# TRANSPORTATION EQUITY IN SAN DIEGO BICYCLE NETWORKS: USING TRAFFIC STRESS LEVELS TO EVALUATE BICYCLE FACILITIES

ALLIE SCRIVENER
B.S. Environmental Policy Analysis and Planning
University of California, Davis, 2010

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## Abstract

Jurisdictions in the San Diego region aim to improve cycling as a viable mode of transportation, and to provide continuous bikeways and increase cycling trips. Provision of bicycle facilities is generally measured by facility type; however, bicycle facilities of the same type are not created equal. Studies show that roadway characteristics such as traffic speed, road size, and type influence bicyclists' traffic stress levels and can affect what types of riders are willing to travel certain routes.

This research uses ArcGIS to map roadway data gathered from the San Diego Regional Data Warehouse, and categorizes road segments into traffic stress levels based on traffic speed, roadway classification, bicycle facility type, and slope steepness. This study also creates an origin-destination matrix which quantifies the relative numbers of locations accessible under each traffic stress network.

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For everyone who has ever ridden, or wished to ride, a bicycle.

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## Introduction

In public policy, we are quickest to address the issues that we have already measured. It makes sense for policymakers to focus on the tasks that lie most clearly before them. What agencies, organizations, and companies produce is often determined by how they quantify their products, projects, and even missions and goals. Therefore, to avoid the risk of veering off-course from what outputs are actually needed and relevant, it matters that the outputs measured by organizations have specific relevance to their constituents (Haas and Fabish, 2013). This research proposes a new performance measure for improving user equitability of bicycle infrastructure.

Jurisdictions in the San Diego region have expressed the importance of providing quality facilities for all transportation users (including cyclists and pedestrians) in their planning documents. The County of San Diego lists provision for the "safe and convenient use of bicycles throughout San Diego County for recreation and as a viable alternative to the automobile as a form of local transportation" and "provide continuous bikeways, affording safe and convenient community-wide accessibility…" as Bicycle Circulation Element Goals in its 2003 Bicycle Master Plan and its 1994 Circulation Element amendment (County of San Diego, 2003). In its 2013 Bicycle Master Plan, the City of San Diego considers cycling to be an environmentally friendly and economical form of transportation accessible to all ages and income levels, as well as a source of recreation for many members of the population. The City also lists cycling as an important source of active transportation, which it considers a critical asset to public health (City of San Diego, 2013).

The San Diego region contains a large network of bicycle infrastructure, which planners continue to expand in efforts to increase ridership. However, survey data collected by the City of San Diego indicates that existing cyclists, as well as would-be recreational and commuting riders, do not consider existing bicycle facilities sufficient for their mobility needs (City of San Diego, 2013). Despite the existence of many miles of bike lanes and segregated bike paths, safety is an on-going concern for those in San Diego who currently bicycle, and a compelling deterrent for those who do not (City of San Diego, 2013). Although the bicycle network in San Diego is large, not all bicycle facilities of the same type are equal. Studies show that factors such as traffic speeds, road widths, slope grades, presence and turnover of on-street parking, obstructions in the

bike lane, pavement quality, and traffic volumes all affect bicyclists' comfort levels and influence the likelihood of a bicyclist traveling a particular route. These factors vary considerably even among facilities of the same type – yet, evaluation of provision of bicycle facilities is generally based on facility type alone. To better quantify what mobility we provide and to increase bicycle ridership, we need to examine bicycle facilities based on the groups that will be using them, such as by applying a metric like traffic stress level, as this research proposes.

Many factors are responsible for user comfort in bicycle facilities. For example, the City of San Diego classifies all bicycle lanes, or lanes painted on roadways to the right of vehicle lanes, as "Class 2" facilities. However, a bike lane along a road on which traffic travels at 50 miles per hour (mph) will create different perceptions of safety for individuals travelling along it from a bike lane alongside a 30-mph road. While some individuals are more tolerant of high traffic speeds than others are, individuals adjacent to 50-mph traffic bear inherently greater risks than do individuals adjacent to 30-mph traffic (AAA Foundation, 2011). This is because the speed differential between a vehicle and a bicyclist or pedestrian affects the risk of injury or death associated with a possible collision; according to the AAA Foundation, the risk of death borne by a pedestrian when struck by a vehicle is 10% when the vehicle is traveling at 23 mph, 25% at 32 mph, 50% at 42 mph, 75% at 50 mph, and 90% at 58 mph. Additionally, faster-moving vehicles pose a shorter time window for a bicyclist to change lanes, respond to obstacles within the roadway, or anticipate oncoming traffic.

Traffic volumes can also vary among different roadways, and can greatly affect bicyclist comfort. A lightly traveled road allows for greater bicycle autonomy and a decreased need for concentration, compared to a road that receives high levels of traffic. Other factors associated with primarily auto-centric roads include traffic behavior, roadway width, number of lanes, number of traffic signals, and road design. Intersections that include, for example, automobile right-hand turn lanes that do not require vehicles to stop, can pose a risk of bicycle-vehicle conflicts if signage and striping do not alert motorists to the possible presence of cyclists. A wide roadway with many lanes, high traffic volumes with fast-moving motorists, and free-flow right turn lanes causing bicyclists to have to merge across lanes and remain alert for traffic from multiple directions are all factors that, individually or together, may cause extra stress and risks for some cyclists.

Even bicycle-specific infrastructure that excludes motor vehicles (such as Class 1 Bicycle Paths) can contain a number of variable factors that can affect the level of stress associated with navigating the roadway. For example, a bicycle-exclusive path, although it excludes the vehicular traffic that can cause discomfort for some cyclists, may have experienced a large amount of wear without proper maintenance. Cracks in pavement, roadway depressions, potholes, and uneven pavement settling can cause bicycle handling difficulty, result in mechanical issues such as flat tires or bicycle damage, and change the riding experience. In some cases these may even cause unexpected single-bicycle accidents. Other factors that can affect user comfort levels include slope grades, lighting, tree coverage, street parking, sidewalk presence, and nearby crime rates.

For these reasons, traffic stress discrepancies often exist among bicycle facilities of the same type. These discrepancies, created by external factors upon bicycle facilities that infrastructure managers classify as equal, cause confusion on both ends. Bicycle infrastructure managers may believe they are providing adequate facilities to maintain mobility for bicycle travel for different members of the population by including bike lanes, paths, and routes. However, individuals' comfort levels may cause them to discriminate between equally-classified facilities in ways that infrastructure managers may not anticipate. On the user end, an individual looking to use an existing bicycle lane may be deterred from future cycling trips after finding that a particular bicycle lane travels alongside traffic moving at speeds greater than 50 mph, or that high-speed right turn lanes interrupt the bicycle lane at every intersection.

This research proposes to quantify San Diego's bicycle facilities by the levels of stress they create in order to provide a clearer picture of which user types are currently served by the bicycle network. This is modeled after a San José study conducted in 2012 which reclassified bicycle facilities by traffic stress level. In the San José study, Mekuria, et. al developed a scale of levels of traffic stress and reclassified San José bicycle facilities to illustrate mobility for each user group. As shown in Table 1, it is relatively simple to divide traffic stress levels into discrete categories. Each category defines a level of traffic stress associated with specific facility properties based on designations established by Mekuria et al. (2012).

**Table 1: Levels of Traffic Stress (LTS)**

| Level of Traffic Stress | Definition |
|---|---|
| 1 | The lowest traffic stress level. Facilities with a level of traffic stress (LTS) of 1 are suitable for all cyclists including children, and do not demand high levels of attention from the cyclist using the facility. Cyclists are either physically separated from traffic, provided with an exclusive travel lane, or share road space with low volumes of vehicles operating at low speeds. Cyclists are given a wide operating space outside vehicular traffic, door zones (the areas into which car doors are opened), and other potential hazards. |
| 2 | Stress level 2 presents little traffic stress, but is still suitable for most riders, except for children who may not be capable of providing adequate attention. LTS 2 facilities may share roadways with motor vehicles, but priority is unambiguously given to the cyclist, traffic levels may be low, and bicycle zones are clearly delineated. |
| 3 | Facilities with stress level 3 generally provide exclusive operating zones to cyclists. Stress levels are less than that from operating within multilane traffic. |
| 4 | Level of stress beyond LTS 3; may include operating within multilane traffic, interacting with potential hazards, or traveling adjacent to high-speed or high levels of traffic. |

*Adapted from Mekuria et. al., "Low Stress Bicycling and Network Connectivity", 2012*

This research proposes to provide a more detailed picture of the bicycle network offered by San Diego and the connectivity available to its different user groups through quantifying San Diego's bicycle facilities by the stress levels associated with them. This detailed bicycle network picture will prove a viable reference for bicycle facility managers and other agencies to better plan for increased mobility among all road users within the region by a quantification of to what extent users are able to use the existing bicycle infrastructure.

This study will provide a detailed bicycle network map identifying classification of the network by user comfort level rather than by facility type, and a matrix that outlines the number of possible routes between particular origins and destinations, for each user comfort level. This information will provide feedback about what mobility options currently exist for each bicycle user group. It will also provide clear direction as to what improvements public agencies can make to the bicycle network to yield the greatest increases in mobility options. Identifying the region's long-term mobility needs, along with its potential easy fixes, can provide great utility to transportation service managers throughout the San Diego region.

The City of San Diego Bicycle Master Plan Update contains bicycle demand analyses, areas of possible locker and rack locations, and proposed bicycle networks. These proposals, if built, would undoubtedly improve bicycling conditions within the city. However, it is important to understand who is currently served by the existing bicycle network, and to improve connectivity for all user groups. The user comfort-based connectivity map will provide insight about potential underserved groups, and provide information about what may be "easy fixes" to improve connectivity. Planners and decision makers throughout the San Diego region should be able to gain insight and identify ways to improve the existing network through this analysis.

Potential stakeholders and interested parties associated with this research include San Diego County; the cities of Carlsbad, Coronado, Chula Vista, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Diego, Santee, San Marcos, Solana Beach, and Vista; the San Diego Association of Governments (SANDAG), the California Department of Transportation (Caltrans), public health agencies and the healthcare industry, people of the San Diego region, cyclists and individuals interested in cycling, families, low income groups, and members of the population who are unable to drive or uninterested in dealing with congestion.

## Literature Review

To reflect the interdisciplinary nature of bicycle infrastructure, this survey of existing literature spans a number of closely linked topics in land use and infrastructure. It examines transportation articles to determine what existing infrastructure quantification has been performed, to what extent land use correlates with travel behavior, and which variables affect individuals cycling on the transportation system.

The San Diego region currently faces long peak-hour delays through traffic congestion, as well as an approximately 42% projected population increase by 2050 (SANDAG, 2010). A study by the Surface Transportation Policy Project (STPP) found that while vehicular congestion exists in many metropolitan areas, its effects on day-to-day life on residents vary significantly based on the viability of other modes of transportation (STPP, 2001). Polling data indicates that 69.3% of San Diegans would be "very likely" to cycle more if provided with more bike lanes on major streets (City of San Diego, 2011). But not all bike lanes are created equal. External factors such as traffic speed, pavement condition, traffic volumes, and even land use, street block size, and road width play a major role in determining ridership for particular areas. With realization spreading across the nation of the need for multi-modal facilities, researchers have been working toward defining critical metrics about bicycle infrastructure and user preference, for the purpose of improving bicycle facilities and increasing bicycle travel.

### Quantification of bicycle infrastructure

Much of the urban development on the west coast has occurred with influence from the automobile (Melosi, n.d.). As a result, transportation planning for the past several decades has focused on decreasing automobile travel times, involving large multilane corridors and arterial streets prioritizing automobile travel, unintentionally at the expense of other modes (Litman, 2014). This mobility and auto-centric emphasis has led to performance measures which further widen the gap between automobiles and other modes of travel, such as vehicle level of service (LOS) measures, lane and road widths, and vehicular travel times (Litman, 2014). With performance measures focused on automobile travel times, traffic management policy has tended toward the widening of lanes, expansion of parking, and general development of vehicle-scale areas – that is, areas in which operating a motor vehicle is given priority.

Litman proposes alternate transportation system performance measures which emphasize transportation system *accessibility* rather than *mobility* – that is, emphasizing the ability of individuals to access needed facilities, rather than the ability of motor vehicles to access the transportation system. Litman points out that the sheer quantity and quality of available data on automobile travel has often led planning trends and decisions to form a bias toward optimizing automobile travel conditions. Some of the recommended changes in performance measurement include measuring delays in pedestrian and bicycle travel (in addition to motor vehicle delays), factoring parking costs when evaluating costs of vehicle ownership, including multi-modal convenience and comfort factors (as opposed to only accounting for automobile convenience and comfort), and measuring crash rates per capita (rather than only per vehicle-mile, which does not account for crashes caused by induced vehicle travel). Use of these performance measures would allow planners to see what changes would maximize the efficiency of the existing transportation system through more quickly and easily transporting a greater number of people rather than vehicles (Litman, 2014).

In keeping with Litman's performance measurement suggestion, this San Diego bicycle study replicates a similar research project conducted in the City of San José, in which Mekuria et al. (2012) classify surface streets and intersections by level of traffic stress presented to bicyclists. The San José study, conducted in May 2012, quantified the connectivity of various stress levels within the city's existing bicycling network using a regional street database with data on speed limits, functional classes, and lane, curb-to-curb, and median widths. It also used a regional traffic signal database, a regional map of bicycle and pedestrian facilities, and field measurements of bicycle lane width. Mekuria et al. ultimately generated a bicycle network map of San José and portions of neighboring cities, showing available bicycle facilities for each level of traffic stress (LTS). These maps helped illustrate available bicycle routes, as well as improvements necessary to improve regional connectivity. Maps showed that without improvements, areas at the lowest levels of traffic stress were isolated from one another, due to the lack of low-stress corridors (Mekuria et al., 2012).

The Mekuria study presents a valuable framework for measuring comfort and accessibility that can be applied to San Diego's infrastructure. Additional sections in the present study will

discuss which elements of the San José study were replicated for this research and which elements differ.

Aside from the San José study, current research quantifying bicycle network efficiency and effectiveness from a user perspective is limited. A study by Landis, et al. (1997) uses bicycle perspectives in real-time to identify important quality of bicycle service factors to develop a bicycle level of service (LOS) formula for assessing infrastructure. According to Landis et al., readily identifiable bicycle LOS would facilitate setting priorities for bicycle facility construction projects, since "the choice between bicycle-facility projects is often made in the absence of an objective supply-side evaluation of the existing roadway facilities". The traditional subjective approach to evaluating road facilities results in either inconsistency or inaccuracy, especially as the same people are not involved in every evaluation (Landis et al., 1997). The study placed participants in actual traffic situations, gathering real-time feedback about user perceptions to inform traffic stress criteria. Researchers then developed a model incorporating traffic volume and speed, traffic mix, potential cross-traffic generation, pavement surface condition, and width of bicycle allowance (Landis et al., 1997). However, according to Mekuria et al. much of this data is not readily available, and the study's calculations generate level of service ratings that come from black box formulas and "have no meaning either to roadway managers or to the general public…" (Mekuria et al., 2012). Because many level of service studies rely on data that is unavailable, it is important to develop a metric that can be used based on data that cities already collect.

In another study, Carter et al. (2007) developed an intersection safety index based on videorecorded bicycle-motorist conflicts and avoidance maneuvers at several intersections in four major U.S. cities. The intersection safety index accounts for traffic volumes and speed limits on both intersection streets, the numbers of lanes, presence of a bicycle lane, presence of on-street parking, the number of right turn lanes, the presence of a traffic signal at the intersection, and the turning behavior of vehicles (Carter et al., 2007). The intersection safety index presents a viable data source for needed improvements; however, the researchers acknowledge that the index is based upon the number of interactions between bicyclists and motor vehicles, and that a high number of interactions is not necessarily unsafe, though they may create a perception of riskiness for bicyclists (Carter et al., 2007). Another study uses roadway

data to create a similar formula for a bicycle comfort index for determining "how compatible a roadway is for allowing efficient operation of both bicycles and motor vehicles" (Harkey et al., 2007).

**Network connectivity and continuity**

Mekuria et al. discuss how low-stress facilities in San José's bicycle network are disjointed due to arterial streets. Their research observes how arterial streets designed for moving automobiles through the city at high speeds interrupts low-stress bicycle corridors, rendering them insufficient as a network for cyclists with lower stress tolerances (Mekuria et al., 2012). Other researchers have identified areas in which bicycle facilities simply dead-end without warning, leaving cyclists stranded (Krizek and Roland, 2005). This study, based in Minneapolis, Minnesota, assesses cyclists' responses to bicycle lane discontinuity (i.e. bicycle lanes becoming displaced at intersections by vehicle right-turn lanes, Class II bicycle lanes ending and becoming Class III facilities, etc). Krizek and Roland identified 30 instances of bicycle facility discontinuity and asked survey respondents to evaluate which dead-end facilities were most in need of correction. Using the data, Krizek and Roland developed a "discontinuity score" model accounting for the type of discontinuity, physical attributes of the roadway, and preferences and characteristics of the cyclist navigating the facility. They concluded that bicycle facility discontinuation on the left side of the street (against motor vehicle traffic), increased crossing distance for intersections, on-street parking adjacent to the discontinued bicycle facility, and increased curb lane width "all contribute to a heightened level of discomfort for the cyclist" (Krizek and Roland, 2005).

**Factors affecting user comfort level**

Several studies have focused on the effects of variables in bicycle networks upon usage levels and user comfort. A variety of research has supported the hypothesis that bicycle-specific facilities enhance the perception of safety in cycling, with wider facilities being most effective. A King County, Washington study conducted by Moudon et al. (2005) using cycling behavior data and parcel-level GIS land use designations found that specific features of the built environment, namely proximity to trails and bike lanes, and "presence of agglomerations of offices, clinics/hospitals, and fast food restaurants, measured objectively, are significant

environmental variables" in determining of the likelihood of cycling. This study suggests that the type of land use and type of facility contribute to the comfort as well as convenience of cycling for transportation (Moudon et al., 2005). Parker et al. found an increase in cycling in a diverse New Orleans neighborhood after the addition of bicycle lanes along two adjacent streets. The study measured bicycle ridership before and after the lane restriping, taking ridership counts on the adjacent streets restriped to include bicycle lanes, as well as the other adjacent streets in the area, to distinguish between changes in rider behavior and new ridership (Parker, 2013). That ridership increased with addition of bicycle lane striping further confirms the importance of infrastructure to road users, especially bicyclists.

In fact, lane width, motor vehicle speed, visibility at intersections, presence of intersections, and street shading (through tree cover) were deemed the most important roadway attributes in determining roadway suitability for cycling among survey respondents in medium-sized cities in urban Brazil (Providelo and Sanches, 2011). These attributes were ranked highest in importance by survey respondents, from a pool of fourteen attributes gathered through focus group studies. The remaining attributes available for survey selection, identified by focus group participants, were: motor vehicle volume, signalization at intersections, presence of heavy vehicles, direction of traffic flow, pavement condition, driveways and side-streets, on-street vehicle parking, roundabouts, and grades (slope steepness) (Providelo and Sanches, 2011). In another stated preference survey, Sener et al. (2009) found that individuals were willing to pay, in terms of extra time spent commuting, to avoid a high number of stop signs, red lights, and on-street parking. With the presence of on-street parking, individuals were interested in avoiding high-turnover parking, parallel parking, and areas with long stretches of on-street parking adjacent to bicycle facilities (Sener et al., 2009). It is important to note the results that consistently stood out in importance among the rest; these attributes can be more heavily focused on from a planning perspective to improve built environments for bicycle use.

Tilahun et al. also developed an adaptive stated preference survey to rank bicycle facilities, using video simulations of various roadway conditions to determine the value, in terms of additional time spent commuting, participants assigned to various bicycle facility features. The study found bike lane improvement to be the most important feature participants would pay additional commuting time to obtain, ranked above parking elimination or off-road improvements alone

(Tilahun, 2006). In another analysis of 35 U.S. cities, Dill et al. found that "higher levels of bicycle infrastructure are positively and significantly correlated with higher rates of bicycle commuting" (Dill et al., 2003). These studies imply that infrastructural improvements have a high potential to enable large gains in ridership.

