure can benefit from basic infrastructure improvements. These areas should be low-priority for investments.

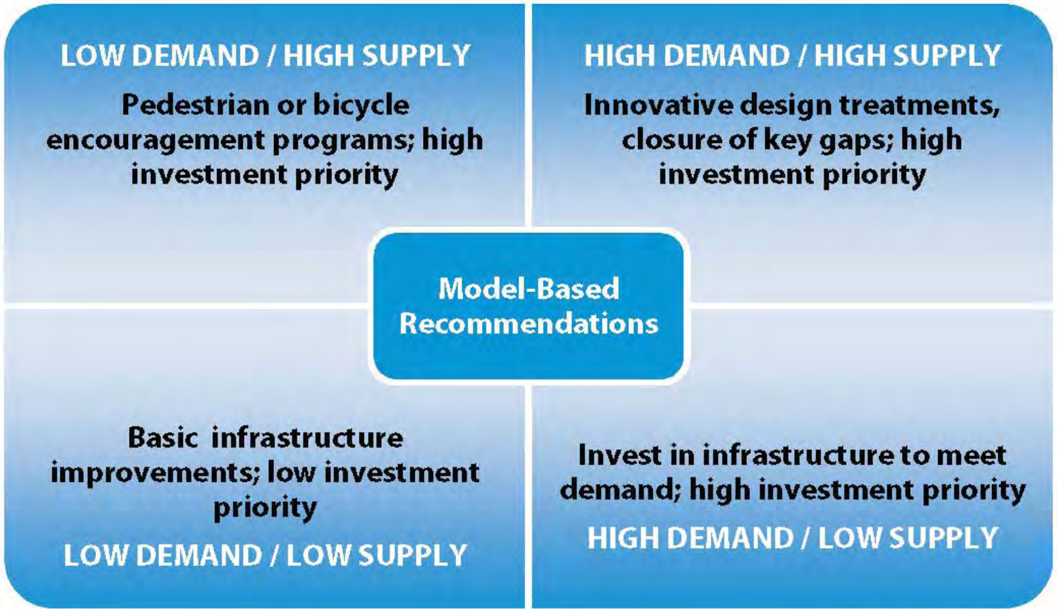

Figure 11: Bicycle Suitability Index Analysis bicycle improvement options

Overall the areas of highest demand for bicycling are centered around the University of Northern Colorado, AIMS College, the 10th Street corridor, the downtown area, and the commercial corridor along US 34. Other areas of Greeley are characterized by more modest potential demand.

Most adult cyclists can circulate comfortably on local and minor collector roadways. Higher order roadways, with speeds exceeding 30 miles per hour, such as the majority of 20th Street or 4th Street, typically act as barriers to bicycling when appropriate bicycle facilities are not provided. Bike lanes decrease the level of traffic stress on many of Greeley's roadways, but enhancing the facilities with bike lane buffers or vertical separation from traffic while also providing a continuous dedicated facility on higher speed or higher volume roadways will further enhance the bicycling experience for all users. Within Greeley, approximately 100 islands of connected facilities exist. Concentrating short term facility construction on gap closure between these islands can significantly increase cycling in Greeley.

Economic and Health Benefits Analysis

Improvements that encourage bicycling can provide a wide range of benefits to a community and its residents. Better bicycling facilities improve safety (as discussed in "Crash Analysis," following) and encourage more people to ride, which in turn improves health, provides a boost to the local economy, creates a cleaner environment, reduces congestion and fuel costs, and contributes to a better quality of life and sense of community. Communities across the country are experiencing the benefits of providing a supportive environment for bicycling. With an improved bicycle network, the City of Greeley can become a stronger, more vibrant community, and take advantage of the many benefits described following.

Improved Health Through Active Living

Regular physical activity is recognized as an important contributor to good health. The Centers for Disease Control and Prevention (CDC) recommend 30 minutes of moderate physical activity each day for adults and 60 minutes each day for children. Unfortunately, many people do not meet these recommendations because they lack environments where they can be physically active. The CDC reports that "physical inactivity causes numerous physical and mental health problems, is responsible for an estimated 200,000 deaths per year, and contributes to the obesity epidemic."[1] These conditions also increase families' medical expenses. Having accessible bicycle facilities available, such as bike lanes and paths, can help people more easily incorporate physical activity into their daily lives. Regular physical activity, such as bicycling, is shown to have numerous health benefits:[2]

- Reduces the risk and severity of heart disease and diabetes
- Reduces the risk of some types of cancer
- Improves mood
- Controls weight
- Reduces the risk of premature death

Increased Property Values

Bicycle facilities such as bike lanes, paths, and trails are popular community amenities that add value to properties nearby. According to a 2002 survey by the National Association of Realtors and the National Association of Homebuilders, homebuyers rank trails as the second-most important community amenity out of 18 choices, above golf courses, ball fields, parks, security, and others.[3] This preference for proximity to trails above the other 18 choices provided is reflected in property values around the country. In the Shepard's Vineyard residential development in Apex, North Carolina, homes along the regional greenway were priced $5,000 higher than other residences in the development – and these homes were still the first to sell.[4] A study of home values along the Little Miami Scenic Trail in Ohio found that single family home values increased by $7.05 for every foot closer a home is to the trail. These higher prices reflect how off-street trails add to the desirability of a community, attracting homebuyers and visitors alike.