Finally, in a report from the Portland Office of Transportation, Roger Geller points out that "no person should have to be 'brave' to ride a bicycle". In discussing user preferences, he identifies four distinct cyclist types ("strong and fearless", or those who would be cycling even if no improvements were made; "enthused and confident", or those made interested by Portland's efforts to improve cycling in the city; "interested but concerned", or those interested in cycling for recreation or transportation but concerned about safety; and "no way no how", or those disinterested in cycling regardless of potential facility improvements), which this study uses for reference in its traffic stress level analysis (Geller, n.d.). Geller points out that the need for improvement is evidenced by numbers: the "interested but concerned" group typically makes up the largest portion of most urban populations in the United States (Geller, n.d.).

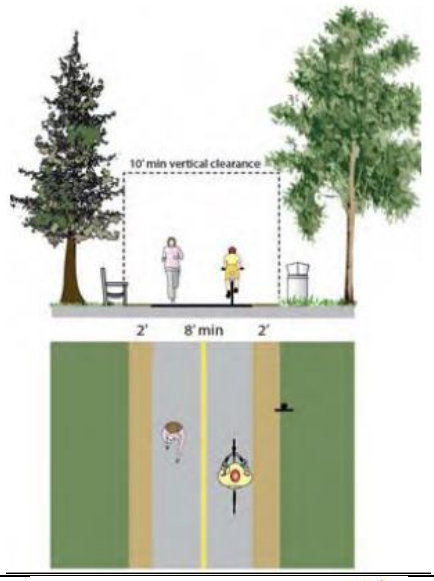
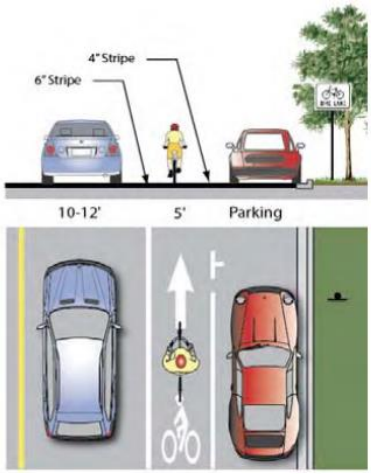
**Policy and Planning**

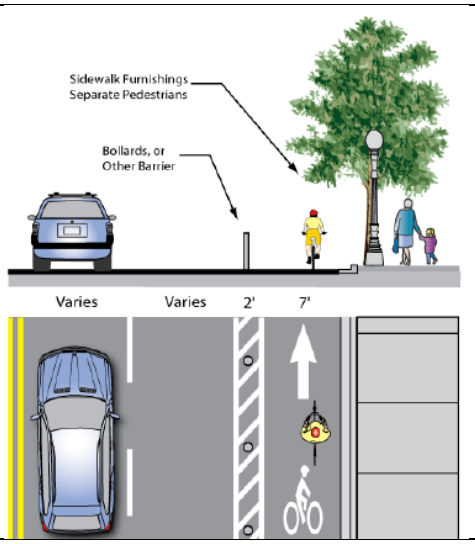
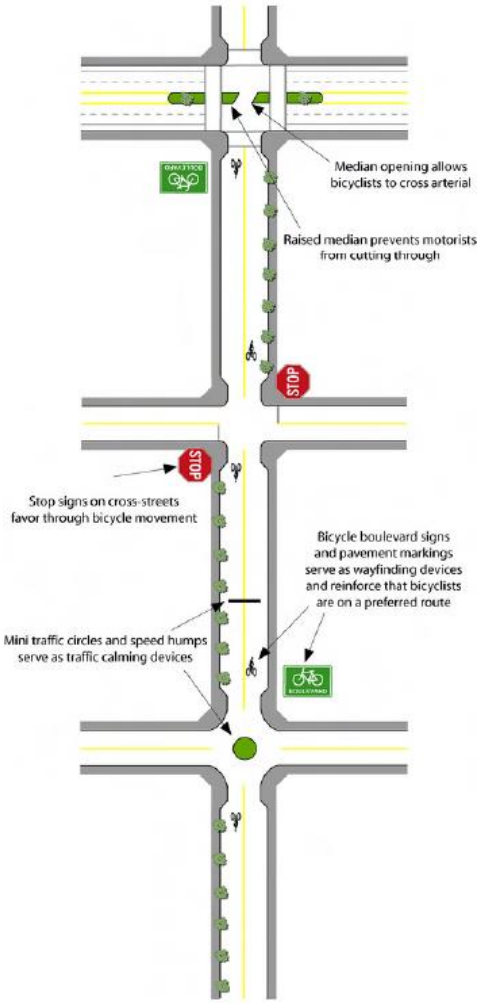
*SANDAG Regional Bicycle Plan: Riding to 2050*

The San Diego Association of Governments (SANDAG) is a regional planning agency that provides a forum for regional decision-making for the 18 cities and unincorporated areas that make up San Diego County (SANDAG, n.d.). SANDAG developed a Regional Bicycle Plan for the San Diego region, presenting "an interconnected network of bicycle corridors that would enable residents to bicycle with greater safety, directness, and convenience within and between major regional destinations and activity centers." (SANDAG, n.d.)

The Regional Bicycle Plan identifies three types of bicycle facilities included in the California Department of Transportation (Caltrans) Highway Design Manual, and two additional facilities currently not recognized in the design manual but compliant with Caltrans standards. The additional facilities are proposed as pilot projects in appropriate segments throughout the region. Table 2 is taken from the Regional Bicycle Plan and illustrates each bicycle facility type that exists within the region or is discussed in the Plan.

**Table 2: Regional Corridor Classification System**

| | |
|---|---|
| Class I – Bike Path: Bike paths are bikeways that are physically separated from vehicular traffic. Also termed shared-use paths, bike paths accommodate bicycle, pedestrian, and other non-motorized travel. Paths can be constructed in roadway right-of-way or independent right-of-way. Bike paths provide critical connections in the region where roadways are absent or are not conducive to bicycle travel. |  |
| Class II - Bike Lanes: Bike lanes are defined by pavement markings and signage used to allocate a portion of a roadway for exclusive or preferential bicycle travel. Within the regional corridor system, bike lanes should be enhanced with treatments that improve safety and connectivity by addressing site-specific issues. Such treatments include innovative signage, intersection treatments, and bicycle loop detectors. |  |
| Class III - Bike Routes: Bike routes are located on shared roadways that accommodate vehicles and bicycles in the same travel lane. Established by signs, bike routes provide continuity to other bike facilities or designate preferred routes through corridors with high demand. Within the regional corridor system, bike routes should be enhanced with treatments that improve safety and connectivity by addressing site-specific issues. |  |

| | |
|---|---|
| Cycle Tracks: A cycle track is a hybrid type bicycle facility that combines the experience of a separated path with the on-street infrastructure of a conventional bike lane. Cycle tracks are bikeways located in roadway right-of-way but separated from vehicle lanes by physical barriers or buffers. Cycle tracks provide for one-way bicycle travel in each direction adjacent to vehicular travel lanes and are exclusively for bicycle use. Cycle tracks are not recognized by Caltrans Highway Design Manual as a bikeway facility. Development of cycle track on segments of the regional corridor system is proposed through experimental, pilot projects. |  |
| Bicycle Boulevards: Bicycle boulevards are local roads or residential streets that have been enhanced with traffic calming and other treatments to facilitate safe and convenient bicycle travel. Bicycle boulevards accommodate bicyclists and motorists in the same travel lanes, typically without specific vehicle or bicycle lane delineation. These roadway designations prioritize bicycle travel above vehicular travel. The treatments applied to create a bike boulevard heighten motorists' awareness of bicyclists and slow vehicle traffic, making the boulevard more conducive to safe bicycle and pedestrian activity. Bicycle boulevard treatments include signage, pavement markings, intersection treatments, traffic calming measures and can include traffic diversions. Bicycle boulevards are not defined as bikeways by Caltrans Highway Design Manual; however, the basic design features of bicycle boulevards comply with Caltrans standards. |  |

*Source: San Diego Association of Governments (SANDAG) Regional Bicycle Plan*

Proposed bicycle facilities within SANDAG's San Diego Regional Bicycle Plan were developed with a Project Prioritization Process, which used Smart Growth Opportunity Areas (SGOAs) including metropolitan centers, urban centers, town centers, community centers, rural villages, mixed-use transit corridors, and special use centers (SANDAG, n.d.). The SGOAs were used to generate origins and destinations within the SANDAG region and to generate a gravity model analysis; thus, the higher the land use intensity and the shorter the distance between two SGOAs, the higher the demand level of the connecting segment along the bicycle network was modeled to be (rephrase) (SANDAG, n.d.).

*County of San Diego Bicycle Transportation Plan*

The County of San Diego Bicycle Transportation Plan "serves as a policy document to guide the development and maintenance of a bicycle network, support facilities and other programs for the unincorporated San Diego County" (County of San Diego, 2003). The Plan incorporates citizen feedback from six workshops held throughout the County, input from surveys, and a Technical Advisory Group consisting of County staff and individuals from Caltrans and the San Diego Bicycle Coalition. Specific goals of the Plan include promoting bicycle transportation, improving the local and regional bikeway network, and Bicycle Circulation Element goals including providing for "the safe and convenient use of bicycles throughout the San Diego County…." (County of San Diego, 2003).

*City of San Diego Bicycle Master Plan*

The City of San Diego conducts detailed analysis of existing infrastructure, neighborhood bicycle policies, and survey data in its General Plan and its 2013 Bicycle Master Plan. The Bicycle Master Plan (BMP) identifies methods of improving the existing bicycle network and increasing connectivity, and lists proposed infrastructure improvements based on funding availability. The City of San Diego conducted extensive outreach in development of the Plan and surveyed residents on bicycle behavior, as well as their needs regarding improvement of the bicycle network. The Plan also includes a gravity analysis identifying demand corridors within San Diego, and response data from the 1,672-participant survey conducted by the City of San Diego and Alta Planning + Design. The BMP update presents a detailed outline of current

bicycle facilities and ridership within San Diego, and extensive data about current residents and their bicycling needs.

*City of Carlsbad Bikeway Master Plan*

According to the City of Carlsbad's 2007 Bikeway Master Plan, bicycle lanes are "present on a portion of every arterial roadway within Carlsbad…." Carlsbad developed its Plan to "enhance and expand the existing bikeway network, connect gaps, … and encourage even more residents to bicycle" (City of Carlsbad, 2007). The Plan includes recommendations to enhance the bicycle network with new bike paths, bike lanes, and bike routes, and development of educational and promotional programs for bicyclists and motorists including outreach programs, facility improvements, and educational programs (City of Carlsbad, 2007).

*City of Coronado Bicycle Master Plan*

The City of Coronado Bicycle Master Plan, developed in March of 2011, establishes bicycle facilities for implementation and identifies opportunities to connect its facilities with the rest of San Diego. It lists bicycle lanes, routes, and paths for improvement and development, and emphasizes analysis of current ridership along specific areas (City of Coronado, 2011). Further, the City emphasizes that it developed its plan using a "cyclist's perspective", with city staff with experience cycling the routes discussed in the Plan.

*City of Chula Vista Bikeway Master Plan*

The City of Chula Vista developed its Bikeway Master Plan in 2011, using field surveys of existing bicycle use, online surveys of city residents, GIS maps incorporating land use and roadway data within the City, and a multi-modal travel analysis including transit services available in Chula Vista (City of Chula Vista, 2011). The City of Chula Vista Bikeway Master Plan makes recommendations based on SANDAG's planned regional bikeway system, the 2005 City of Chula Vista Bikeway Master Plan, and input from field work, the public, and GIS analysis (City of Chula Vista, 2011). Its bicycle facility recommendations are listed by bicycle facility type in its Bikeway Master Plan.

*City of Del Mar*

A bicycle plan could not be located for the City of Del Mar.

*City of El Cajon Bicycle Master Plan*

The 2011 City of El Cajon Bicycle Master Plan was developed with the goal of maximizing connections between transit, employment, residential areas, and activity areas by providing bicycle infrastructure as an alternative to automobile travel. The City of El Cajon held a public workshop and distributed an online survey and incorporated survey results, GIS data, field investigations, and public input to create a summary of gaps and deficiencies in the bicycle network. The Plan proposes bicycle path, route, and lane improvements.

*City of Encinitas Bikeway Master Plan*

The City of Encinitas developed its Bikeway Master Plan in 2006 with an emphasis on the "cyclist's perspective". Planners rode potential routes to assist with plan development and incorporated GIS data with respect to housing, population, employment densities, and a bicycle suitability model (City of Encinitas, 2006). The Plan surveyed the city's existing bicycle infrastructure using field surveys and GIS mapping, and gathered input from local cyclists and community meetings (City of Encinitas, 2006). Further, the Plan emphasizes that

> The aim of planning for bicycles should not be focused on any particular product so much as it should be focused on the safe and efficient travel of cyclists … [which] will generally require both the use of the existing transportation infrastructure and the construction of special facilities… (City of Encinitas, 2006).

The City of Encinitas also emphasizes that plans should be made with consideration of the constraints and opportunities presented by bicycle travel, and that bicyclists' ages, abilities, experiences, and traffic judgment may be widely varied (City of Encinitas, 2006). The Plan identifies several constraints to cycling under the City's current system, including steep road grades, a lack of connectivity, and high motor vehicle speeds, acknowledging that these factors disproportionately impact less-experienced cyclists (City of Encinitas, 2006). The Plan makes bicycle path and lane facility recommendations.

*City of Escondido Bicycle Master Plan*

The City of Escondido developed its Bicycle Master Plan in 2012 as an update to the City's 1993 Bicycle Facilities Master Plan, with the purpose of developing a feasible plan for an

"interconnected network of on- and off-street bicycle facilities that serves all of Escondido's neighborhoods…." (City of Escondido, 2012). The Plan recommends enhancing the existing bicycle network in Escondido and completing current gaps in the network. It includes bicycle path, lane, and route facility recommendations.

*City of Imperial Beach Bicycle Transportation Plan*

Similar to the Cities of Encinitas and Coronado, the City of Imperial Beach developed its 2008 Bicycle Transportation Plan with a "cyclist's perspective", with plan preparers riding facilities firsthand to experience them from a bicycle. The City incorporated GIS data about housing, population, and employment densities in its mapping and planning recommendations for the Plan. It lists current constraints to cycling including a lack of amenities such as restrooms and bicycle parking along its Bayshore Bikeway, high motor vehicle speeds adjacent to its bicycle lanes, and narrow roadways that may not provide space for bicycle lanes. The Plan recommends developing bicycle paths, lanes, and routes in specific areas throughout the City (City of Imperial Beach, 2008).

*City of La Mesa Bicycle Facilities and Alternative Transportation Plan*

The 2012 Bicycle Facilities and Alternative Transportation Plan was developed by the City of La Mesa to provide a conceptual plan for addressing opportunities to connect existing and proposed facilities. The City of La Mesa developed the plan with a "cyclist's perspective", and intends the plan to result in an increase in the number of commuters choosing to ride a bicycle or walk to nearby destinations (City of La Mesa, 2012). Similar to the other plans for the San Diego Region, the City of La Mesa Bicycle Facilities and Alternative Transportation Plan makes recommendations based on public input and GIS data, and recommends bicycle lane, path, and route facility improvements.

*Lemon Grove Bikeway Master Plan Update*

The 2006 Lemon Grove Bikeway Master Plan Update includes recommendations to expand the existing bicycle network by connecting gaps and addressing constrained areas, and encourage more residents in the City to bicycle. It recommends bicycle lanes, paths, and routes, and includes education programs to encourage safe bicycling (City of Lemon Grove, 2006).

*National City Bicycle Master Plan*

The National City Bicycle Master Plan emphasizes the provision of interconnected bicycle corridors and support facilities in order to make cycling practical and desirable to a dense, urbanized community (City of National City, n.d.) The City collected feedback through four public workshops and a community bicycle tour, and provides recommendations based on public input, best practices, and analysis of existing conditions and opportunities. The Plan recommends bicycle path, lane, and route improvements.

*City of Oceanside Bicycle Master Plan*

The 2008 City of Oceanside Bicycle Master Plan incorporates document review, field work including bicycle riding of routes, GIS analysis of field work data, and community input to analyze Oceanside's existing bikeway system (City of Oceanside, 2008). The Plan incorporates trip Origin and Destination analysis and a multi-modal analysis of the transportation system. It identifies high motor vehicle speeds, highway crossings, and narrow roadways as constraints to cycling under the current network, and makes recommendations for bicycle lane, path, and route improvements to the network.

*City of Poway*

A bicycle plan could not be located for the City of Poway.

*City of San Marcos Master Trails Plan and Bikeway Master Plan*

A Bikeway Master Plan exists for the City of San Marcos according to its website, but only the Master Trails Plan could be located.

*City of Santee Bicycle Master Plan*

The 2009 City of Santee Bicycle Master Plan emphasizes consideration of all segments of the cycling population and development of a complete bikeway system for local and regional connectivity. The Plan emphasizes a safe, maintained, and "destination-oriented" system that includes access to employment centers, residential areas, high-use activity centers, and other modes of transportation, and to bicycle parking facilities (City of Santee, 2009). The City lists

high motor vehicle speeds, highway crossings, and narrow roadways as constraints to cycling, and recommends complete streets and bicycle path, lane, and route facility improvements.

*Solana Beach Bicycle Transportation Plan*

The 1993 Solana Beach Bikeway Master Plan has been updated in 1996 (Addendum 1) and 2005 (Addendum 2). The original Plan provides recommendations for bicycle facilities and programs, including specific locations for bicycle lanes, routes, and signage; inclusion of bicycle loop detectors in signalization; and bicycle safety and awareness programs and staff (City of Solana Beach, 1993). The 1996 update included estimates of new bicycle commuters, described the bicycle safety and education programs, and provided information about how the plan's recommendations would be implemented and funded. Further, the 1996 update described volume, speed, vehicle characteristics, proximity of bicyclist to motor vehicle traffic, and pavement conditions as factors influencing a bicyclist's "perception of interaction hazard" (City of Solana Beach, 1996). The 2005 addendum renamed the Bikeway Master Plan to be the Bicycle Transportation Plan, and identifies the funding programs under which the City's bicycle projects are funded.

*City of Vista 2014 Bicycle Master Plan*

The City of Vista Bicycle Master Plan was created to guide the development of bicycle infrastructure through community input and an existing needs analysis, with the goal of improving bicycling in Vista. The Plan cites health, environmental, and economic benefits of cycling, and provides recommendations based on key destinations for the area including transit access, neighborhoods, schools, recreation, employment centers, and activity destinations. The Plan includes recommendations for bicycle paths, shared-use trails, one-way cycle tracks (on-street bicycle facilities with physical separations from traffic), side paths (sidewalk extensions with one- or two-way bicycle space), bicycle lanes, buffered bicycle lanes, bicycle routes, and bicycle boulevards (ordinary roadways designed to prioritize bicycle travel) for implementation within the area (City of Vista, 2014).

**Synthesis**

Existing bicycle research delves extensively into the relationship between bicycling and land use, and provides valuable insight about bicyclists' preferences. Both planners and researchers recognize that decisionmakers need to understand the types of features cyclists prefer to have nearby, as well as what cyclists may go out of their way to avoid. This recognition is further demonstrated through current research about bicycle needs, as well as local plans' emphasis on incorporating cyclists' perspectives into development of bicycle infrastructure plans.

In addition, the literature references a need for more accurate performance measurement for evaluating bicycle facilities, which this study aspires to provide for San Diego.

# Methodology

## Research Design

In this study, I quantify the San Diego region's bicycle facilities through analysis of spatial datasets of bicycle infrastructure provided by the San Diego Geographic Information Source (SanGIS). The geographic information systems (GIS) software allows categorization and quantification of spatial data, so that existing bicycle routes may be modified to account for the external factors that influence their comfort levels to users.

### *Field site*

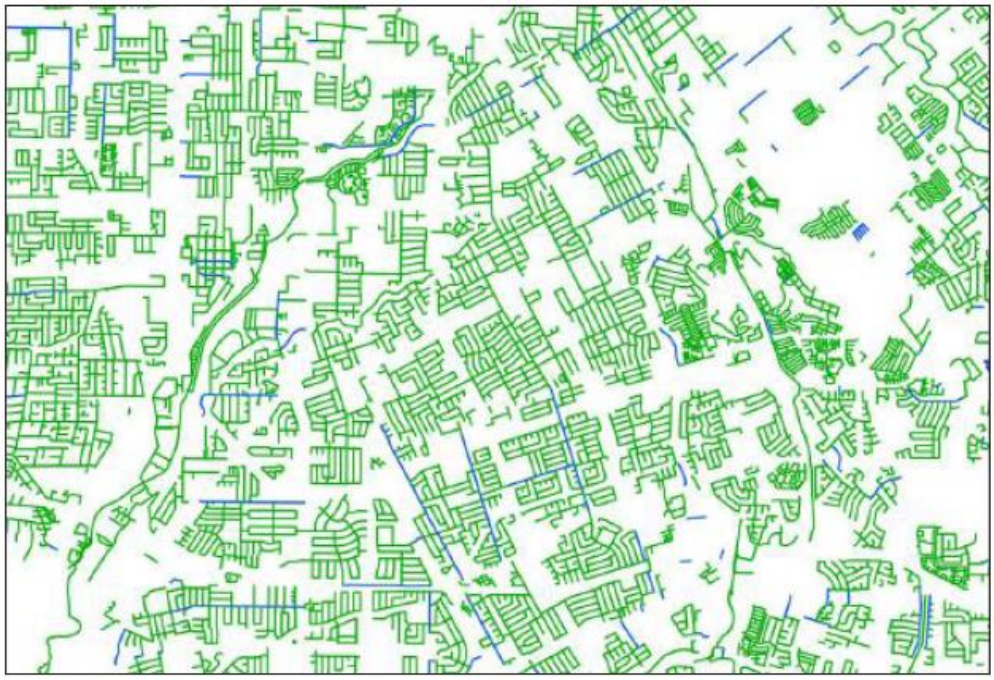
I chose the San Diego region as a research location because its year-round temperate weather, culture of outdoor activity, and high congestion during peak-hour traffic make it a prime location for bicycle use as a method of transportation. Although infrastructure conditions may currently make the region an undesirable choice for bicycle use as a method of transportation, residents may likely be interested in bicycling for transportation provided appropriate infrastructure, since there are currently more San Diegans who cycle for utilitarian than recreational reasons (City of San Diego, 2013). Due to San Diego's mild climate and thriving outdoor community, it is likely that road and traffic conditions serve as more of a deterrent to bicycling than do weather and culture in the region. This presents planners and decision makers an opportunity to increase cycling simply through improving infrastructure.

### *Mekuria et. al.*

This study is primarily modeled after Mekuria et. al.'s 2012 analysis, which generated a bicycle facility network map for each level of traffic stress. The LTS 1 map (the lowest level of traffic stress) generated by the Mekuria study showed several intraconnected areas of low traffic stress which were disconnected from one another (see Figure 1), demonstrating that individuals interested in traveling by bicycle without encountering substantial traffic stress currently do not have mobility options beyond individual neighborhoods and residential areas. Although Mekuria et. al. performed this analysis for the San José area, it was expected that the car-focused transportation system of San Diego, as well as its high speed limits and its canyons, freeways, and other geographic features/obstructions would show similar results.

Data in this study will be presented primarily through maps displaying the Level of Traffic Stress networks.

**Figure 1: Stress Map by Mekuria et al. showing LTS 1 in green**



*Source: Mekuria et al. 2012*

*Levels of Traffic Stress*

Table 3 below describes various types of bicycle users and what levels of stress each group can most frequently tolerate. The distinct categories are relatively mutually exclusive, and could allow policymakers to distinguish between facilities that will serve various user groups with increased clarity. Traffic stress levels in Table 3 are adapted from Mekuria et al. and Roger Geller.

**Table 3: Levels of Traffic Stress Tolerated by various User Groups**

| User Group | Description | Level of Traffic Stress Tolerated |
|---|---|---|
| Strong and Fearless | Members of the population who would use a bicycle to travel even if no bicycle-specific infrastructure was in place at all; will ride regardless of conditions | All levels |
| Enthused and Confident | Members of the population attracted to cycling, or attracted through public efforts to encourage the activity | 1, 2, 3 |
| Interested but concerned | Members of the population who identify safety as a primary reason for not cycling | 1; some 2 |
| No way no how | Members of the population with no interest whatsoever in riding a bicycle in urban areas | None |

*Source: Roger Geller's "Four Types of Cyclists", Portland Office of Transportation*

This study uses the LTS criteria established by Mekuria et al., with influence from Roger Geller's "Four Types of Cyclists", to determine LTS thresholds for measuring San Diego's bicycle network. Table 4 illustrates specific components of how the categories are quantified; these are discussed in further detail in Table 6.

**Table 4: Bicycle Level of Traffic Stress (LTS) Criteria**

| Criteria and/or Characteristics | Levels of Traffic Stress (LTS) | | | |
|---|---|---|---|---|
| | LTS 1 | LTS 2 | LTS 3 | LTS 4 |
| Physical separation from traffic | X | X | | |
| Ample operating space | X | X | | |
| Clearly delineated travel lane or area | X | X | X | |
| Low traffic speeds and/or volumes | X | X | | |
| Suitable for children | X | | | |
| Moderate traffic speeds and/or volumes | | | X | |
| Bicycle facility integrated with multilane traffic | | | | X |
| High traffic speeds and/or volumes | | | | X |
| Potential hazards to avoid (i.e. poor road conditions/ narrow operating space / fast right-hand turn lanes) | | | | X |

*Source: "Low Stress Bicycling and Network Connectivity", Mekuria, et. al., 2012*

*Data Analysis*

The study will assign a level of traffic stress to every section of road and bicycle path in San Diego using the following characteristics.

Roadway speed

Roger Geller (n.d.), Providelo and Sanches (2011), the AAA Foundation (2011), and Mekuria et al. (2012) note traffic speed as the among the most important determinants for bicycle use, safety, and comfort levels. This study will add information about adjacent roadway speeds to appropriate bicycle facilities and use the information to help determine traffic stress levels.

Bike lane and path grades

Bicyclists have varying levels of fitness and bicycle handling skill, and steep grades may pose stress or challenges to some cyclists. San Diego is a geographically diverse area with many canyons and mountains, and its roads and bicycle facilities follow the existing topography. While physically fit cyclists may brave steep grades during commutes, or even seek them out for recreation or exercise, many individuals cycling for transportation or light exercise may in fact avoid these facilities.

Bicycle facility type

While extreme differences may exist among facilities of the same type (as discussed throughout this report), bicycle facility types are inherently different from one another and, cause inherent differences in traffic stress levels (Mekuria et al., 2012; Geller, n.d.). Bicycle facility types are therefore included in this study; the relationship between bicycle facility type is discussed in Table 4 and Table 6.

Other characteristics not accounted for in this study

**Bike lane width:** Bicycle lane and path width affects the amount of operating space allotted to a cyclist, and is shown by studies to have a positive correlation with user comfort level and bicycle ridership (Mekuria et al., 2012). However, bicycle lane width data is not publicly available and it is therefore not included in this study.

**Road width:** Road width, which can determine traffic behavior, road noise, and the number of lanes a bicyclist has to cross in order to make a left turn or cross an intersection, may affect cyclist level of traffic stress, both in number of lanes and in standard units such as feet. However, road width data does not exist on a consistent basis throughout the network, so it is not included in this study.

**Roadway shoulder presence and width:** The presence and size of a roadway shoulder can affect operating space afforded to traffic and bicyclists, especially where a bicycle lane is not present. It may also correlate with changes in motorist behavior. However, this data did not consistently exist for the San Diego region, and is therefore not included in this study.

**Traffic volumes:** Traffic volumes can also play a role, although their effect on traffic stress level is obscured since higher traffic volumes may result in lower vehicle speeds. However, the data for traffic volumes does not exist on a consistent basis throughout the network and it is therefore not included in this study.

**Pavement quality:** While studies have identified pavement condition as less important than vehicle speed, bicycle facility width, and even tree cover, San Diego in particular suffers from extreme pavement wear and tear on its surface streets and bicycle facilities (TRIP, 2013). Surveys conducted by the City of San Diego in its Bicycle Master Plan Update cited pavement condition as a major area requiring improvement in order to increase bicycle mobility. However, this study does not include pavement quality as a factor in determining level of traffic stress, because the data does not exist in a compatible format for combining with the rest of the data used in this study.

**Street parking presence and turnover:** Street parking may affect the amount of operating space afforded to bicyclists, especially when there is a narrow bicycle lane or none at all, since it forces bicyclists to choose between riding closer to roadway traffic, or riding closer to parked cars and accept some risk of hitting or being hit by an opening car door. Some bicyclists prefer to avoid riding adjacent to parked vehicles (Krizek and Roland, 2005), while others simply prefer to avoid busy areas involving frequent parking turnover with vehicles frequently crossing the bicycle lane (Mekuria et al., 2012). However, there is currently no region-wide data about on-street parking in San Diego County, and so this data is not included in the present study.

**Unrestricted vehicle right-turn lanes:** Unrestricted vehicle right-turn lanes are most commonly used in freeway onramps, which are designed to allow motorists to increase speed as they transition from surface streets to freeway speeds (FHWA, 2006). Free-flow onramp facilities provide motorists the opportunity to make high-speed right turns onto freeways in dedicated right-turn lanes; however, this can create additional conflicts when bicycle facilities are also

present. In some bicycle facility retrofits, the high-speed onramps are retained in place while signage directs motorists to slow for bicyclists and pedestrians, placing safety responsibility on the motorist but leaving the risk with the bicyclist or pedestrian, doing little to improve bicycle and pedestrian comfort. However, freeway onramps are not included in this study because the data did not provide for an adequate way to allow them to influence adjacent roadways' traffic stress levels.

**Presence and width of median:** Studies are mixed as to the effect of road medians on bicyclists' traffic stress levels; however, this information is included in the Mekuria (2012) study. However, data pertaining to presence and width of roadway medians does not consistently exist for the entire San Diego region; therefore, it is not included in this study.

**Lighting:** Lighting, while an important determinant of cyclists' safety and level of traffic stress, is of relevance only during night time cycling. Since there is an immediate need to improve daytime cycling facilities for San Diegans, analysis of lighting facilities was not conducted for this study.

The data generated in this study may be used to identify areas of the San Diego bicycle network that require minor improvements in order to increase bicycle use. The study will demonstrate overall mobility options for each bicycle user type, and identify areas of potential improvements to bicycle mode share by delineating corridor mobility needs. In addition, the generation of a user-ready "level of traffic stress" bicycle network map may provide San Diego area residents with the ability to make informed route decisions while planning bicycle travel, rather than encountering surprises such as high vehicle speeds, steep slopes, or major streets while traveling Class I, II, or III bicycle routes. The classification of San Diego bicycle facilities based on level of traffic stress rather than facility type alone provides transportation planners the opportunity to provide equitable multi-modal transportation that enhances transportation system accessibility and improves long-term mobility.

### Origin, form, and purpose of data

This study extracts useful metrics from existing bicycle and traffic data and to create mobility corridor information, analyzing the current transportation system for bicycle accessibility. I use

secondary data obtained from the City and County of San Diego, the San Diego Association of Governments (SANDAG), and the San Diego Geographic Information Source (SanGIS), a Joint Powers Authority between the City of San Diego and County of San Diego. This report primarily uses spatial obtained from SanGIS through its Regional Data Warehouse, which provides public access to spatial data pertaining to the County of San Diego. Metadata and applicable tables pertaining to the data used are included in the Appendices.

The data is primarily in "shapefile" format, a digital vector (non-topological) storage format for storing geometric location and associated attribute information (US Geological Survey, 2013). Shapefiles are created and used by geographic information system (GIS) software, which enables users to map, model, query, and analyze large quantities of data within single geographic databases (Environmental Protection Agency, 2013). The shapefile format enables this research to modify the attributes of existing bicycle route data to account for external factors that affect traffic stress levels.

The original bicycle infrastructure data was gathered for the purpose of providing members of the public with bicycle route information, and for providing city and county planners with a reference guide of bicycle facilities through the region. The data exists in a shapefile for ArcGIS use, and contains a "Properties" table delineating classification. Map layers may be classified based on one or multiple "fields" (columns) from the data layer's attribute table. The bicycle route data provides spatial coding and information for every bicycle facility within the County of San Diego, and allows entry of additional characteristics through ArcGIS.

**Sources and use of data**

The shapefiles used in this study were selected based on their ability to provide spatial data about the following roadway attributes within San Diego County:

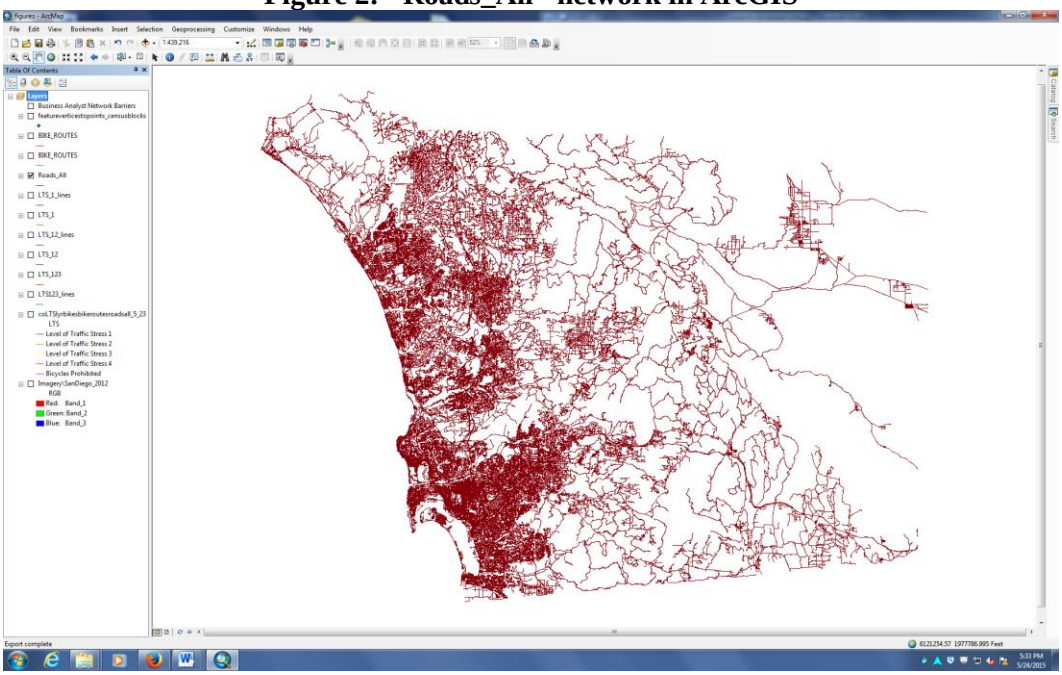
- Roadway classification (i.e. local, rural, collector, etc)
- Roadway speed
- Bicycle facility type
- Bicycle facility grade, or steepness

The following sections describe the shapefiles from the SanGIS/SANDAG Regional Data Warehouse used in this study. Table 5 summarizes the data and lists relevant information, including data source, type, and date.

*"Roads_All"*

The "Roads_All" shapefile is a set of all roadway centerlines within San Diego County, collected using data gathered from all jurisdictions within the county. It includes all public, private, built, unbuilt, active, and inactive roads, divided into roughly _ foot segments. The dataset includes information such as zip codes for each side of the road, intersection identification numbers, one-way designations, and more. Although a substantial amount of data is provided per road segment, many useful attributes were not included in this study because they were not consistently applied to the road segments throughout the region. A listing of all data provided in the layer is provided in the Metadata, listed in Appendix _. The roadway classifications specified in this shapefile are listed in Table 6. Figure 2 illustrates the spatial network included in the "Roads_All" shapefile.

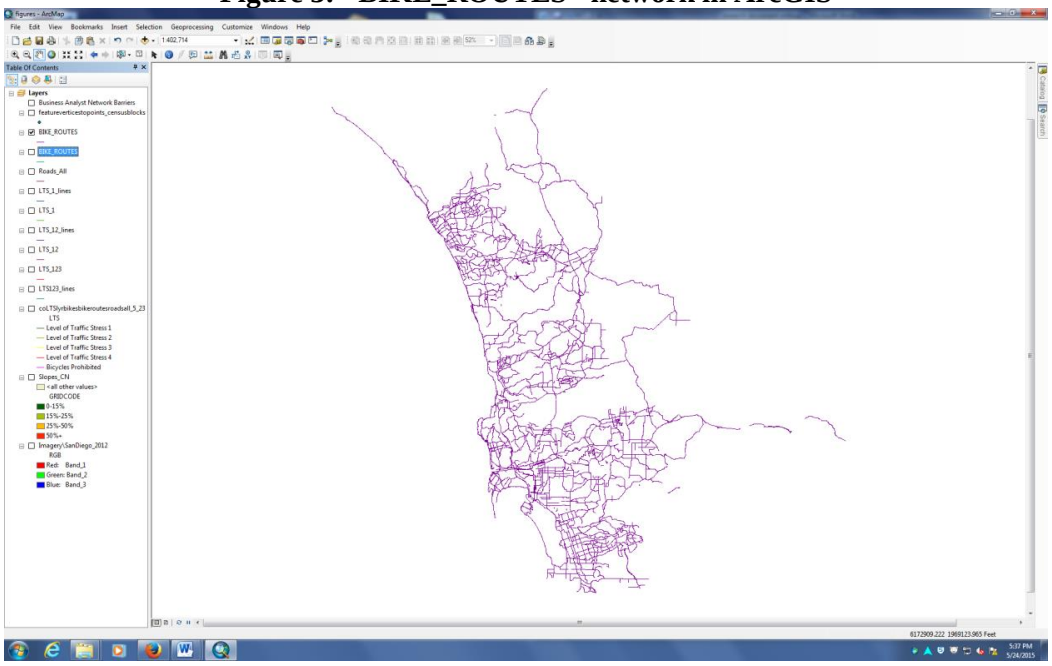
**Figure 2: "Roads_All" network in ArcGIS**



*"BIKE_ROUTES"*

The "BIKE_ROUTES" dataset includes all existing bicycle facilities in the San Diego Region, in line format. The dataset uses the SanGIS "Roads_All" layer as its basis, which allows both datasets to be merged without alignment issues. SANDAG obtained bicycle network data from local jurisdictions within the San Diego region in 2014, creating a regional dataset from the information and performing additional updates in 2015. The data features were segmented to account for changes in facility characteristics. The bicycle network class types are listed in Table 6 on page 39.

**Figure 3: "BIKE_ROUTES" network in ArcGIS**



*"Slopes_CN"*

The "slopes" layer contains polygon files expressing percent slopes throughout the San Diego region. The dataset was built from a 10-meter global resource information database (GRID) derived from interferometric synthetic aperture radar (IfSAR) elevation surface data for the County of San Diego. Figure 4 below illustrates the slope data output for the region, and Figure 5 shows slopes by percent grade for a subset of the region.

**Figure 4: "Slopes_CN" polygons in ArcGIS**

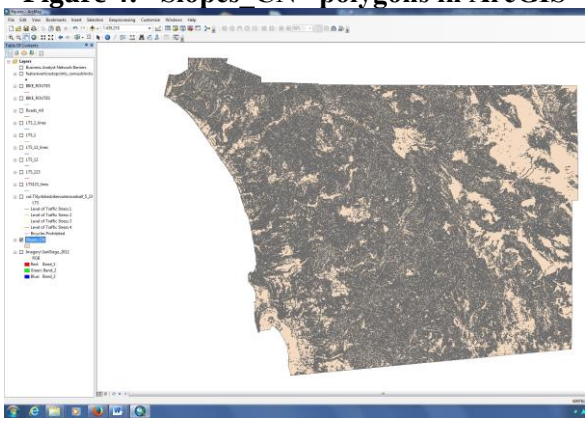
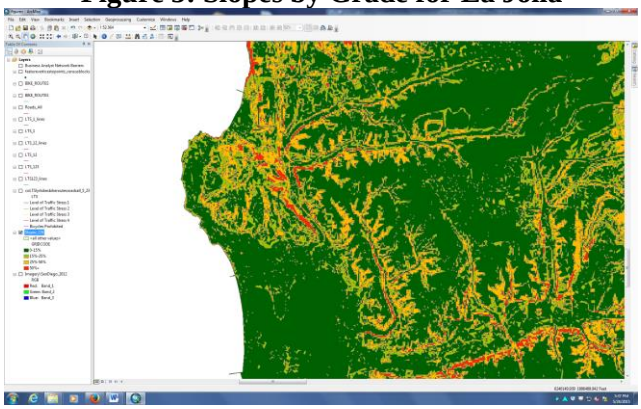


**Figure 5: Slopes by Grade for La Jolla**



*"PLACES"*

The "PLACES" dataset includes a wide variety of locations within San Diego County, including government and administrative facilities, recreational facilities, theme parks, historical sites, universities, schools, medical facilities, natural and manmade features, athletic facilities, businesses, retail centers, residential facilities, telecommunication structures, industrial centers, and more. The "PLACES" dataset is used as a supply of origins and destinations for the network analyst to create the origin/destination matrix for each traffic stress level network to compare connectivity.