Improved Environmental Quality

Greeley is currently a nonattainment area for Ozone, repeatedly exceeding the National Ambient Air Quality Standards (NAAQS). Providing the option of bicycling as an alternative to driving can reduce the volume of car-related emissions, which in turn improves air quality. Cleaner air reduces the risk and complications of asthma, particularly for children, the elderly, and people with heart conditions or respiratory illnesses.[5] Lower automobile traffic volumes also help to reduce neighborhood noise levels and improve local water quality by reducing automobile-related discharges that are washed into local rivers, streams, and lakes. Based on existing bicycle mode shares in the City of Greeley, estimated annual bicycling benefits already include 1,957,941 fewer vehicle miles traveled with 1,592,797 pounds of CO_2 emissions reduced (see detailed analysis in the following sections for more information).

Trails are a key component of any bicycle network and carry environmental benefits as well. Off-street trails in natural corridors help to preserve wildlife habitats and act as buffers against natural hazards, such as flooding. By conserving plant cover, these trails also preserve the natural air filtration processes provided by plants, filtering out harmful pollutants, such as ozone, sulfur dioxide, carbon monoxide, and airborne heavy metal particles. By providing a vegetative buffer along streams, rivers, and other waterways, trails also prevent soil erosion and filter out pollution from agricultural operations and road runoff.

Transportation Benefits

Some Greeley residents do not have access to a vehicle or are unable to drive. According to the University of Michigan's Transportation Research Institute, 15.3 percent of persons age 15 to 39 do not have a driver license, citing car ownership expense and preference for walking or bicycling as primary reasons. Similar trends have been reported in lower income and older segments of the population. Providing a well-connected bicycle network provides those who are unable or unwilling to drive with a safe transportation option. Bicycle improvements can increase access to important destinations for the young, the elderly, low-income families, and others who may be unable to drive or do not have a motor vehicle.

Investing in bicycle facilities can also help to reduce congestion and the pollution, gas costs, wasted time, and stress that comes with it. Each person who makes a trip by bicycle is one less car on the road or in the parking lot. A network of wide shoulders, bike lanes, and paths gives people the option of making a trip by bike, which helps to alleviate congestion for everyone.

Bicycle facilities can also help to substantially reduce transportation costs by providing a way of getting around without a car for some trips. About half of all trips taken by car are three miles or less, equivalent to a 15-minute bike ride.[6] With a safe, convenient bicycle network, some of these shorter trips could be comfortably made by bike, saving money on gas, parking costs, and vehicle wear and tear over time.

Children can also benefit greatly from a safe, well connected bicycle network in their neighborhoods. In recent years, increased traffic and a lack of pedestrian and bicycle facilities have made it less safe for children to travel to school or to a friend's house. In 1969, 48 percent of students walked or biked to school, but by 2001, less than 16 percent of students walked or biked to or from school. By reevaluating and improving the regional bicycle network, children in the City of Greeley could once again safely bike in their communities. Ensuring that children have safe connections to their schools and throughout their neighborhoods can encourage them to spend time outdoors, get the physical activity they need for good health, and offer a higher quality of life.

Transportation and recreation options will be especially important for older Americans in the coming years. According to the Brookings Institution, the number of older Americans is expected to double over the next 25 years. Seniors who find themselves unable to drive or who become uncomfortable with driving will find that their mobility is severely limited if another transportation option isn't available. Trails and other bicycle facilities will provide seniors with a place to take a low-intensity bike ride or a stroll around the neighborhood, or a way to get to nearby shops and services.

1. U.S. Department of Health and Human Services. Centers for Disease Control and Prevention. (1996). Physical Activity and Health: A Report of the Surgeon General.
2. National Prevention Council. (2011). National Prevention Strategy: America's plan for better health and wellness. Retrieved from http://www.healthcare.gov/.prevention/nphpphc/strategy/report.pdf.
3. National Association of Homebuilders. (2008). www.nahb.com.
4. Rails to Trails Conservancy. (2005). Economic Benefits of Trails and Greenways.
5. Health Effects Institute (2010). Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. Special Report 17.
6. U.S. Department of Transportation and Federal Highway Administration. (2009). National Household Travel Survey.

Direct Benefits to Businesses

In addition to potential for higher worker productivity, reduced health costs, and an improved quality of job applicants and employee pool due to increased desirability of living in Greeley, numerous studies have been completed that show direct benefits to businesses in bicycle friendly communities and along corridors with improved bicycle facilities. In Fort Worth, Texas, there was a 163% increase in retail sales over two years after a bicycle lane and improved bike parking were installed in the Near Southside Community (Fort Worth South, Inc., 2011, 2009). The University of Minnesota conducted a study that estimated that, in the Twin Cities, customers using the bicycle share system alone spent an additional $150,000 at adjacent restaurants and businesses in one season (Wang et al., 2012). Although the majority of the research data available currently is in mid-to large-sized cities, many small- to mid-sized communities are beginning the difficult task of tracking direct benefits improved bicycle (and walking) facilities and culture have on businesses. Greeley can contribute information to this national trend and compare itself to other communities as this plan is implemented through sales tax tracking and "Report Card" measurements (see recommendations section).

Estimating Economic and Health Benefits In Greeley

Introduction

Bicycling is gaining new interest from communities across the United States after decades of neglect in which a one-size-fits-all approach to roadway design focused on motor vehicle transportation. With low levels of funding and comparatively low mode share, bicycling faces an uphill battle to prove its utility as a viable, efficient mode of transportation. Many of bicycling's greatest strengths – such as improving community health through physical activity – are not accounted for when evaluating transportation projects. Quantifying these factors demonstrates the importance of bicycling transportation and helps compare benefits with costs.

The benefits created by bicycling are directly linked to levels of use or activity. For each mile traveled by bicycling instead of driving, about one pound of greenhouse gas emissions is prevented, a few less cents are spent on gas, and a person gets a few minutes closer to reaching their recommended healthy levels of physical activity. People who bike to work – which, according to 2010-2012 American Community Survey (ACS) data, is roughly 700 employees in Greeley every weekday – free up road area and parking spaces that are shared among the remainder of the population who drive and carpool.

When bicycling rates increase, these associated benefits add up to create healthier and more affordable communities. Because bicycling is used for recreation and transportation, it plays a role in a person's set of daily behaviors. Bicycling regularly for transportation and recreation keeps a person physically active on a regular basis not only through daily commuting, but also through non-work trips such as trips to school, social visits, or trips to the grocery store.

To calculate the current benefits of bicycling in Greeley, the first step is to estimate existing levels of use.

Estimating Bicycle Activity

A number of tools for measuring bicycling activity exist; however, each individually falls short of establishing a complete picture of current activity. The following section describes the strengths and weaknesses of the most commonly used tools, and presents a methodology for estimating activity across the City of Greeley.

User Counts

User counts, typically conducted at points throughout the roadway network during peak travel hours, capture levels of bicycling activity on streets or paths during a short period of time. While user counts can be instructive in comparing relative levels of use between one street and another or between timeframes on the same facility, they do not fully capture the spectrum of bicycling activity happening across the community over the length of the year. Counts are well suited to studying where people bike, but do not provide answers to other important questions, such as:

- What destinations are people bicycling to, and where are they coming from?
- How far are they traveling?
- What is the purpose of their trip?
- How often do they make similar bicycling trips?
- How often do they make other kinds of bicycling trips?
- Do other residents also make similar types of trips by bicycling, or do they typically travel by another mode?

Therefore, while user counts are a good tool for measuring bicycling at a certain location, user surveys are needed to estimate the overall role of bicycling in the transportation patterns of residents across the region.

User Surveys

Transportation user surveys often ask respondents about their perceptions – e.g., their feeling of safety on a street – and about their usual travel behavior. The American Community Survey (ACS), an ongoing survey conducted by the US Census Bureau, collects social, economic and demographic information from respondents, and includes a question on respondents' commute to work. Sampling over 250,000 households per month, the ACS is the largest survey that asks Americans about their transportation habits, and the most widely available source of bicycling data in communities. According to the 2010-2012 ACS,[7] 1.6% of workers in Greeley bicycle to work (represents the 3-year percentage reported by ACS; 5-year percentage is 1.8%). This percentage is known as commute mode share; the percentage of a community's population making their journey to work by a certain mode of transportation compared to all modes. (See Table 10 for other reported commute mode shares in the region.)

Although commute mode share data is able to capture wider information about bicycling than user counts alone, work commutes are just one type of trip. Greeley residents make many other types of trips (to school, college, go shopping, etc.) by a variety of modes. Detailed household travel surveys can provide more information on travel patterns and help measure the full spectrum of bicycling trips happening in the community.

Household Travel Surveys

Household travel surveys are usually conducted by phone, where an operator interviews each respondent using a detailed script to record a travel diary. To complete a travel diary, respondents are asked to recall all of their trips during a recent period of time, usually the last 24 hours or the previous full day. Detailed information is collected on the qualities of each trip, including the trip purpose, time of day, duration, length, mode, and other factors. By collecting this data from a large sample of people across the population, household travel surveys can provide information on where, why, and how far people are bicycling for transportation. Though a recent household travel survey for the Greeley is not available, national data from the 2009 National Household Travel Survey (NHTS 2009) can be used to estimate the number of other types of bicycling trips being made in addition to work trips.

Estimating Overall Activity

Employed Workers and Adults

Overall adult bicycling activity can be estimated by combining available local data such as ACS commute mode share with national trip purpose information from NHTS 2009. On average, 1.6 utilitarian bicycle trips are made for every bicycle-to-work trip in the United States. An additional 4.8 social/recreational bicycling trips are made for each walking or bicycling commute trip, respectively (see Figure 12). Assuming

7. The Census Bureau recommends using 3-Year sample data sets for increased reliability of estimates over 1-Year samples. This report references 2010-2012 3-Year ACS data unless otherwise noted.

travel behavior in Greeley is similar to these national averages shows how bicycling trips can add up beyond just commute trips, and provide a significant portion of the physical activity necessary to meet the health needs of the community.

College Students

Student commute trips to school and college are estimated independently of ACS data, because the populations making those trips are substantially different from the employed workforce surveyed by ACS. National data on college trip mode share from NHTS 2009 was used to represent trips to local colleges and universities like the University of Northern Colorado.