**Figure 6: "PLACES" in ArcGIS**

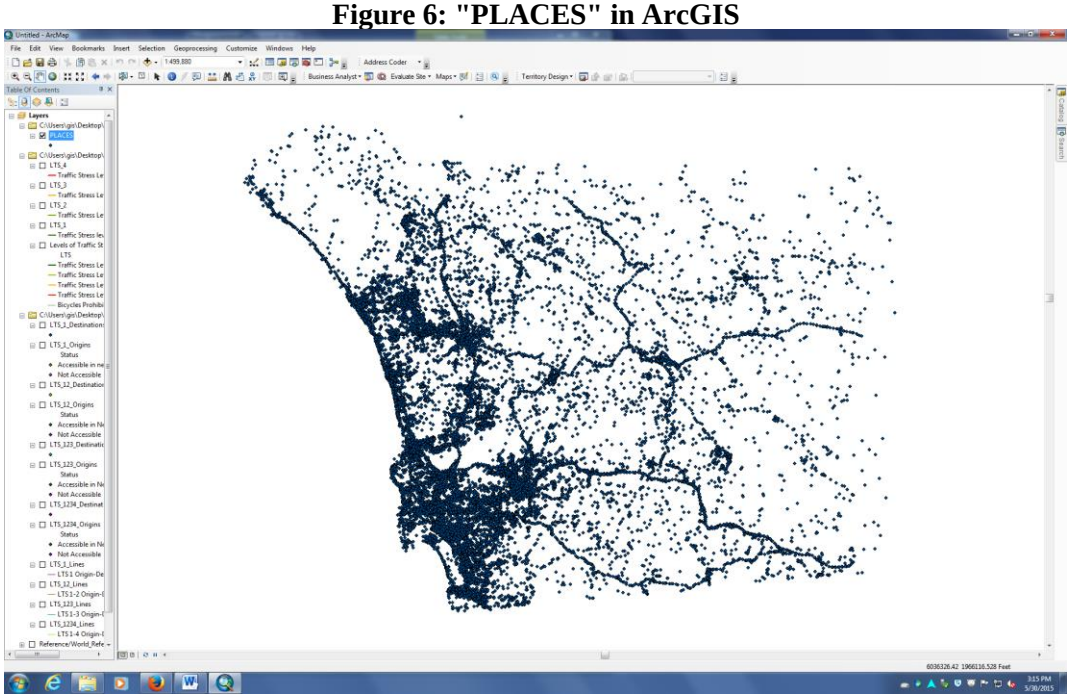


**Table 5: Shapefiles used in study**

| Name | Contents | Source | Date | Extent | Feature Type | Number of Records | Data Used in Study |
|---|---|---|---|---|---|---|---|
| "Roads_ All" | Centerline segments for roads (active, inactive, public, private, constructed, or unconstructed) | Data received from all official jurisdictions within San Diego County. | 5/4/15 | Spatial: San Diego County | Line | 157,914 | • Road name<br>• Speed (average driving speed established by emergency vehicle dispatch agencies)<br>• Functional Class (i.e. freeway; local; etc.)[1]<br>• Segment length |
| "BIKE_ ROUTES" | Existing bicycle facilities in the San Diego Region, based on the "Roads_All" layer | SANDAG, using input from local jurisdictions. | 4/10/15 | San Diego Region | Line | 15,815 | • Route (type of facility)<br>• Segment length |
| "Slopes_ CN" | Aggregated slopes for San Diego County using Interferometric Synthetic Aperture Radar (IfSAR) elevation surfaces of the County. | County of San Diego Land Use and Environmental Group GIS Service | 1/1/05 | San Diego County | Polygon | 367,820 | • Percent slope grade in four aggregated categories:<br>-Less than 15% slope<br>-15% to 25% slope<br>-25% to 50% slope<br>-Slope 50% or greater |
| "PLACES" | Point layer showing location of areas and specific features including businesses and outdoor features. | County of San Diego, SANDAG, San Diego County Sheriff, US Board on Geographic Names | 4/25/13 | San Diego County | Point | 28,580 | • Facility name<br>• Address<br>• Type of facility |

[1] A list of all functional classes and their associated traffic stress levels is provided in Table 6.

**Assigning Levels of Traffic Stress**

In order to assign traffic stress levels based on specific attributes, the data above were loaded into an ArcGIS map document, and then combined into one shapefile corresponding to bicycle infrastructure data. Each characteristic was allocated a contribution to bicycle level of traffic stress (LTS) based on user preference data gathered in previous studies. The LTS values based on facility and traffic characteristics are shown in Table 6. The LTS values for each roadway characteristic were assessed and then combined into an overall traffic stress classification using a weakest link methodology; in this way, each road segment received a LTS equal to the greatest contributing LTS. For example, a light collector street (LTS 2) with an over 50% slope (LTS 4) would be rated LTS 4. A bicycle lane (LTS 2) adjacent to 35-mph traffic would receive an LTS rating of at least 3, depending on the other characteristics of the roadway.

**Table 6: Level of Traffic Stress Calculation by Road Attribute**

| | **Criteria** | **LTS** |
|---|---|---|
| Speed | 0-25 mph | 1 |
| | 26-34 | 2 |
| | 35-45 | 3 |
| | 46+ | 4 |
| Bicycle Facility | No designation[2]: | |
| | -Local Road with speed < 25mph | 1 |
| | -Private Road with speed<25mph | 1 |
| | -Unpaved road with speed<50mph | 1 |
| | -Recreational Parkway | 1 |
| | -Pedestrian/Bikeway | 1 |
| | -Military with speed<25mph | 1 |
| | -All others | 2 |
| | Class 1 – bike path | 1 |
| | Class 2 – bike lane | 2 |
| | Class 3 – bike route | 2 |
| | Multi-Use Path | 1 |
| | 8: Other suggested Routes | 2 |
| | 15: Bikeways coming soon | 6 (non-existent) |
| | 6: Freeway Shoulder with bike access | 4 |
| Road type | 1...Freeway to freeway ramp | 5 (prohibited unless "Bike_LTS" > 0 and < 4 ) |
| | 2...Light (2-lane) collector street | 2 |
| | 3...Rural collector road | 3 |
| | 4...Major road/4-lane major road | 3 |
| | 5...Rural light collector/local road | 2 |
| | 6...Prime (primary) arterial | 3 |
| | 7...Private street | 1 |
| | 8...Recreational parkway | 1 |

[2] As shown in Figure 2 and Figure 3, the "Roads_All" network is far more extensive than the "BIKE_ROUTES" network. For features with no bicycle facility designation, road criteria were used to determine the bicycle level of traffic stress. This was done to account for facilities such as local roads, which studies have shown produce low traffic stress for bicycles, but to retain the ability for bicycle facility type to influence traffic stress in other situations.

| | Criteria | LTS |
|---|---|---|
| | 9...Rural mountain road | 3 |
| | A...Alley | 2 |
| | B...Class I bicycle path | 1 |
| | C...Collector/4-lane collector street | 3 |
| | D...Two-lane major street | 2 |
| | E...Expressway | 5 (prohibited unless "Bike_LTS" > 0 and < 4 ) |
| | F...Freeway | 5 (prohibited unless "Bike_LTS" > 0 and < 4 ) |
| | L...Local street/cul-de-sac | 1 |
| | M...Military street within base | 1 |
| | P...Paper street | 6 (prohibited) |
| | Q...Undocumented | n/a |
| | R...Freeway/expressway on/off ramp | 5 (prohibited unless "Bike_LTS" > 0 and < 4 ) |
| | S...Six-lane major street | 4 |
| | T...Transitway | 1 |
| | U...Unpaved road | 1 |
| | W...Pedestrianway/bikeway | 1 |
| Slope | 0-15% | 1 |
| | 15%-25% | 2 |
| | 25%-50% | 3 |
| | >50% | 4 |

**Creating the Origin-Destination Matrix**

The ArcGIS software provides a network analysis tool that allows line shapefiles to be converted into transportation networks for travel analysis. The Network Analyst tool can provide shortest-path route analysis, find facilities within a certain radius, or create origin-destination matrices.

For this analysis, the challenge was finding only the destinations available along certain traffic stress level networks – without traveling into a higher stress facility. Therefore, the LTS network was separated into four shapefiles, shown in Table 7 below. By creating a shapefile for each facility that included all lower-stress facilities, I was able to create a realistic transportation network for each prospective user type. For example, an individual traveling by bicycle and comfortable cycling on LTS 3 facilities would not avoid LTS 1 or LTS 2 facilities; therefore, all locations available from LTS 1, 2, or 3 would be available for this individual.

**Table 7: Origin-Destination Matrix Shapefiles**

| Name | Traffic Stress Levels Included |
|---|---|
| LTS_1 | All Level of Traffic Stress 1 facilities |
| LTS_12 | All LTS 1 facilities plus LTS 2 facilities |
| LTS_123 | All LTS 1, 2, or 3 facilities |
| LTS_1234 | All LTS 1, 2, 3, or 4 facilities |

The next step was to create a Network Dataset for each traffic stress network. ArcGIS provides several configuration options for Network Dataset creation. In this case, no additional constraints were selected, as

traffic stress levels were already built into the analysis by being located in separate files. The analysis settings selected for this study are included in Appendix B.

Finally, I imported each Network Dataset and a set of Origins and Destinations into the Origin/Destination Matrix under the Network Analyst tool. In this case, I used the "POINTS" shapefile described above as the origins and destinations for the analysis for each traffic stress network, in order to ensure an equal comparison. When importing the origins and destinations into the Origin/Destination Matrix tool, I set a search tolerance for 200 feet – this would be the maximum distance a destination or origin could deviate from the bicycle network and still be analyzed for routes in the matrix. Each bicycle network origin/destination analysis was conducted with a trip distance limit of 5 miles. Thus, all trips identified under each origin/destination matrix for each level of traffic stress would obey the following rules:

- Locate only the origins/destinations that are within 200 feet of the bicycle network
- Locate only the routes between origins/destinations that use bicycle facilities at or below the threshold traffic stress level
- Routes may only be up to five miles long

**Strava Global Heatmaps**

Strava has released a global heatmap containing 77,688,848 rides from its dataset (Mach, 2014). According to Strava, in denser metropolitan areas nearly half of the uploaded rides are commutes, rather than solely recreational rides (Strava, 2014).

This research examines Strava heatmaps side-by-side with traffic stress networks for San Diego to determine whether there is a relationship between the areas most frequently traveled and their traffic stress levels.

As described in the Methodology section, I set out in this study to produce three products:

1. A bicycle level of traffic stress (LTS) map for the San Diego region
2. An origin-destination matrix for each LTS network illustrating its connectivity
3. A comparison between bicycle demand for the region and traffic stress levels

The sections below reveal the findings of this research with respect to these products.

## Bicycle Level of Traffic Stress Map for San Diego Region

Figure 7 through Figure 13 show the network for each traffic stress level for particular areas in the San Diego region. Although at first glance it appears as though the entire region is populated with Traffic Stress Level 1 facilities, a close look at Figure 8 reveals the disconnections between LTS 1 bikeways.

**Figure 7: Traffic Stress Levels for San Diego County**

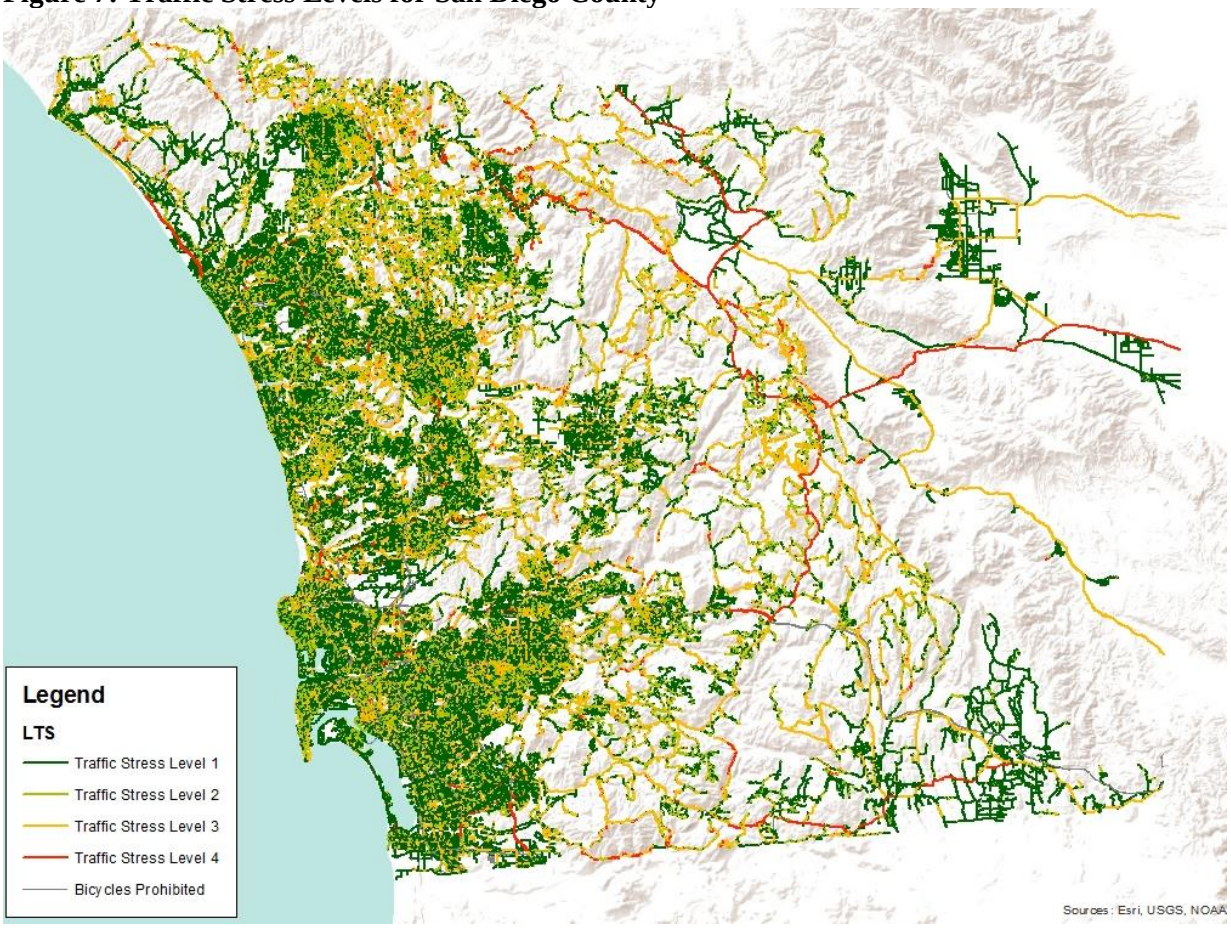


**Figure 8: LTS 1 Facilities in La Jolla**


The disconnections between LTS 1 facilities in La Jolla are characteristic of the bicycle network throughout the region. Local, low-speed streets are interconnected by collector and arterial streets and interrupted by freeways and natural features.