School Children

National baseline K-8 school trip data from Safe Routes to School (SRTS) was used to estimate mode share for K-12 school trips such as those in District 6. For each type of trip, average trip distance was applied to estimate the total distance traveled by bicycling. National average trip distance multipliers are sourced from NHTS and SRTS, ranging from 0.36 miles for the K-12 walk to school to 3.54 miles per adult bike commute trip. Although Greeley-specific school commute mode share data is not currently available, a survey gathering mode share and trip distance information would provide a baseline for future comparison.

Figure 12: Ratio of Bicycle-to-Work Trips to Other Bicycling Trips (Source: NHTS 2009)

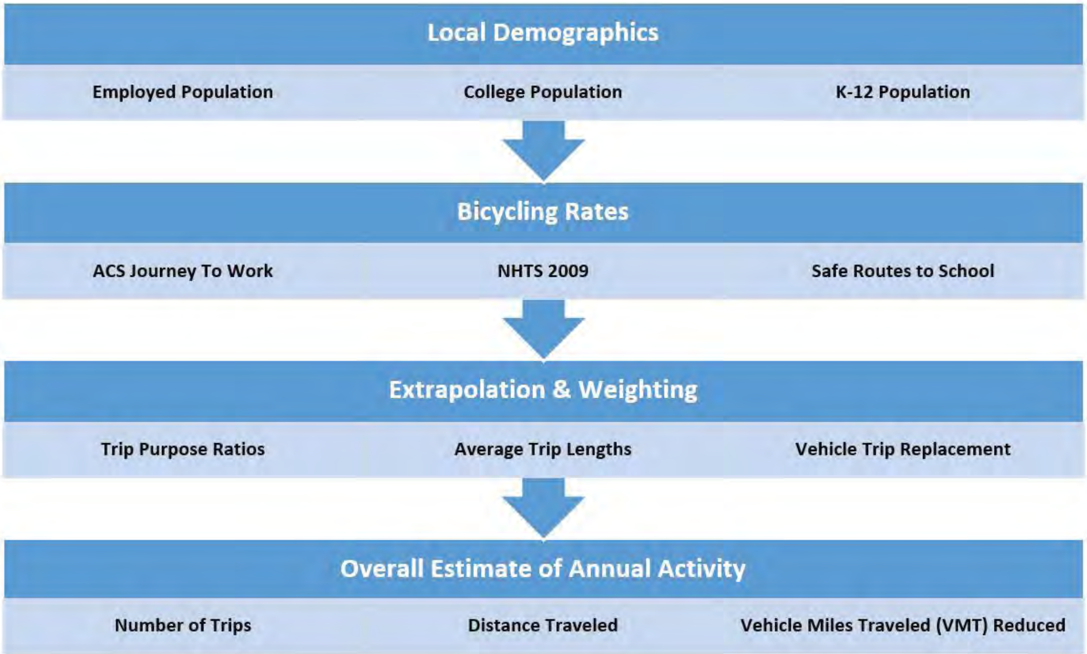

Figure 13: Greeley existing walking and bicycling overall activity estimate methodology

Table 3: Bicycling Activity Estimation References - Trip Purpose Multipliers

OVERALL BIKE ACTIVITY EXTRAPOLATION - TRIP PURPOSE MULTIPLIERS		
Factor	**Value**	**Source/Note**
Commute Trip Mode Share		
Bike:	0.42%	ACS 2010-12
College Trip Mode Share		
Bike:	1.67%	NHTS 2009[8]
School Trip Mode Share (K-12)		
Bike:	1.00%	SRTS Baseline, 2010[9]
Utilitarian Trip Multiplier		
Bike:	1.61	NHTS 2009 (average number of utilitarian trips per commute trip)
Social/Recreational Trip Multiplier		
Bike:	4.77	NHTS 2009 (average number of soc./rec. trips per commute trip)

Table 4: Bicycling Activity Estimation References - Trip Distance Multipliers

OVERALL BIKE ACTIVITY EXTRAPOLATION - TRIP DISTANCE MULTIPLIERS		
Factor	**Value**	**Source/Note**
Commute Trip Distance (miles)		
Bike:	3.54	NHTS 2009
College Trip Distance (miles)		
Bike:	2.09	NHTS 2009
School Trip Distance (K-12)		
Bike:	0.77	SRTS Baseline, 2010
Utilitarian Trip Distance (miles)		
Bike:	1.89	NHTS 2009
Social/Recreational Trip Distance (miles)		
Bike:	2.20	NHTS 2009

Table 5: Bicycling Activity Estimation References - Annual Multipliers

OVERALL BIKE ACTIVITY EXTRAPOLATION - ANNUAL MULTIPLIERS		
Factor	**Value**	**Source/Note**
Annual Work Days	251	261 Weekdays - 10 Federal holidays
Annual College Class Days	150	Assumes two 15-week semesters/three 10-week quarters
Annual K-12 School Days	160	Colorado state minimum[10]

Bicycling and Walking Activity Estimate References and Methodology

Figure 13 provides a visual depiction of the steps used to translate local and national transportation data into an annual estimate of bicycling activity currently happening in Greeley.