**Figure 9: LTS 1 Facilities in San Diego**

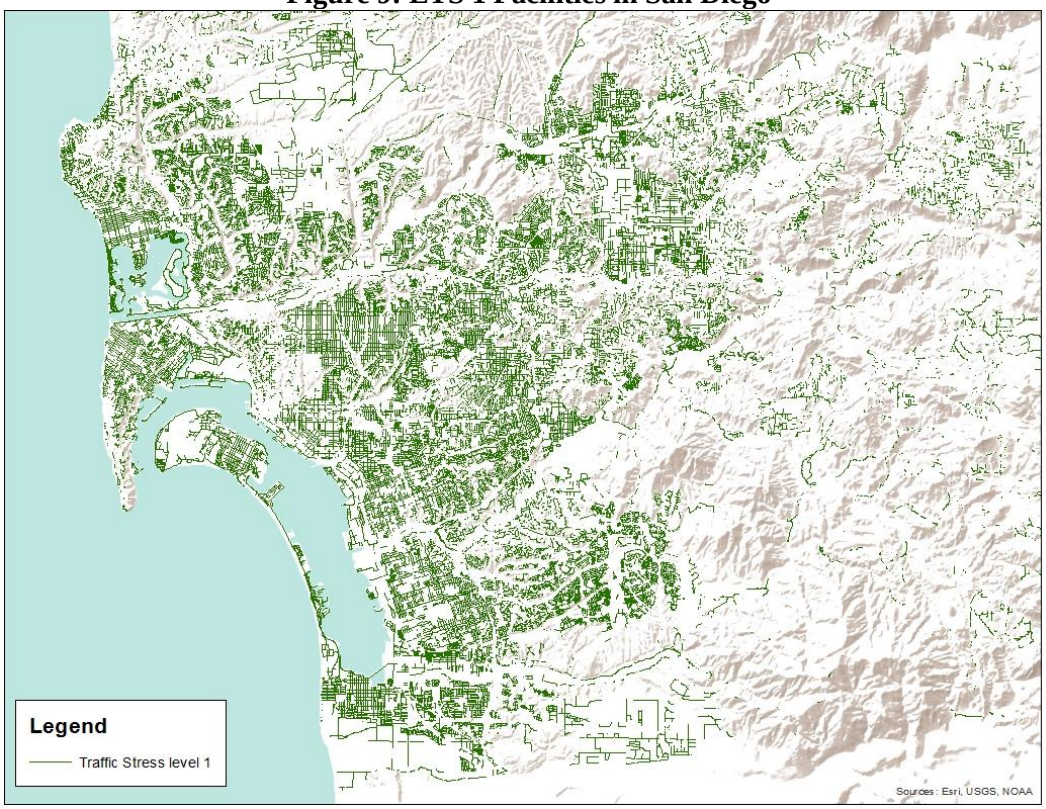



**Figure 10: LTS 2 Facilities in San Diego**

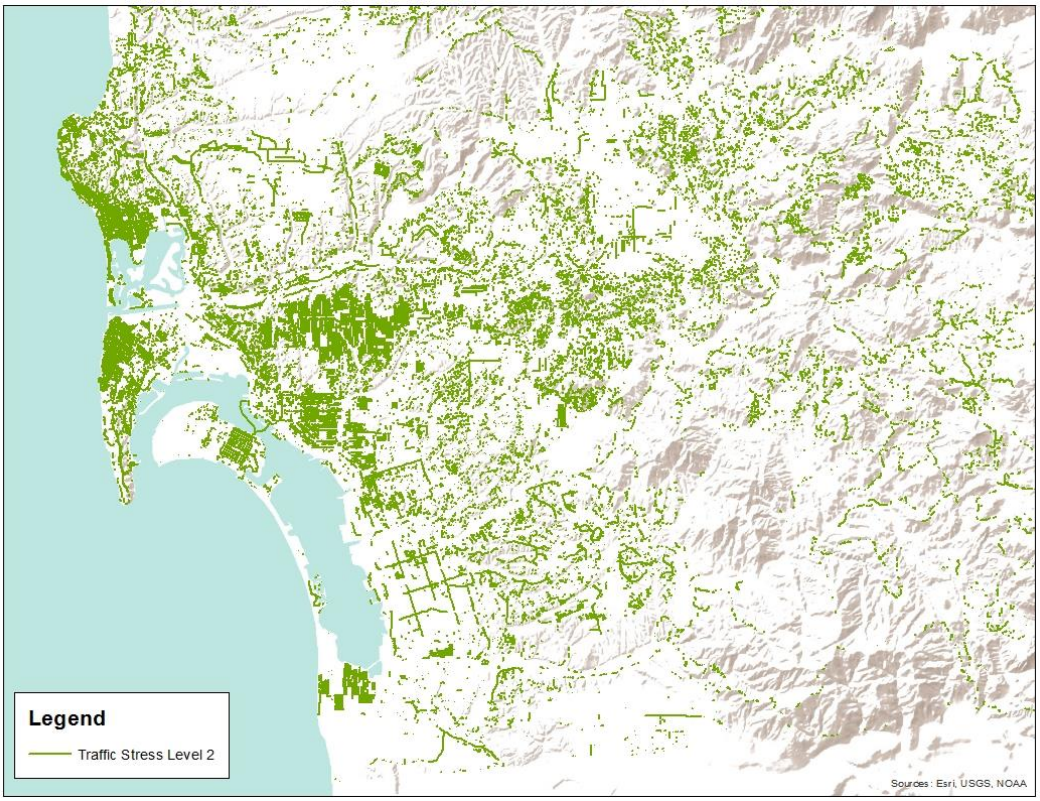


**Figure 11: LTS 3 Facilities in San Diego**

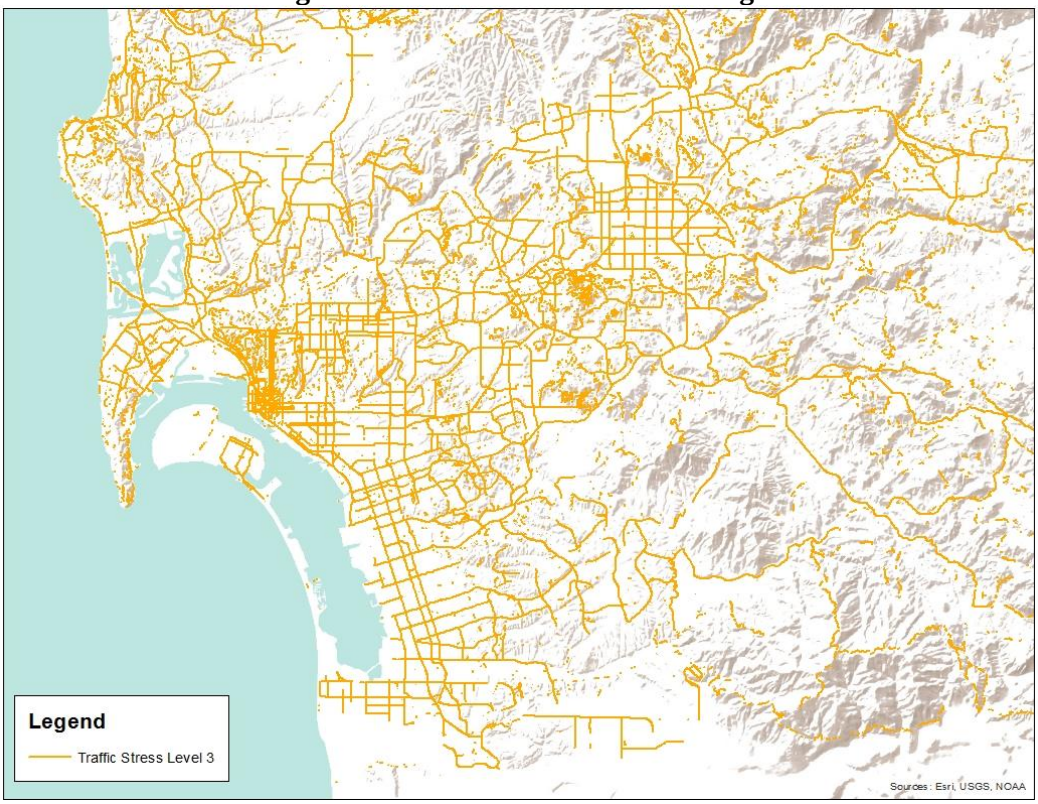



**Figure 12: LTS 4 Facilities in San Diego**

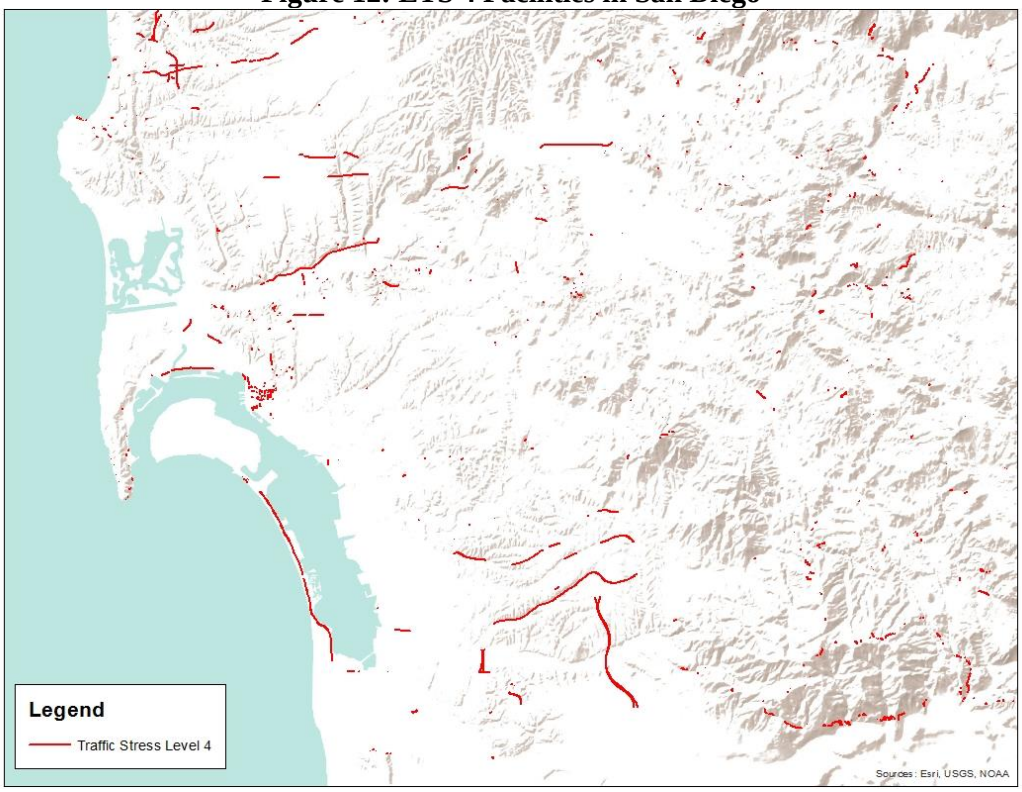
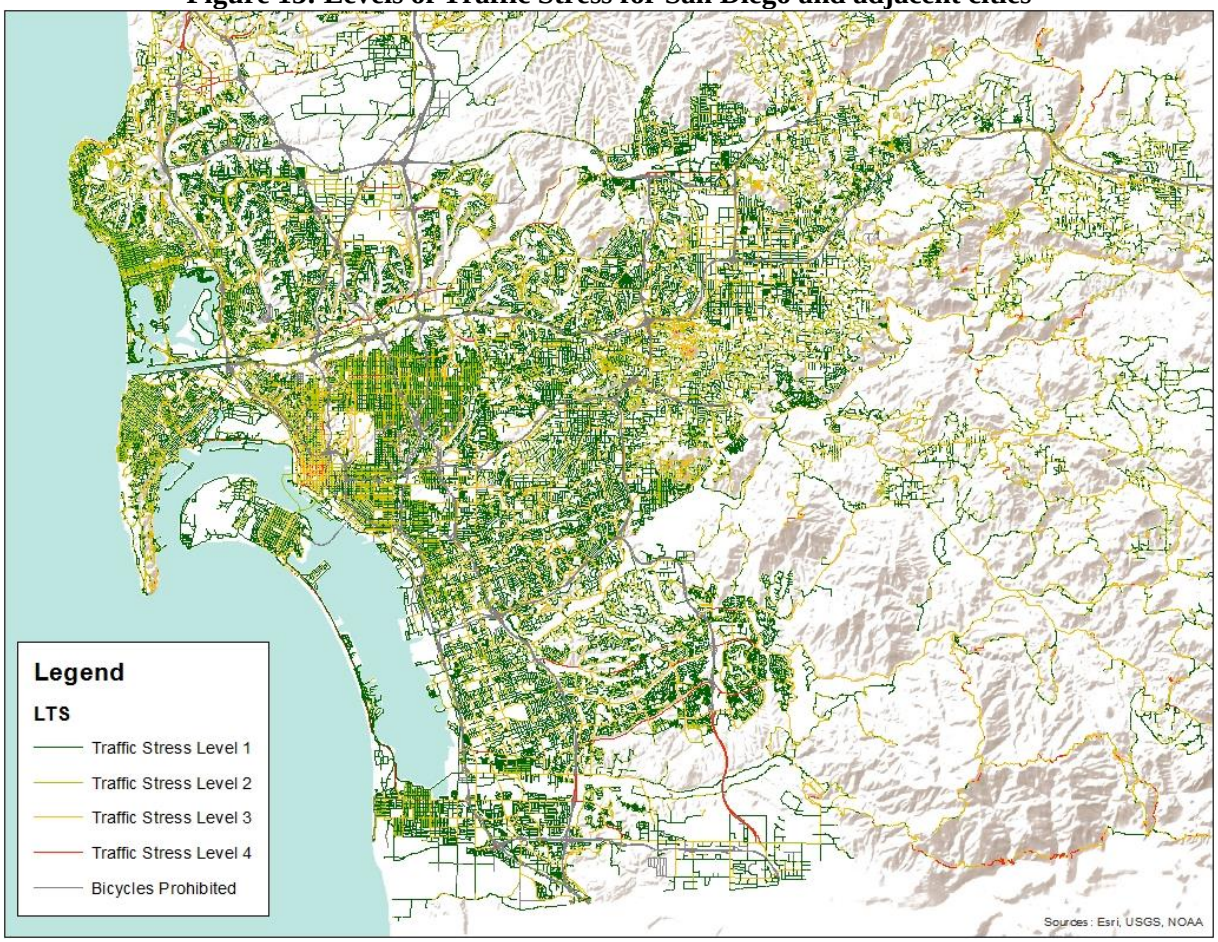


**Figure 13: Levels of Traffic Stress for San Diego and adjacent cities**




## Origin-Destination Matrices for Traffic Stress Levels

Table 8 lists the number of possible origin/destination connections for each traffic stress level within a five-mile radius. Only one route is calculated for each origin/destination pair; where two facilities may be connected by more than one route, only the shortest path is counted in the number of routes. The same set of locations is used for both "origins" and "destinations" in the network origin/destination matrix.

**Table 8: Origin/Destination Results for each LTS**

| | LTS 1 | LTS 1-2 | LTS 1-3 | LTS 1-4 |
|---|---|---|---|---|
| Unlocated Origins | 13,647 | 11,088 | 6,013 | 5,255 |
| Unlocated Destinations | 13,647 | 11,088 | 6,013 | 5,255 |
| Origin/Destination connections available | 264,451 | 1,267,295 | 19,530,570 | 22,758,325 |

Figure 14 through Figure 17 illustrate the routes available for each traffic stress level network in San Diego County, based on origins and destinations provided by the "PLACES" data layer. Each straight line represents an origin-destination connected route.

**Figure 14: San Diego County Origin-Destination Matrix for LTS 1**

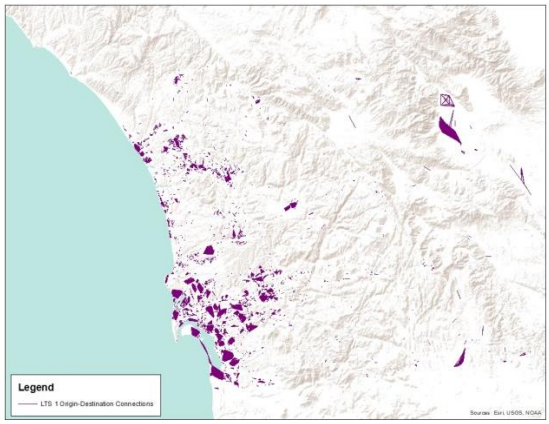



**Figure 15: San Diego County Origin-Destination Matrix for LTS 1-2**

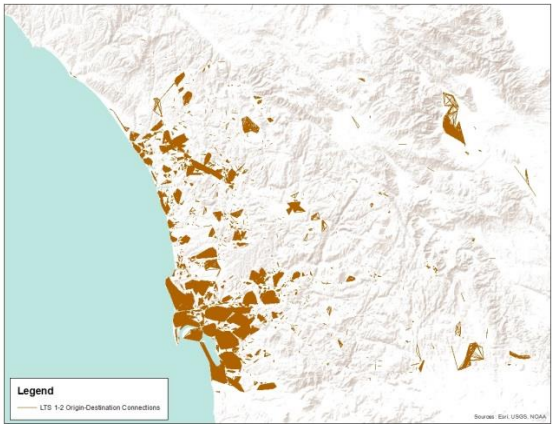



**Figure 16: San Diego County Origin-Destination Matrix for LTS 1-3**

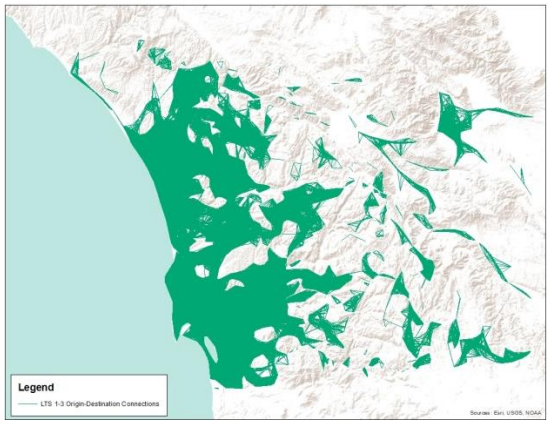



**Figure 17: San Diego County Origin-Destination Matrix for LTS 1-4**

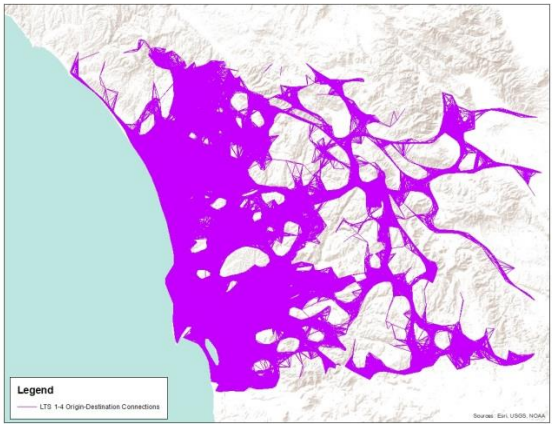



Figure 18 and Figure 19 illustrate available routes for traffic stress level networks in the City of Coronado, with traffic stress networks and origins and destination delineated for each level of traffic stress.

**Figure 18: City of Coronado Origin-Destination Matrix for LTS 1**

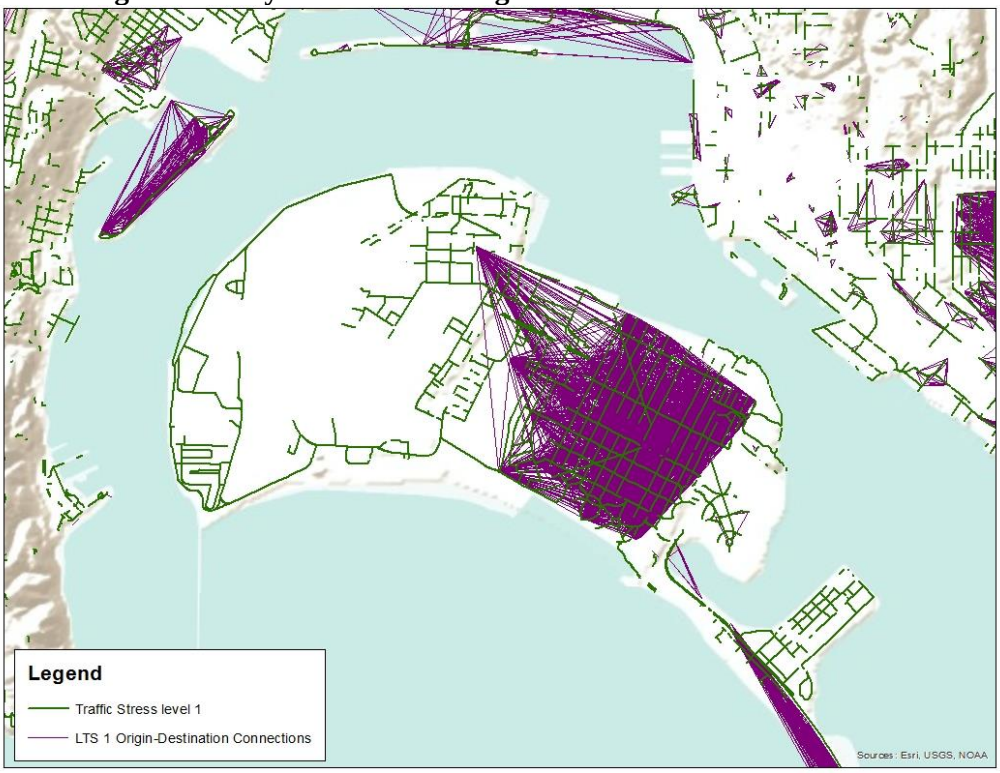
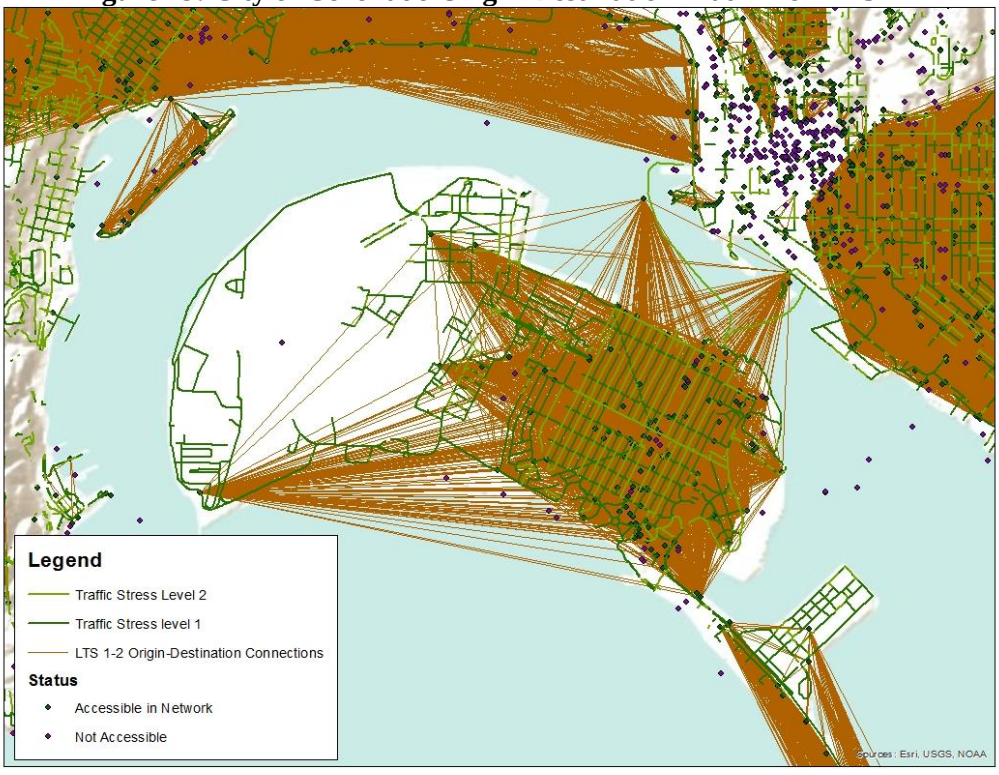



**Figure 19: City of Coronado Origin-Destination Matrix for LTS 1-2**




## Bicycle Travel Demand Comparisons

Figure 21 through Figure 23 compare the traffic stress maps with Strava data for the San Diego region.

**Figure 20: LTS map for San Diego County**

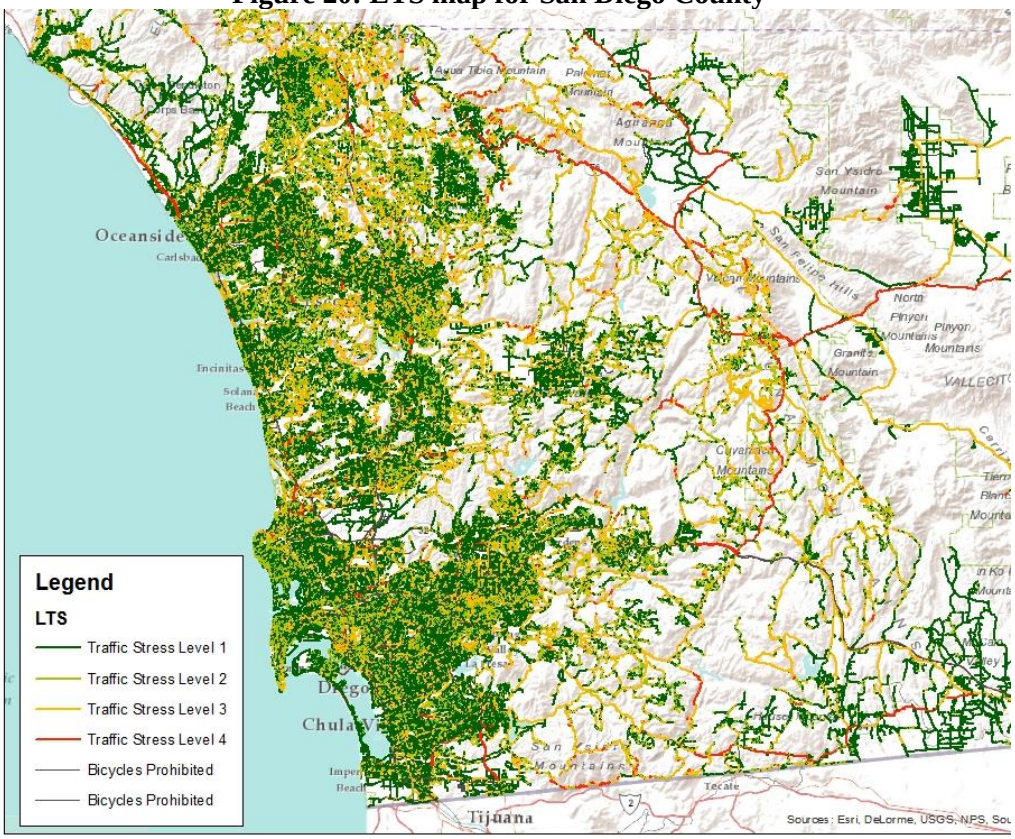



**Figure 21: Strava Heatmap for San Diego County**

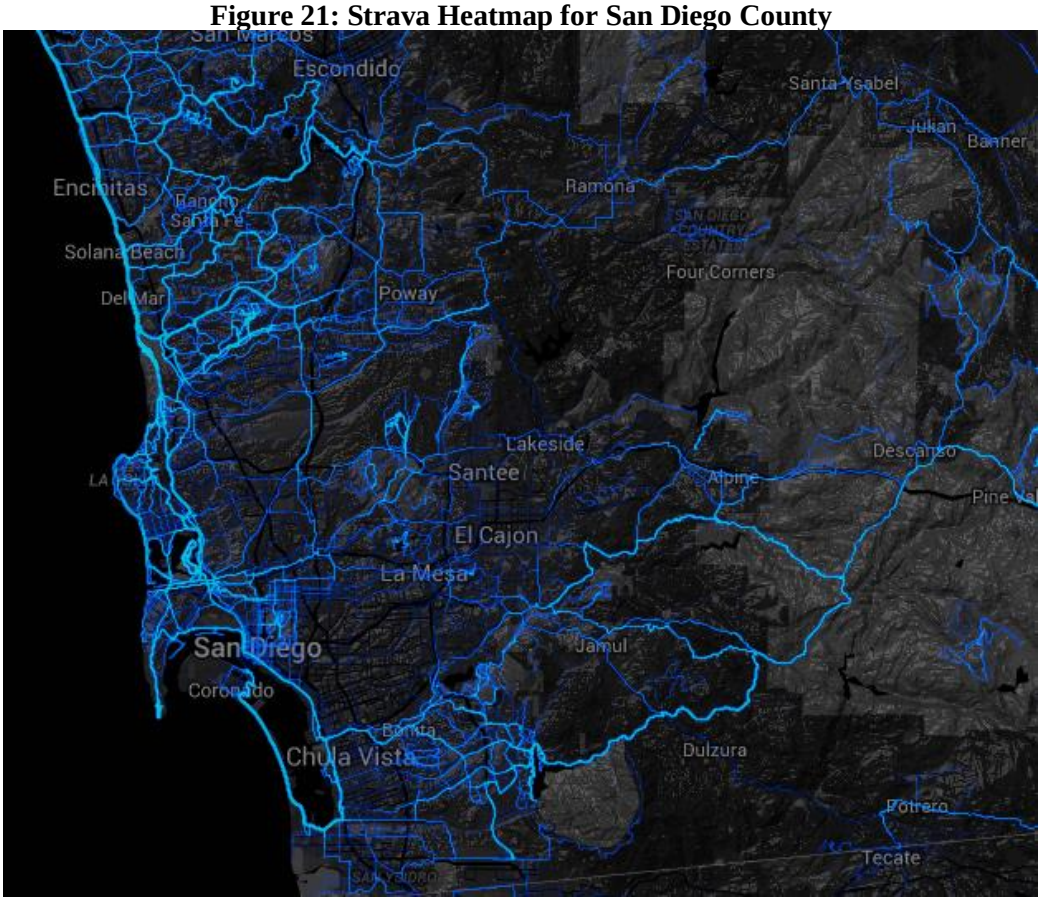


**Figure 22: La Jolla Strava Heatmap and LTS 1-2**

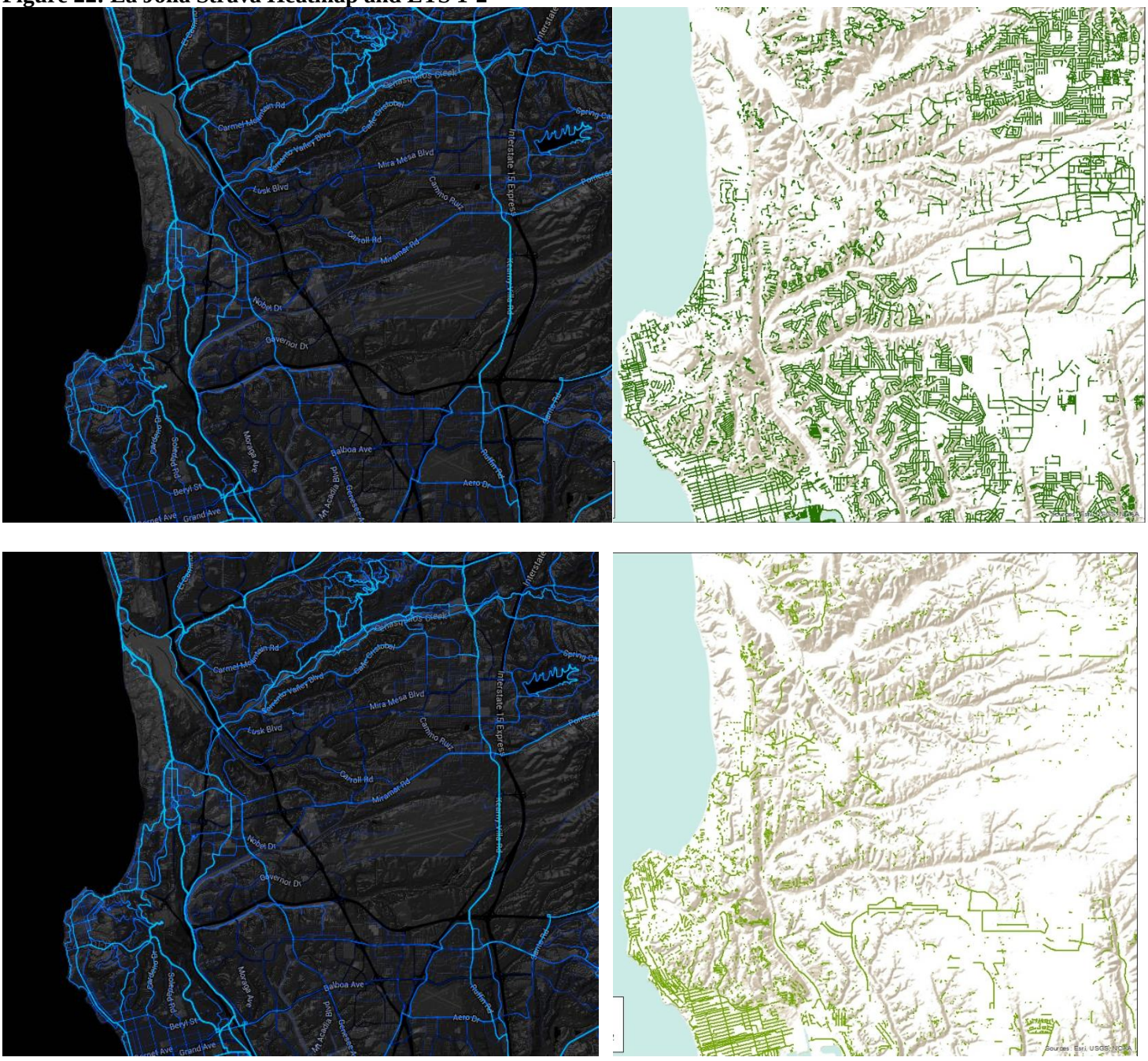
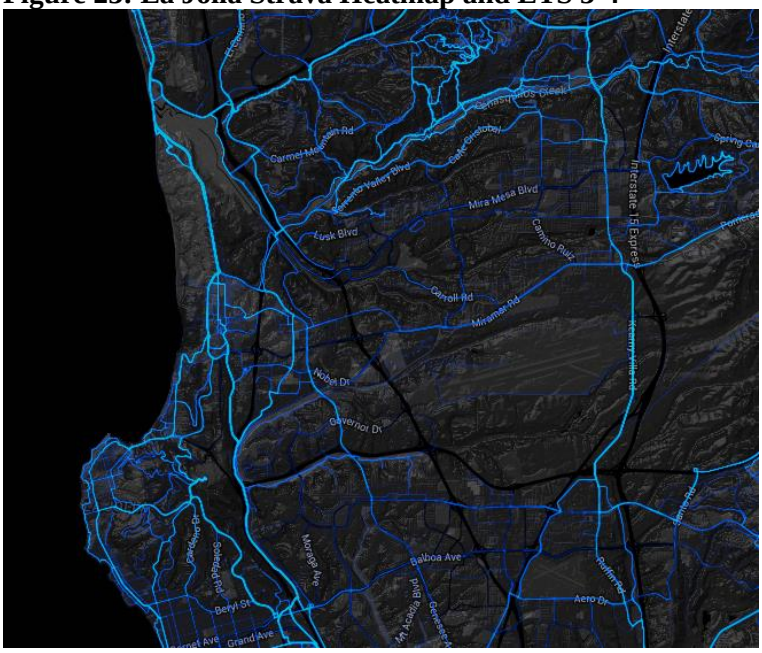
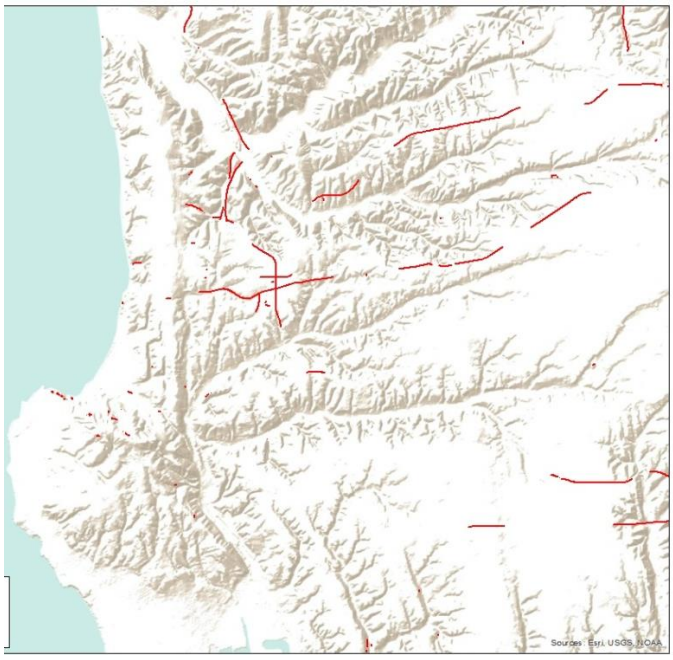


**Figure 23: La Jolla Strava Heatmap and LTS 3-4**





## Discussion

Figure 8 through Figure 23 provide an overall picture of the bicycling experience in San Diego County. As shown in Figure 7, lower stress bicycle facilities tend to cluster in metropolitan and residential areas, while unincorporated and rural areas tend to be predominated by higher stress facilities. Additionally, LTS 1 facilities tend to provide connectivity at the most basic level, while LTS 2 and 3 facilities provide routes between these areas. This is a logical result of the common municipal street structure: small, low-speed local roads make up our neighborhoods, and larger, higher-speed (and higher-stress) arterial roads connect the neighborhoods. Figure 8 provides a clear example of this, illustrating clusters of LTS 1 facilities with no low-stress facilities to connect them. In the origin-destination matrices, Figure 14 through Figure 19 illustrate the exponential gains in mobility a person traveling by bicycle may achieve simply by increasing his or her tolerance for traffic stress. Figure 24 and Figure 25 illustrate the origin-destination matrices for LTS 1-2 and LTS 1-3 for San Diego County.

**Figure 24: San Diego County Origin-Destination Matrix for LTS 1-2**

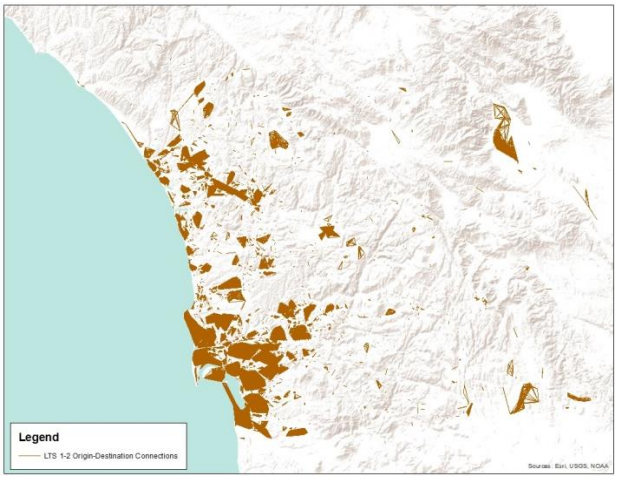
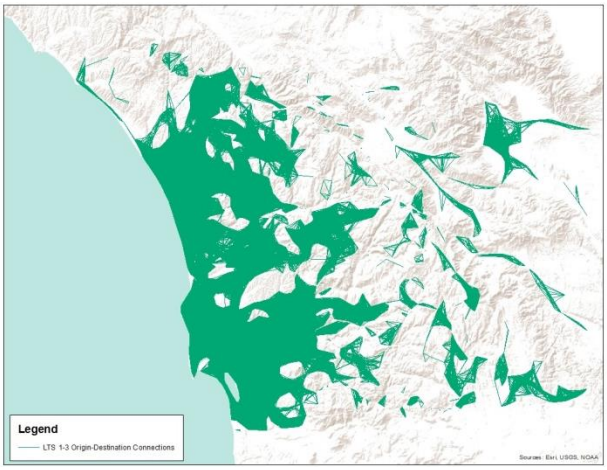



**Figure 25: San Diego County Origin-Destination Matrix for LTS 1-3**




In Figure 26, I added an overlay of the LTS 3 road network to the LTS 1-3 origin-destination matrix. The LTS 1-2 matrix accounts for destinations available through using both the LTS 1 and the LTS 2 networks, and the LTS 1-3 matrix accounts for destinations available using the LTS 1, 2, and 3 networks. By providing regional connections to the roadway network, the LTS 3 facilities provide a dramatic increase in mobility from LTS 1-2 to LTS 1-3. Expanding into the LTS 3 roadway network allows access to over 18 million more destinations than are reachable the LTS 1-2 network alone.

**Figure 26: San Diego County Origin-Destination Matrix for LTS 1-3 with LTS 3 facilities**

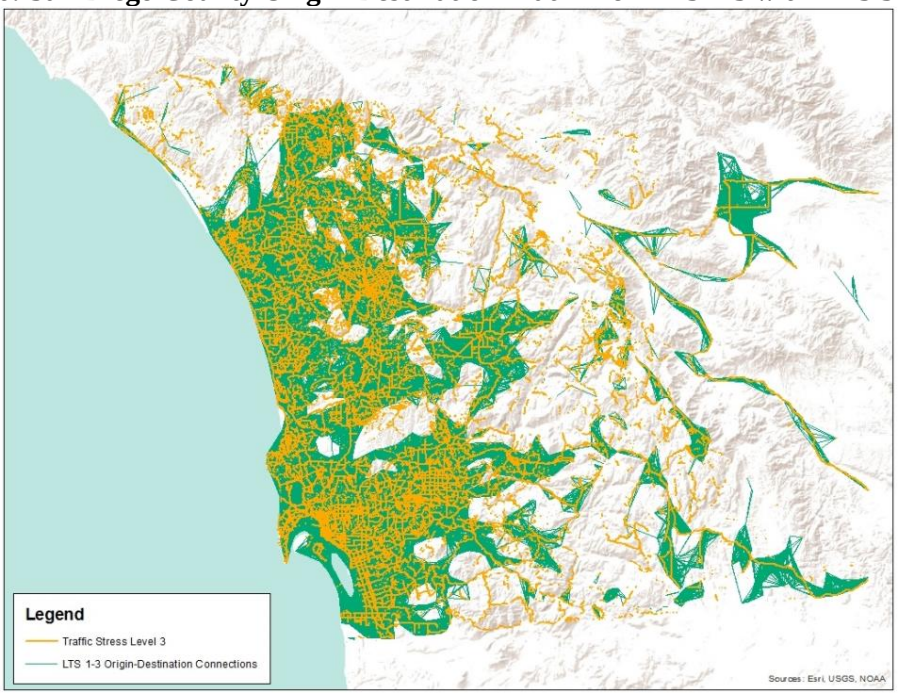
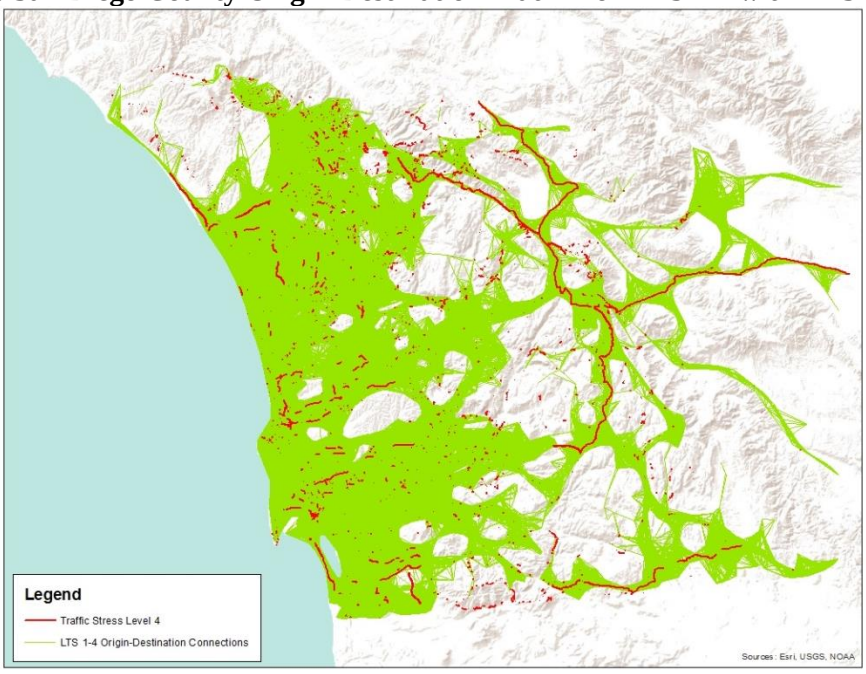



Figure 27 illustrates the increased accessibility gained from expanding into the traffic stress level 4 network. Although there are relatively few LTS 4 facilities compared to LTS 1, 2, and 3, expanding into the LTS 4 network allows for increased connectivity between the lower stress level facilities, allowing an increased number of destinations to be reached.