The scale of health benefits created by bicycling are based on the number of people using bicycling for transportation, the rate at which they bike, and the distance they travel using active transportation. By multiplying estimates of overall bicycling trips with average trip distances and normal travel speeds, these data can be used to estimate quantities of physical activity generated by current transportation behaviors in the community at large.

8. 2009 National Household Travel Survey (http://nhts.ornl.gov/det/Extraction3.aspx).
9. Safe Routes to School Travel Data: A Look at Baseline Results. National Center for Safe Routes to School, 2010 (http://www.sacog.org/complete-streets/toolkit/files/docs/NCSRTS_SRTS%20Travel%20Data.pdf).
10. Number of Instructional Days/Hours in the School Year, Education Commission of the States, 2013 Update (http://www.ecs.org/html/Document.asp?chouseid=10668).

Physical Activity Benefits of Active Transportation

Current levels of bicycling in Greeley – 1.6% of commute trips - are higher than the national average of 0.57%. It is clear that bicycling activity in Greeley returns significant benefits to the region. By bicycling for transportation, Greeley residents can incorporate meaningful physical activity into their daily schedule. Exercise from bicycling transportation typically falls under moderate intensity physical activity (see Figure 14).

For many Greeley residents, meeting the CDC's recommended minimum guideline of 150 minutes of moderate intensity physical activity per week could be as simple as commuting or making daily errands by bicycle[11]. A bicycle commute of 2.5 miles each way, five times per week, is sufficient to meet the CDC's recommended guideline.

Moderate Intensity

- Walking briskly (3 miles per hour or faster, but not race-walking)
- Water aerobics
- Bicycling slower than 10 miles per hour
- Tennis (doubles)
- Ballroom dancing
- General gardening

Vigorous Intensity

- Race walking, jogging, or running
- Swimming laps
- Tennis (singles)
- Aerobic dancing
- Bicycling 10 miles per hour or faster
- Jumping rope
- Heavy gardening (continuous digging or hoeing)
- Hiking uphill or with a heavy backpack

Figure 14: Examples of moderate and vigorous physical activity (Source: CDC[12])

Table 6: Example Physical Activity Benefits from Daily Active Transportation

EXAMPLE PHYSICAL ACTIVITY FROM ACTIVE TRANSPORTATION			
Active transportation mode	**Commute Distance (miles, round trip)**	**Assumed Speed**	**Weekly Minutes of Exercise (assumes 5 day work week)**
Walking	1.5	3 mph	150
Bicycling	5.0	10 mph	150
CDC recommended weekly physical activity (minutes)			**150**

Table 7: Greeley Estimated Annual Activity Transportation Trips

GREELEY ESTIMATED PHYSICAL ACTIVITY BENEFITS OF ACTIVE TRANSPORTATION	
Trip Type	**Number of Trips**
Commute bicycling trips	332,324
Utilitarian bicycling trips	535,411
K-12 school bicycling trips	53,322
College commute bicycling trips	55,610
Social/recreational bicycling trips	1,584,512
Estimated annual bicycling transportation trips	**2,561,179**

Table 8: Greeley Active Transportation Physical Activity Benefits - Distance Traveled

GREELEY ESTIMATED PHYSICAL ACTIVITY BENEFITS OF BICYCLING		
Estimated annual miles biked	**Average Distance (miles)**	**Total Annual Distance (miles)**
Commute bicycling trips	3.54	1,176,427
Utilitarian bicycling trips	1.89	1,013,709
K-12 school bicycling trips	0.77	40,949
College commute bicycling trips	2.09	116,048
Social/recreational bicycling trips	2.20	3,484,719
Estimated annual miles traveled by bicycle		**5,831,853**

Table 9: Greeley Active Transportation Physical Activity Benefits - Hours of Activity

GREELEY ESTIMATED PHYSICAL ACTIVITY BENEFITS OF ACTIVE TRANSPORTATION			
	Distance Traveled (miles)	**Assumed Speed**	**Total Hours of Exercise**
Bicycling Trips	**5,831,853**	**10 mph**	**583,185**

Current levels of bicycle transportation (and walking, for comparison) already make a significant contribution to the overall level of physical activity and health of residents in the community. Given the estimates of annual bicycling activity using the methodology described previously, Greeley residents bike nearly 2.6 million trips annually, traveling more than 5.8 million miles. This translates into 600,000 hours of moderate intensity physical activity annual from bicycling (see Table 7, Table 8 and Table 9).

Potential Increased Benefits

Greeley is taking steps to improve the accessibility, safety, and quality of the bicycling environment. The League of American Bicyclists has recognized Greeley as a Bronze Bicycle Friendly Community (BFC) since 2013. The city's improvements to the bicycle network are starting to show results, and further improvements that increase bicycling rates could return greater annual health benefits to the community.

Other cities awarded Bicycle Friendly Community designation can provide a valuable reference point for setting goals and creating a vision for what role bicycling

11. Physical Activity Guidelines for Americans, CDC, 2008 (http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html).
12. Measuring Physical Activity Intensity, CDC (http://www.cdc.gov/physicalactivity/everyone/measuring/).