**Figure 27: San Diego County Origin-Destination Matrix for LTS 1-4 with LTS 4 facilities**



Finally, the Strava heat map indicates a closer correlation with LTS 3 facilities than any other traffic stress network. This relationship is possibly due to the fact that the median cycling skill and traffic comfort level are likely to be higher than those of the San Diego population as a whole, since an individual must actively seek and download the Strava application, which in theory requires some knowledge or personal network associated with cycling. Further, LTS 3 facilities tend to be the most direct roads and offer the largest range of mobility, and are likely to be the main routes used, as half the reported Strava rides are commutes (Strava, 2014). While it would be valuable to show heatmaps indicating that lower stress facilities are the most popular for cycling travel, the lack of this finding is likely due to the lack of connectivity through the lower stress networks. Therefore, it remains plausible that an increase in low-stress connections between low-stress facilities would yield an increase in the number of cycling trips overall.

**Significance of Findings**

This study provides three main outputs: a more detailed picture of San Diego's bicycle network, a close look at the mobility provided by each level of the network, and a snapshot of the current use levels of cycling facilities in San Diego. It also provides a methodology for providing a bicycle stress network, perhaps with better data than was incorporated into this study.

It is well known that interruptions in the bicycle network are commonly encountered by those who ride bicycles on a regular basis. While these interruptions are often dealt with through braving higher-severity traffic conditions or accepting a longer detour to arrive at one's destination, the possibility remains that these route interruptions serve as a deterrent for many from using a bicycle for transportation or even recreation. Understanding what contributes to traffic stress for individuals on bicycles, and including these factors in the bicycle network, provides a much clearer picture of what facilities are actually available for travel.

**Limitations of this Study**

*Excluded data*

Perhaps the largest limitation of this study is that it does not account for some of the variables studies have shown to be the largest influences of cyclists' levels of traffic stress. These

variables are discussed under Research Design and include pavement quality, traffic volumes, and bicycle facility widths, among others.

In addition, the lack of sufficient data about bicycle paths – namely their widths and pavement quality – cause this study to treat all bicycle paths as equal facilities but for slope steepness, when in fact bicycle paths can vary widely in LTS due path width and pavement quality, as well as a number of factors including lighting, nearby crime rates, and vegetation encroaching into the cycling space.

*Data integrity of point locations*

SanGIS's "PLACES" data layer provides a useful mechanism for examining a range of possible origins and destinations that included a variety of land use types, as well as a set of locations geographically dispersed throughout the San Diego Region. However, because the data is combined from an assortment of GIS layer types for a variety of intended uses, some of the data points are not truly potential destinations available to an individual riding a bicycle. For example, the dataset contains "harbor" and "extractive industrial" land use types that are in some instances plotted by ArcGIS as located in the Pacific Ocean.

*Limitations of Origin-Destination Matrix Model*

Figure 19 and illustrates instances in which the destinations described above are captured as possible trips, since the Coronado Ferry, an available travel choice for bicyclists, is included as a LTS 1 facility. Because the origin-destination model considers any point within 200 feet of a network dataset to be accessible, travel points adjacent to the Coronado Ferry route were included as viable travel destinations by bicycle. The model considers points along a network to be accessible from that network regardless of their position on the line segment (i.e. at the end or in the middle), because a bicyclist may in theory choose to stop at any point along an ordinary street. This logic, of course, becomes flawed in the ferry scenario, as the ferry does not make stops along its route. However, these instances represent a minority of cases within the travel model, as the ferry is the only non-bicycle route included in the network analysts, and is included because it is considered part of the bicycle network in the "Bike_Routes" dataset. The number of trips identified for each traffic stress level is a fraction of trips available for the region since not all possible destinations are captured in the "PLACES" layer, and since the trips are capped

at a five-mile length and do not account for inclusion of other modes of travel. The model is not intended to illustrate the total number of trips possible, but instead to provide a comparison between the mobility levels of each traffic stress network, and to illustrate the relative mobility gains yielded by expanding into a higher stress network.

*Possible Strava skew*

Although approximately half of the cycling trips represented in Strava Heatmaps are commute trips (Strava, 2014), it can be reasonably expected that most individuals new to cycling or who cycle infrequently are not represented among Strava's users. It can further be expected that the median and mean traffic stress tolerances represented by Strava users may be slightly higher than the median and mean traffic stress levels tolerated by the County of San Diego population as a whole. Data at this level is not currently available; however, it would be useful for future studies to create heat maps based on general travel demand of the overall San Diego population.

*Intersections*

Mekuria et al. pointed out that when a low traffic stress facility crosses a higher stress facility, individuals with a low tolerance for traffic stress may be deterred from even crossing the intersection, diminishing the number of trips available. The San José study conducted by Mekuria et al. accounts for this by excluding higher stress facility crossings from the available trips in their traffic stress model. In this study, such interruptions are not counted as barring potential trips because employing this capability would require modeling and data manipulation that were not feasible under the time constraints. Figure 28 illustrates that higher stress crossings do not "interrupt" a lower stress facility in this study.

**Figure 28: LTS 2 and LTS 3 Intersection**

# Conclusion

The San Diego region presents ample opportunities for recreational and transportation cycling through its year-round temperate climate and its active culture. While jurisdictions within the region express the importance of providing quality facilities to increase cycling, performance is usually measured based on the facility type, which does not account for other factors that influence whether the facilities are used. This research demonstrates that roadway attributes can be used to generate maps that provide a greater picture of the bicycling experience for an area.

Intuitively, based on traffic speed, bicycle facility type, and slope grade, the current system provides the greatest mobility to the bravest cyclists. However, this study's findings provide San Diego planners the opportunity to develop measures that help provide equitable facilities for all individuals riding bicycles. With development of a low-stress network that provides adequate mobility to each user type, San Diego has the potential to meet its goals of improving cycling as a viable mode of transportation, and of increasing the number of cycling trips throughout the region.

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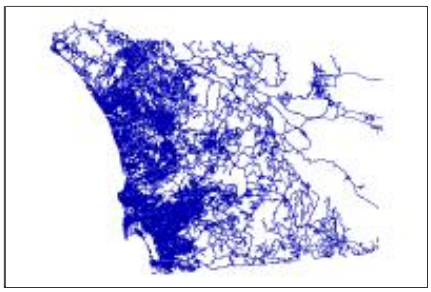
# Appendix A

**SanGIS Shapefile Metadata**

# ROADS_ALL



## Tags

Roads, San Diego County, Transportation, Freeway, Highway, Collector, Arterial, Streets

## Summary:

This dataset comprises centerline segments for roads (both active and inactive, public and private, constructed or of record) in San Diego County based on data received from all official jurisdictions within the County (the County and 18 cities).

## Feature Type: Line

## Number of Records: 158254

## Publication Date: 2015-06-02

## Date of Data (Temporal Period Extent): 2015-06-02

## Extent: The spatial extent of this dataset is San Diego County. The temporal extent is variable.

### Extent in Longitude Latitude

**North** 33.509492
**West** -117.597058 **East** -116.080209
**South** 32.530639

### Extent in the item's coordinate system

**North** 2129010.001133
**West** 6151037.000000 **East** 6613422.000000
**South** 1775474.668000

## Description:

This dataset comprises road centerlines for all roads in San Diego County. Road centerline information is collected from recorded documents (subdivision and parcel maps) and information provided by local jurisidictions (Cities in San Diego County, County of San Diego). Road names and address ranges are as designated by the official address coordinator for each jurisidcition. Jurisdictional information is created from spatial overlays with other data layers (e.g. Jurisdiction, Census Tract).
The layer contains both public and private roads. Not all roads are shown on official, recorded documents. Centerlines may be included for dedicated public

roads even if they have not been constructed. Public road names are the official names as maintained by the addressing authority for the jurisdiction in which the road is located. Official road names may not match the common or local name used to identify the road (e.g. State Route 94 is the official name of certain road segments commonly referred to as Campo Road).
Private roads are either named or unnamed. Named private roads are as shown on official recorded documents or as directed by the addressing authority for the jurisdiction in which the road is located. Unnamed private roads are included where requested by the local jurisidiction or by SanGIS JPA members (primarily emergency response dispatch agencies).
Roads are comprised of road segments that are individually identified by a unique, and persistent, ID (ROADSEGID). Roads segments are terminated where they intersect with each other, at jurisdictional boundaries (i.e. city limits), certain census tract and law beat boundaries, at locations where road names change, and at other locations as required by SanGIS JPA members. Each road segment terminates at an intersection point that can be found in the ROADS_INTERSECTION layer.
Road centerlines do not necessarily follow the centerline of dedicated rights-of-way (ROW). Centerlines are adjusted as needed to fit the actual, constructed roadway. However, many road centerline segments are created intially based on record documents prior to construction and may not have been updated to meet as-built locations. Please notify SanGIS if the actual location differs from that shown. See the SanGIS website for contact information and reporting problems (http://www.sangis.org/contact/problem.html).
Note, the road speeds in this layer are based on road segment class and were published as part of an agreement between San Diego Fire-Rescue, the San Diego County Sheriff's Department, and SanGIS. The average speed is based on heavy fire vehicles and may not represent the posted speed limit.

## Credits:

SanGIS using information from documents recorded with the County of San Diego and the addressing authorities in the 18 cities in San Diego County.

## Use Limitation:

Data is generalized and created for use in regional projects. Please refer to SanGIS GIS data end user use agreement and disclaimer which is available at the following: http://www.sangis.org/Legal_Notice.htm.
See Metadata Description item for futher information.

## Topics and Keywords

### Topic Categories: Planning Cadastral Transportation

### Themes:

Roads, Streets, Transportation, Routes, Centerlines, Highways, Freeways, Expressways, Collector

### Places:

California, County of San Diego, Carlsbad, Coronado, Chula Vista, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, Lemon Grove, La Mesa, National City, Oceanside, Poway, San Diego, San Marcos, Solana Beach,

Santee, Vista

## Resource Details:

Status: On Going
Type: Vector
Update Frequency: Weekly
Next Update: 2014-09-05

## Spatial Reference System:

Type: Projected
Reference: GCS_North_American_1983
Projection: NAD_1983_StatePlane_California_VI_FIPS_0406_Feet

Identifier: 2230
Codespace: EPSG
Version: 7.11.2

## Contacts:

### Point of Contact

Operations Manager, Operations Manager
SanGIS
5510 Overland Ave, Suite 230
San Diego, California. 92123

webmaster@sangis.org
(858) 874-7000

### Distributor

SanGIS
5510 Overland Avenue, Suite 230
San Diego, California. 92123
Data Librarian
Data Librarian
webmaster@sangis.org
(858) 874-7000

## Distribution Ordering Instructions:

Refer to SanGIS website (http://www.sangis.org/services/index.html) to obtain further information on mapping and data extraction services available from SanGIS.

## Online Ordering Description:

The roads_all dataset is available for download as shapefile from http://www.sangis.org/download.index.html and roads can also be viewed on the SanGIS interactive webmap (http://sdgis.sandag.org;)

## Fields:

### Overview:

Road segments are uniquely identified by the road segment identifier (ROADSEGID). This attribute is persistent over time. There are over 65 attributes for each road segment. These attributes provide information in 5 general categories:

Coordinate Values (12 attributes) - To/From and mid-point X and Y coordinates of segment and a pseudo-elevation value at each end of the segment. Coordinate value attributes are:
F_LEVEL, T_LEVEL, FNODE, TNODE, FRXCOORD, TOXCOORD, FRYCOORD, TOYCOORD, MIDXCOORD, MIDYCOORD, NAD83E, NAD83N

Address Range (8 attributes) - Low and high addresses on left and right sides of segment. Left/Right is defined by the direction of the segment as determined by the address range. Road direction is from low to high address. Address range attributes are:
ABHIADDR, ABLOADDR, LHIGHADDR, RHIGHADDR, LLOWADDR, RLOWADDR, LMIXADDR, RMIXADDR

Road Name (10 attributes) - Official road name component values. Fields are provided for systems that allow a maximum of 20 characters in a road name or 30 characters in the name component. Official road names are abbreviated to 20 or 30 characters if needed (road names only not including pre- and post-direction and suffix/types). Road names are assigned based on the ROADID value. ROADID is referemce to the road name maintained by SanGIS in a road name table. All roads with the same ROADID will have the same road name values. Road name attributes are:
RD20FULL, RD20PRED, RD20NAME, RD20SFX, RD30FULL, RD30PRED, RD30POSTD, RD30NAME, RD30SFX, ROADID

Jurisdiction Overlays (14 attributes) - Values calculated from a spactial overlay of the road segment with various jurisdictional layers maintained by SanGIS. Jurisdiction overlays are provided for left and right sides of the segment. Left/Right is defomed by the direction of the segment as determined by the address range. Road direction is from low to high address. Left/Right overlay values are calculated based on a point that is 7 ft left or right of the segment midpoint. All other overlays are calculated at the midpoint of the segment. Jurisdictional overlay attributes are:
L_BEAT, R_BEAT, L_BLOCK, R_BLOCK, L_PSBLOCK, R_PSBLOCK, L_TRACT, R_TRACT, L_ZIP, R_ZIP, LJURISDIC, RJURISDIC, LPSJUR, RPSJUR

Segment Specfic (21 attributes) - All attributes that are specific to the road segment and not included in the categories above. These values are assigned by SanGIS based on rules specified by SanGIS JPA member agencies.

### Citation:

SanGIS. Contact SanGIS for additional information on any attribute. Refer to ROADS_INTERSECTION for road segment termination types.

**__FID (OID)**

Internal feature number.

**ROADSEGID (Double)**

Road segment indentifier. Unique key to road segment. Persistent over time.

**RULEID (Double)**
This field is created by ArcGIS as part of the Feature Class Representation.

**L_BEAT (Integer)**
Law (police) beat number on left side of road.
Value derived from a spatial overlay of the LAW_BEATS layer at a point 7' left of the segment midpoint.

**POSTDATE (Date)**
Identifies last date that road segment was changed

**LPSJUR (String)**
Public safety jurisdiction code on left side of road.
Value derived from a spatial overlay of the JUR_PUBLIC_SAFETY layer at a point 7' left of the segment midpoint.

Code; Description
CB; Carlsbad
CN; Unincorporated
CO; Coronado
CV; Chula Vista
DM; Del Mar
EC; El Cajon
EN; Encinitas
ES; Escondido
IB; Imperial Beach
LG; Lemon Grove
LM; La Mesa
NC; National City
OC; Oceanside
PW; Poway
SD; San Diego
SM; San Marcos
SO; Solana Beach
ST; Santee
VS; Vista

**PENDING (String)**
Recording status indicator of map creating this road segment
Y=yes, recording pending
N=no, map recorded or not available

**R_ZIP (Double)**
Five digit zip code number on right side of road.
Value derived from a spatial overlay of the ZIPCODE layer at a point 7' right of the segment midpoint.

**TNODE (Double)**
ID of the intersection point at the TO point (end) of the segment. Refers to the unique intersection point ID attribute (INTERID) in the ROADS_INTERSECTION layer.
Each road segment has an associated intersection point at the start and end

points.

**RHIGHADDR (Double)**
Highest address value on the right side of the road.
Generally the value at the TO (end) node.

**ROADID (Double)**
Road name identifier. Refers to the unique ROADID in the SanGIS road name table. Road name components are assigned to a segment based on a lookup by ROADID in the road name table. All segments with the same ROADID value make up a "road" in the more general sense.

**DEDSTAT (String)**
Dedication status

Code; Description
A; Abandoned
D; Dedicated
L; Dedicated, but unofficially named Alley
O; Offer for dedication (street reservation)
P; Private street
Q; Undocumented
U; Undedicated

**SEGSTAT (String)**
Road segment status

Code; Description
A; Approved
C; Constructed
M; Maintained
R; Recorded
T; Tentative

**NAD83E (Double)**
California State Plane Zone 6, NAD83 Easting (X) coordinate at the FROM (start) node

**ONEWAY (String)**
One way street code
Code; Description
F; Addresses increases in same direction as traffic flow
T; Addresses increase in opposite direction of traffic flow
Null; Two-way streets

**NAD83N (Double)**
California State Plane Zone 6, NAD83 Northing (Y) coordinate at the FROM (start) node

**SUBDIVID (Double)**
SanGIS subdivision ID (links to SUBDIVISION layer).
Field updated by spatial join with Subdivision layer or added by editor from

LOTS layer. Not populated for all segments.

**RD20SFX (String)**

Road Suffix (aka street type) for 20 character road name abbreviations - always two letters

Code; Description
AL; ALLEY
AR; ARCADE
AV; AVENUE
BL; BOULEVARD
BP; BIKEPATH
BR; BRIDGE
BY; BYPASS
CE; CORTE
CG; CROSSING
CP; CAPE
CR; CIRCLE
CS; CRESCENT
CT; COURT
CV; COVE
CY; CAUSEWAY
DR; DRIVE
DY; DRIVEWAY
EX; EXTENSION
EY; EXPRESSWAY
FR; FERRY
FY; FREEWAY
HY; HIGHWAY
IN; INTERCHANGE
LN; LANE
LP; LOOP
ML; MALL
PA; PATH
PE; POINTE
PL; PLACE
PS; PASS
PT; POINT
PY; PARKWAY
PZ; PLAZA
RA; RAMP
RD; ROAD
RW; ROW
SQ; SQUARE
ST; STREET
TL; TRAIL
TR; TERRACE
TT; TRUCKTRAIL
WK; WALK
WY; WAY

**LLOWADDR (Double)**

Lowest address value on the left side of the road.
Generally the value at the FROM (start) node.

**F_LEVEL (Integer)**

Psuedo elevation value at the FROM (start) node of the segment.
The F_LEVEL (from level) AND T_LEVEL (to level) attributes define relative vertical separation between road segments. Values range from 0 to 9 with 0 defining a road segment below ground level and level 1 are road segments usually at ground level. Values 2 to 9 define a relative vertical separation to the base ground level road segment. Value 2 segments would be above a value 1 segment but lower than a value 3 segments. An example would be the I-805/I-8 interchange across Mission Valley where the F_LEVEL and T_LEVEL values for the road segments through the interchange range from 1 to 4. An individual road segment can have different F_LEVEL and T_LEVEL values indicating a transition between vertical separations.

**RD30SFX (String)**

Abbreviated street name suffix (aka street type) for 30 character road names. That is, the part of the road name that describes the type of street. Up to four letter abbreviations are used according to the SanGIS standards manual as shown below. Does not necessarily match with US Postal Service suffix designations.

ALY: ALLEY
ARC: ARCADE
AVE: AVENUE
BP: BIKEPATH
BLVD: BOULEVARD
BRG: BRIDGE
BYP: BYPASS
CSWY: CAUSEWAY
CIR: CIRCLE
CTE: CORTE
CT: COURT
CV: COVE
CRES: CRESCENT
XING: CROSSING
DR: DRIVE
DRWY: DRIVEWAY
EXPY: EXPRESSWAY
EXT: EXTENTION
FRY: FERRY
FWY: FREEWAY
GLEN: GLEN
HWY: HIGHWAY
INTR: INTERCHANGE
LN: LANE
LOOP: LOOP
MALL: MALL
PKY: PARKWAY
PASS: PASS
PATH: PATH
PL: PLACE
PLZ: PLAZA
PT: POINT
PTE: POINTE
RAMP: RAMP
RD: ROAD
ROW: ROW
SQ: SQUARE
ST: STREET

TER: TERRACE
TRL: TRAIL
TKTL: TRUCKTRAIL
WALK: WALK
WAY: WAY

**RD30PRED (String)**

One or two character abbreviation for pre-direction component (direction preceeding the road name) of road names abbreviated to 30 characters.

E; East
N; North
S; South
W; West
NE; Northeast
NW; Northwest
SE; Southeast
SW; Southwest

**RD20PRED (String)**

One character abbreviation for pre-direction component (direction preceeding road name) of road names abbreviated to 20 characters.