Table 10: Comparison Bicycling Commute Mode Share Rates

Geography	BFC Level	Population	Employed Population	Bicycle Mode Share
United States	-	306,603,772	139,488,206	0.53%
Greeley, Colorado	Bronze	94,217	41.399	1.60%
Longmont, Colorado	Silver	84,474	42,312	0.96%
Arvada, Colorado	Silver	107,960	53,657	0.68%
Pueblo, Colorado	-	107,364	41,459	0.57%
Grand Junction, Colorado	-	59,586	26,626	2.49%
Fort Collins, Colorado	Platinum	146,235	75,098	6.39%
Boulder, Colorado	Platinum	100,403	53,247	10.52%

Table 11: Potential Physical Activity Benefits of Increased Bicycling in Greeley

GREELEY POTENTIAL ANNUAL BICYCLING BENEFITS		
	Current	Goal Bike Mode Share
Bicycle Commute Mode Share	**1.60%**	**5.0%**
Annual bicycling trips	2,561,179	8,003,684
Annual miles bicycled	5,831,853	18,537,041
Annual hours of physical activity	583,185	1,822,453

Note: Estimates reflect conceptual benefits that would be generated at given increases in bicycling as if they exis Greeley* today. *Values are rounded for readability and do not reflect future demographic growth or other multipl changes.

could play in local transportation in future. Around the state, 19 other cities, 42 businesses and two universities have achieved Bicycle Friendly status. Bicycle friendly communities have reputations for livability and the quality of their bicycling programs and environment, providing examples for how active transportation can help create healthier, livable communities. Table 10 shows existing bicycling commute rates in Greeley compared to other peer communities and local BFC communities.

Table 11 and Table 12 explore the potential benefits of increased bicycling rates in Greeley if, for reference, the bike mode share were increased to the 5% goal.

The analysis reveals that Greeley is already realizing close to $2.7 million (see Table 12) in community-wide benefits from existing bicycling activity. With incremental increases in mode share for bicycling and walking, those monetary benefits will grow exponentially, equating to a significant return on investment when it comes to bicycling infrastructure, policies, and programs.

Table 12: Potential Air Quality and Economic Benefits of Increased Bicycling in Greeley

GREELEY POTENTIAL ANNUAL ECONOMIC BICYCLING BENEFITS		
	Current	**Goal Bike Mode Share**
Bicycle Commute Mode Share	**1.60%**	**5.0%**
Annual VMT Reduced	1,957,941	6,118,566
Air Quality		
CO2 Emissions Reduced (pounds)	1,592,797	4,977,491
Other Vehicle Emissions Reduced (pounds)	63,540	198,563
Total Vehicle Emissions Costs Reduced	$66,285	$207,141
Social Benefits		
Reduced Traffic Congestion Costs	$137,056	$428,300
Reduced Vehicle Crash Costs	$978,971	$3,059,284
Reduced Road Maintenance Costs	$293,691	$917,784
Individual Benefits		
Household Vehicle Operation Cost Savings	$1,106,237	$3,456,991
Health Care Cost Savings from Physical Activity	$94,838	$296,369
Total Benefits:	**$2,677,077**	**$8,365,866**

Note: Estimates reflect conceptual benefits that would be generated at given increases in bicycle use as if they existed in Greeley* today. *Values are rounded for readability. Values are not discounted and do not reflect future demographic growth, cost changes or other multiplier changes

Crash Analysis

Introduction

Safety is another reason to improve bicycling conditions in Greeley and a primary factor to consider in the development of specific recommendations. Although the incidence of crashes involving bicycles in Greeley may not be high, concern about safety is the primary obstacle to bicycling more frequently in Greeley (see "Survey Results"). A Safe Routes to School (SRTS) survey in 2004 found that 30 percent of parents consider traffic-related danger to be a barrier to allowing their children to walk or bike to school. Improving bicyclist safety can also be accomplished by increasing the number of people who bike. Installation of protected bike lanes in New York City created a 56% reduction in injuries to all street users. In addition, improving bicycling facilities and conditions often improves pedestrian facilities and safety, due to better delineation of space for bicyclists and pedestrians and increased volume and awareness of non-motorized users.

The City of Greeley provided four years of bicycle crash data, between 2010 and 2013. Data from police reports was compiled into a crash database by the City of Greeley's Transportation Services Division. During this time, a total of 122 crashes involving bicycles were reported. Over the same period, there were a total of 8864 vehicular crashes in the city. Bicycles were included in just over one percent of the total crashes.

Due to its central role in residents' choice of whether or not to ride a bicycle and to determine if any specific locations should be reviewed during the recommendations phase for safety improvements, the project team reviewed and analyzed existing crash data necessary to identify potential crash patterns. Following is a description of the available crash data, discussion of patterns within the data, and recommendations based on analysis of this data.

Findings

The project team reviewed the data to find patterns that indicate specific issues or opportunities for improvement. Crashes occurred at 54 different intersections throughout Greeley and did not show concentrations at specific locations. Across the city, there was a 95% increase in reported bicycle related crashes between 2010 and 2011 and then a slight decrease from 2011 to 2012 and 2012 to 2013. There was an average of 30 crashes per year over the four years analyzed. Just over 30% of crashes resulted in an injury. One cycling fatality was reported in 2011. Approximately 80% of the crashes occurred during daylight with dry road conditions, indicating that weather and lighting are generally not contributing factors of bicycle-related crashes.

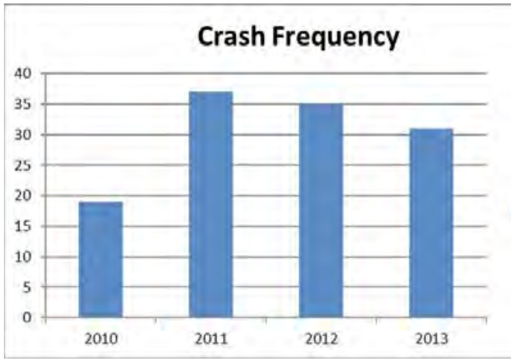

Figure 15: Crash frequency in Greeley by year

Crash Locations

The majority of crashes, 77% or 94 crashes, occurred at intersections or were intersection-related. The location with the highest number of crashes is at the intersection of 20th Street and 23rd Avenue with four total bicycle crashes during the four year period. Nonetheless, crash locations are fairly evenly distributed across the city, with general accumulation of crash locations around the downtown area and the University of Northern Colorado campus. Approximately one third of all crashes occurred within one mile of the downtown area.

There are four types of bike facilities present in Greeley: sidepaths (8 to 10-foot wide shared use sidewalks), shared roadways with a designated shared lane (sharrow), striped bike lanes, and off-street trails. Of the total crashes, 46% occurred

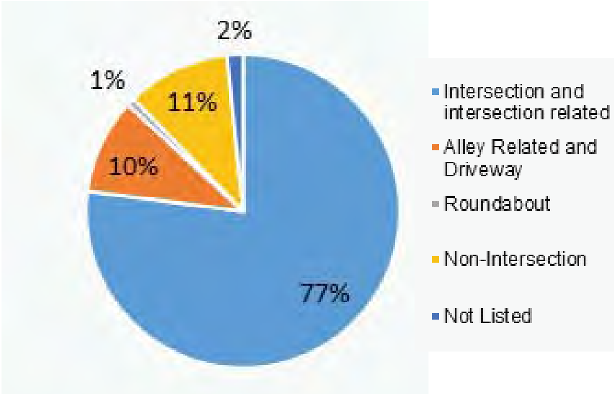

Figure 16: Locations of bicycle-related crashes

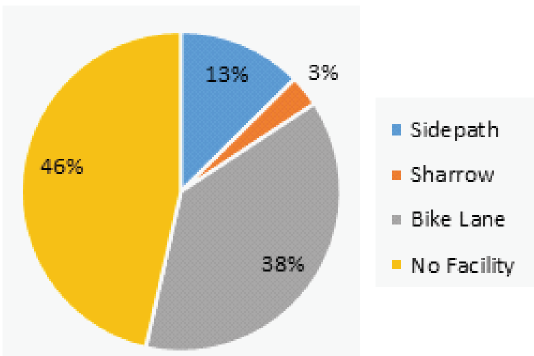

Figure 17: Crash location by bicycle facility type

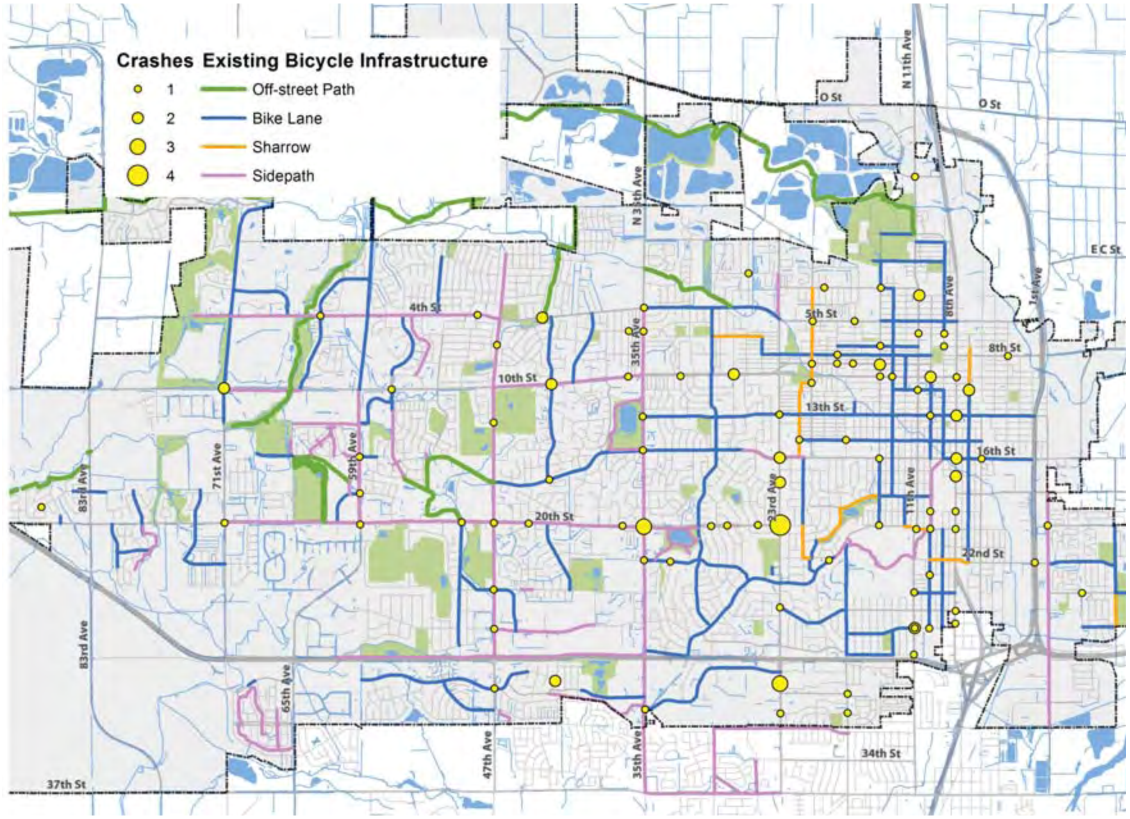

Figure 18: Bicycle crash locations in Greeley

on roads where there was no biking facility present and 38% occurred on roads where a designated bike lane is present. Although the data shows that 13% of crashes occurred where sidepaths are present, it is not clear whether or not crashes occurred on the shared path or on the adjacent roadway. No crashes were reported on off-street trails.

Figure 19: Causes of bicycle-related crashes in Greeley

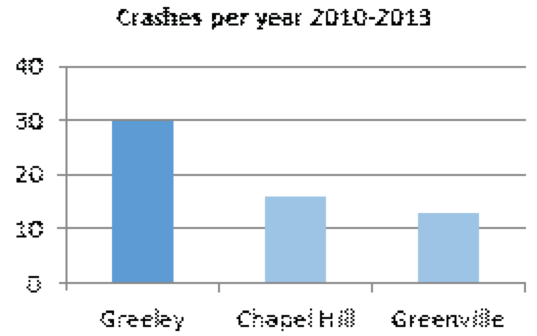

Figure 20: Comparison of crashes per year in select cities

Crash Types

Of the 122 bicycle-related crashes 34% (42 crashes), were caused by failure to yield to right-of-way. Careless driving was the reported cause for 15% of crashes. The most common crash reported was a "right hook" collision, where a motorist passes a cyclist on the left and turns right into the cyclist's path. There were 30 right hook crashes reported. Of the 122 crashes approximately 46%, or 58 crashes, reported the bicycle to be the vehicle at fault. The most common crashes with the bicycle at fault were aggressive/careless riding and failure to yield to right-of-way.

Crash Analysis Comparisons and Conclusions

It is fairly difficult to determine the significance of bicycle crash trends or rates of crashes within because of the lack of historic data and limited information about overall bicycle usage within the city. To develop a basic comparison of bicycle crash rates, bicycle crash rates for Chapel Hill and Greenville, NC were used. These cities were selected for several reasons:

- The North Carolina Department of Transportation offers an on-line bicycle and pedestrian crash data tool that allows users to develop a data query for citywide data available at www.pedbikeinfo.org/pbcat_nc/_bikequery.cfm
- Chapel Hill is similar to Greeley in that it is a college town, with about half the population of Greeley (57,000 compared to 93,000) and a slightly lower population density
- Greenville has a population that is comparable to Greeley (89,000 compared to 93,000) and a similar population density

Comparing bicycle crash rates of these cities with Greeley indicates that Greeley, with 3.0 crashes per 10,000 people, has much higher incidents of bicycle crashes per capita as compared to Greenville (1.4 crashes per 10,000 people), but a similar crash rate to Chapel Hill with 2.8 crashes per 10,000 people.

The high percentage of crashes where the bicycle was at fault in Greeley indicates that some cyclists are not obeying the rules of the road. Enforcement and education programs could potentially reduce the number of crashes. Based on the available crash data, there is a need to increase awareness and education for both motorists and bicyclists. A public education program or campaign is recommended to enhance safety and minimize future crashes. The effects and success of public education should be measured by continued efforts to collect and analyze bicycle crash data.

Crashes predominantly occurred on roadways where there is either no existing bike facility or where there is a designated bike lane. Based on this data alone it is not possible to determine whether crashes are occurring because of increased use or inadequate design or maintenance of those facilities. These data do, however, confirm an assumption that roadways without bike facilities are dangerous for cyclists and implies that additional bike facilities would improve safety for cyclists.

No specific locations were identified to have significantly more bicycle crashes as compared to other crash locations. This indicates that broader, City-wide approaches to improving safety may benefit more bicyclists than site-specific investments. Based upon crash information, location-specific enhancements should also consider existing gaps and demands in the bicycle network as determining factors for system improvement.

Historically bicycle crashes, particularly those that occur with only one person involved, or two bicycles, or even a bicycle and a car that doesn't result in injury are rarely reported. As a result, the primary limitation of crash data is that it studies reported crashes only and does not reflect near-misses, nor does it consistently capture non-injury, or minor-injury crashes. To understand common circumstances of safety issues, crash data should be combined with additional information about existing roadway characteristics including the presence of bike facilities and traffic volume. Additionally, bicycle counts are needed to identify travel patterns and understand the exposure of bicyclists throughout the City. A bicycle count program is recommended to track crash rates based on ridership over time, and better understand the relative risk of bicycle crashes. Comparing bicycle crash data with vehicular traffic volumes, facility types, and public input could be used to determine appropriate locations and solutions for improving safety.

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