E; East
N; North, Northwest or Northeast
S; South, Southwest or Southeast
W; West

**TOXCOORD (Double)**

X (Easting) coordinate of the end (TO) point of the segment. California State Plane, Zone 6, NAD83

**MIDXCOORD (Double)**

X (Easting) coordinate of the mid-point of the segment. California State Plane, Zone 6, NAD83

**SPEED (Integer)**

Average driving speed based on segment classification (SEGCLASS). This attribute is not intended to be the posted speed limit for the roads segment. SPEED is established by emergency vehicle dispatch agencies generally based on heavy fire vehicles in order to allow the Fire Department to determine realistic response times.

**FRYCOORD (Double)**

Y (Northing) coordinate of the start (FROM) point of the segment. California State Plane, Zone 6, NAD83

**FRXCOORD (Double)**

X (Easting) coordinate of the start (FROM) point of the segment. California State Plane, Zone 6, NAD83

**L_TRACT (Double)**

US 2010 census tract number on left side of road.
Value derived from a spatial overlay of the CENSUS_TRACT layer at a point 7' left of the segment midpoint.

### R_TRACT (Double)

US 2010 census tract number on right side of road.
Value derived from a spatial overlay of the CENSUS_TRACT layer at a point 7' right of the segment midpoint.

### CARTO (String)

Cartographic display indicator. Used to provide more appropriate cartographic representation. Generally the same as SEGCLASS. Not rigorously maintained.

Code; Description
1; Freeway/Expressway
2; Highway/State Routes
3; Minor Highway/Major Roads
4; Arterial or Collector
5; Local Street
6; Unpaved Road
7; Private Road
8; Freeway Transition Ramp
9; Freeway On/Off Ramp
A; Alley
H; Speed Hump
M; Military Street within Base
P; Paper Street
Q; Undocumented
W; Walkway

### SEGCLASS (String)

Segment class

Code; Description
1; Freeway/Expressway
2; Highway/State Routes
3; Minor Highway/Major Roads
4; Arterial or Collector
5; Local Street
6; Unpaved Road
7; Private Road
8; Freeway Transition Ramp
9; Freeway On/Off Ramp
A; Alley
H; Speed Hump
M; Military Street within Base
P; Paper Street
Q; Undocumented
W; Walkway
Z; Named Private Street

### RD20NAME (String)

Official road name abbreviated to 20 characters according to rules established in the SanGIS policy and procedures manual. Attribute

maintained for compatibiltiy by older systems with limited length fields.

**T_LEVEL (Integer)**

Psuedo elevation value at the TO (end) node of the segment.
The F_LEVEL (from level) AND T_LEVEL (to level) attributes define relative vertical separation between road segments. Values range from 0 to 9 with 0 defining a road segment below ground level and level 1 are road segments usually at ground level. Values 2 to 9 define a relative vertical separation to the base ground level road segment. Value 2 segments would be above a value 1 segment but lower than a value 3 segments. An example would be the I-805/I-8 interchange across Mission Valley where the F_LEVEL and T_LEVEL values for the road segments through the interchange range from 1 to 4. An individual road segment can have different F_LEVEL and T_LEVEL values indicating a transition between vertical separations.

**RD30FULL (String)**

Road full name including pre-direction, suffix (type), and post-direction indicators. Road name component abbreviated to 30 characters per SanGIS policy and procedure manuals. Full field limited to 41 characters (2 each for pre- and post-direction, 4 for suffix, 30 for name, plus spaces)

Note that there are only a few road segments in the county that have road names longer than 30 characters

**RD30POSTD (String)**

One or two character abbreviation for post-direction component (direction following the road name or suffix) of road names abbreviated to 30 characters.

E; East
N; North
S; South
W; West
NE; Northeast
NW; Northwest
SE; Southeast
SW; Southwest

**RD30NAME (String)**

Offical name of road abbreviate to 30 characters. Does not include pre- and post-direction or suffix components.

Note that there are very few road names in the county that exceed 30 characters in length.

**R_BEAT (Integer)**

Law (police) beat number on right side of road.
Value derived from a spatial overlay of the LAW_BEATS layer at a point 7' right of the segment midpoint.

**MIDYCOORD (Double)**

Y (Northing) coordinate of the mid-point of the segment. California State Plane, Zone 6, NAD83

**ADDSEGDT (Date)**
Date road segment was created

**TBMGRID (String)**
Thomas Brothers Map grid designation. Letter value indicates row and number value indicates column.

**FIREDRIV (String)**
Fire drivability as established by San Diego Fire-Rescue department. Used for routing. Exclusively for use by San Diego Fire-Rescue

Code: Description
Y; Yes
N; No

**TBMPAGE (String)**
Thomas Brothers Map page number created by an overlay of the mid-point of the road segment with the Thomas Brothers Map page layer.

**R_BLOCK (Double)**
US 2010 census block number on right side of road.
Value derived from a spatial overlay of the CENSUS_BLOCK layer at a point 7' right of the segment midpoint.

**L_BLOCK (Double)**
US 2010 census block number on left side of road.
Value derived from a spatial overlay of the CENSUS_BLOCK layer at a point 7' left of the segment midpoint.

**RJURISDIC (String)**
Jurisdiction code on right side of road.
Value derived from a spatial overlay of the JUR_MUNICIPAL layer at a point 7' right of the segment midpoint.

Code; Description
CB; Carlsbad
CN; Unincorporated
CO; Coronado
CV; Chula Vista
DM; Del Mar
EC; El Cajon
EN; Encinitas
ES; Escondido
IB; Imperial Beach
LG; Lemon Grove
LM; La Mesa
NC; National City
OC; Oceanside
PW; Poway
SD; San Diego
SM; San Marcos
SO; Solana Beach
ST; Santee

VS; Vista

**L_ZIP (Double)**

Five digit zip code number on left side of road.
Value derived from a spatial overlay of the ZIPCODE layer at a point 7' left of the segment midpoint.

**FNODE (Double)**

ID of the intersection point at the FROM point (start) of the segment. Refers to the unique intersection point ID attribute (INTERID) in the ROADS_INTERSECTION layer.
Each road segment has an associated intersection point at the start and end points.

**RIGHTWAY (Integer)**

Width of right-of-way

**LJURISDIC (String)**

Jurisdiction code on right side of road.
Value derived from a spatial overlay of the JUR_MUNICIPAL layer at a point 7' right of the segment midpoint.

Code; Description
CB; Carlsbad
CN; Unincorporated
CO; Coronado
CV; Chula Vista
DM; Del Mar
EC; El Cajon
EN; Encinitas
ES; Escondido
IB; Imperial Beach
LG; Lemon Grove
LM; La Mesa
NC; National City
OC; Oceanside
PW; Poway
SD; San Diego
SM; San Marcos
SO; Solana Beach
ST; Santee
VS; Vista

**RPSJUR (String)**

Public safety jurisdiction code on right side of road.
Value derived from a spatial overlay of the JUR_PUBLIC_SAFETY layer at a point 7' right of the segment midpoint.

Code; Description
CB; Carlsbad
CN; Unincorporated
CO; Coronado
CV; Chula Vista
DM; Del Mar

EC; El Cajon
EN; Encinitas
ES; Escondido
IB; Imperial Beach
LG; Lemon Grove
LM; La Mesa
NC; National City
OC; Oceanside
PW; Poway
SD; San Diego
SM; San Marcos
SO; Solana Beach
ST; Santee
VS; Vista

**Shape (Geometry)**
Feature geometry shape (multipoint, polyline, or polygon)

**TOYCOORD (Double)**
Y (Northing) coordinate of the end (TO) point of the segment. California State Plane, Zone 6, NAD83

**OBMH (String)**
On base military housing indicator (Y=yes or N=no)

**LHIGHADDR (Double)**
Highest address value on the left side of the road. Generally the value at the TO (end) node.

**ABHIADDR (Double)**
Absolute high address of road segment regardless of left or right side.

**FUNCLASS (String)**
Functional Class

Code; Description
1; Freeway to freeway ramp
2; Light (2-lane) collector street
3; Rural collector road
4; Major road/4-lane major road
5; Rural light collector/local road
6; Prime (primary) arterial
7; Private street
8; Recreational parkway
9; Rural mountain road
A; Alley
B; Class I bicycle path
C; Collector/4-lane collector street
D; Two-lane major street
E; Expressway
F; Freeway
L; Local street/cul-de-sac
M; Military street within base

P; Paper street
Q; Undocumented
R; Freeway/expressway on/off ramp
S; Six-lane major street
T; Transitway
U; Unpaved road
W; Pedestrianway/bikeway

**R_PSBLOCK (Double)**
Public Safety Census Block

Value derived from a 7' offset from the midpoint of the road centerline to the SanGIS pseudo Census Blocks layer right of the road centerline.

These are "Pseudo" census blocks created by SanGIS and used exclusively for San Diego Police Department crime statistics. Usually the PSBLOCK will be the same as the census block but in some cases the census block is divided into two or more smaller portions so that no block spans two police beats. The Pseudo blocks are not published in the regular census block layer.

**TBMQUAD (String)**
Thomas Brothers quad value. Incomplete and no longer maintained. Thomas Bothers no longer publishes quad values. Attribute retained for use by legacy systems.

**POSTID (String)**
SanGIS internal identifier for last person or process to change road segment

**RD20FULL (String)**
Road full name including pre-direction and suffix (type). Road name component abbreviated to 20 characters per SanGIS policy and procedure manuals. Full field limited to 25 characters (1 for pre-direction, 2 for suffix, 20 for name, plus spaces). Post direction indicator is not included.

Maintained for legacy system compatibility.

**L_PSBLOCK (Double)**
Public Safety Census Block

Value derived from a 7' offset from the midpoint of the road centerline to the SanGIS pseudo Census Blocks layer left of the road centerline.

These are "Pseudo" census blocks created by SanGIS and used exclusively for San Diego Police Department crime statistics. Usually the PSBLOCK will be the same as the census block but in some cases the census block is divided into two or more smaller portions so that no block spans two police beats. The Pseudo blocks are not published in the regular census block layer.

**RLOWADDR (Double)**
Lowest address value on the right side of the road.
Generally the value at the FROM (start) node.

**RMIXADDR (String)**

Indicator showing whether odd and even (mixed) address are both shown on the right side of road.
Y=yes - right side addresses are both odd and even numbers
N=no - right side addresses are only odd or only even numbers

**ABLOADDR (Double)**
Absolute low address of road segment regardless of left or right side.

**LMIXADDR (String)**
Indicator showing whether odd and even (mixed) address are both shown on the left side of road.
Y=yes - left side addresses are both odd and even numbers
N=no - left side addresses are only odd or only even numbers

**LENGTH (Double)**
Road segment length

**SHAPE_LEN (Double)**

## Metadata Last Update: 2015-06-02

Regional GIS Data Warehouse (RGDW) Publication Stylesheet 1.4

# BIKE_ROUTES

## Tags

SANDAG, San Diego, Bike, Bike Routes, Bike Facilities, Bike Network, Bike Map, Go By Bike

## Summary:

Existing (2015) Bike facilities in the San Diego Region. This dataset was developed for the primary purpose of updating the SANDAG San Diego Regional Bike Map and the interactive bike map on the iCommute website.

## Feature Type: Line

## Number of Records: 15815

## Publication Date: 2015-04-10

## Date of Data (Temporal Period Extent): 2015-04-01

## Extent: San Diego Region.

### Extent in Longitude Latitude

**North** 33.435499
**West** -117.594319 **East** -116.508519
**South** 32.537685

### Extent in the item's coordinate system

**North** 2102186.000008
**West** 6151525.999974 **East** 6481995.000124
**South** 1778032.009866

## Description:

This dataset uses the SanGIS Roads_All layer as the basis for the linear features. SANDAG obtained input on bike network data from local jurisdictions in 2014 and consolidated the data into a regional dataset. Additional updates were performed in 2015 including adding facility classification types and updating elevation values. Features were also segmented to account for changes in facility

characteristics and to add jurisdiction names. For specific information regarding the status of bike facilities represented in the data, please contact bike planning staff for the respective local jurisdictions.
This dataset is available for viewing in an interactive web map. Visit SANDAG's homepage at www.sandag.organd navigate on the left panel to find "iCommute" under Services. In the new webpage that opens, the Bike Map is available under the "bike to work" section.

## Credits:

SANDAG Technical Services - GIS

## Use Limitation:

*Please read the SANDAG Data Disclaimerfirst before using SANDAG GIS data.*

## Topics and Keywords

Topic Categories: Transportation

Themes:

Bike, Bike Routes, Bike Facilities, Bike Network, Bike Map

Places:

San Diego, San Diego County, San Diego Region

## Resource Details:

Status: On Going
Type: Vector
Update Frequency: Annually
Next Update: 2016-04-01

## Spatial Reference System:

Type: Projected
Reference: GCS_North_American_1983
Projection: NAD_1983_StatePlane_California_VI_FIPS_0406_Feet

Identifier: 2230
Codespace: EPSG
Version: 7.11.2

## Contacts:

Point of Contact

Pat Landrum, GIS Manager
SANDAG

401 B Street, Suite 800
San Diego, CA. 92101

Pat.Landrum@sandag.org
(619) 595-5602

### Distributor

SanGIS
5510 Overland Ave, Suite 230
San Diego, CA. 92123
webmaster@sangis.org
(858) 874-7000

## Distribution Ordering Instructions:

Visit the San Diego Regional Data Warehouse at:
http://rdw.sandag.org/

Click "Accept" at the bottom of the GIS Data End User Agreement. This dataset, labeled "BIKE_ROUTES", is available for download under the "Transportation" category.

## Online Ordering Description:

Downloadable as a shapefile.

## Fields:

### Overview:

This dataset is a spatial representation of San Diego County's bicycle network based on San Diego County road network data. Significant attribute fields in this dataset are the RD20FULL, ROUTE, Jurisdiction, and Max_Elev fields. RD20FULL represents the road linear features and corresponding names based on the SanGIS Roads_All layer. ROUTE signifies the linear features for the bicycle network, as defined by class (see ROUTE attribute details for information on the bicycle classes). Jurisdiction delineates which jurisdiction each bike segment falls within. Max_Elev is the highest elevation along the linear segment.

### Citation:

Information on bicycle facility classifications is available from the Highway Design Manual at:
http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp1000.pdf

**__FID (OID)**
Internal feature number.

**Shape (Geometry)**
Feature geometry.

**RD20FULL (String)**
SanGIS road names.

**ROUTE (Double)**
From-To Bike Facility Classification.

Bike Network Class Descriptions:
1 = Multi Use Path
2 = Bike Lane
3 = Bike Route
6 = Freeway Shoulder Bicycle Access
8 = Other Suggested Routes
15 = Bikeways Coming Soon

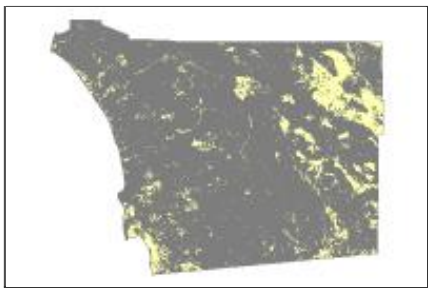
**JURISDICTI (String)**
**Max_Elev (Double)**
Highest elevation along linear segment. The elevation values were derived from the Esri World Elevation Terrain Data Service using the 3D Analyst --> Functional Surface --> Add Surface Information tool in ArcToolbox.

**ROUTE_CLAS (String)**
**SHAPE_LEN (Double)**

## Metadata Last Update: 2015-04-28

Regional GIS Data Warehouse (RGDW) Publication Stylesheet 1.4

# Slopes_CN



## Tags

slope, relief, percent slope

## Summary:

This layer was generated to show County-wide relief representation, expressed as 'percent slope' and aggregated in four classifications, based on their percentages and their increase in slope severity. Aggregation into the classifications was performed to assist in increased readability and simplification of map symbolization tasks.

## Feature Type: Polygon

## Number of Records: 367820

## Publication Date: 2005-01-01

## Date of Data (Temporal Period Extent): 2005-01-01

## Extent: San Diego County

### Extent in Longitude Latitude

**North** 33.511553
**West** -117.597986 **East** -116.080156
**South** 32.530161

### Extent in the item's coordinate system

**North** 2129759.999958
**West** 6150763.740027 **East** 6613437.000025
**South** 1775304.099981

## Description:

Aggregated slopes for San Diego County. This dataset was built from a 10 meter GRID that was derived from a 2002 IfSAR elevation surface of the entire County. The IfSAR data was processed as first returns using X band data and that means that houses, trees, and other surface features show-up in the elevation model. Once the elevation model was reclassed and resized from its original resolution to a larger 10 meter resolution, the slope function was applied to it through GRID. This continuous surface built in GRID is the Raster GRID model called

[sde.SANGIS.slope_stp_83]. This dataset was later reclassed and then vectorized into all slopes greater than 25%. That dataset exists as a vector dataset in SDE called [sde.SANGIS.SLOPE_STEEP25]. The GRID classifications in the source slope range from 0% slope to 2484.47753% slope. This translates essentially into flat to 87.70 degrees in angle. The reason 90 degree slopes are not recorded is most likely related to the 10 meter grid cell in horizontal distance. This translates into nowhere in the county is there a vertical elevation change greater than 787 feet (H= h+D*tan(Theta)) in a horizontal distance of less than 30 feet. This product recieved additional processing yielding four classifications of slopes: slopes less than 15% slope, slopes 15% to less than 25%, slopes 25% to less than 50% and slopes 50% or greater.

## Credits:

Ross Martin with County of San Diego, Planning and Development Services, LUEG GIS Service.

## Use Limitation:



## Topics and Keywords

Topic Categories: Geoscientific Planning Cadastral

Themes:

slope, relief, percent slope

Places:

County of San Diego, California

## Resource Details:

Status: Completed
Type: Vector
Update Frequency: Not Planned
Next Update: Not specified

## Spatial Reference System:

Type: Projected

Reference: GCS_North_American_1983
Projection: NAD_1983_StatePlane_California_VI_FIPS_0406_Feet

Identifier: 2230
Codespace: EPSG
Version: 7.11.2

## Contacts:

### Point of Contact

Ross Martin, GIS Manager
County of San Diego, Planning & Development Services, LUEG-GIS Service
5510 Overland Ave, Suite 310
San Diego, California. 92123

Ross.Martin@sdcounty.ca.gov
(858) 334-3829

### Distributor

SanGIS
5510 Overland Ave, Suite 230
San Diego, California. 92123
SanGIS
webmaster@sangis.org
(858) 874-7000

## Online Ordering Description:

Downloadable as a Shapefile from http://www.sangis.org/download/index.html

## Fields:

### Overview:

County-wide relief representation, expressed as 'percent slope' and aggregated into the four classifications of: Slopes less than 15% slope, slopes 15% to less than 25%, slopes 25% to less than 50% and slopes 50% or greater.

Attribute item GRIDCODE is Code for aggregate slope categories

**__FID (OID)**
Internal feature number.

**Shape (Geometry)**
Feature geometry.

**GRIDCODE (Double)**
Code for aggregate slope categories

1, Slope less than 15% slope
2, Slope 15% to less than 25%
3, slope 25% to less than 50%

4, Slope 50% or greater

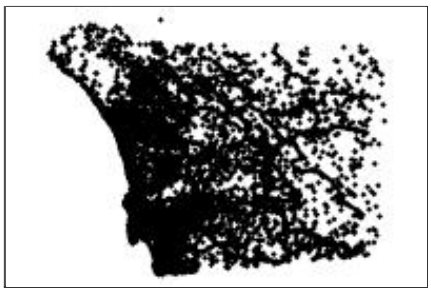
**Shape_Area (Double)**
Area of feature in internal units squared.

**SHAPE_LEN (Double)**

## Metadata Last Update: 2015-04-06

Regional GIS Data Warehouse (RGDW) Publication Stylesheet 1.4

# PLACES



## Tags

Places, Place Names

## Summary:

Created to represent areal features as point features on small scale mapping efforts, as well as representing features more appropriately depicted with point symbols across a broad range of mapping scales.

## Feature Type: Point

## Number of Records: 28580

## Publication Date: 2013-04-25

## Date of Data (Temporal Period Extent): 2009-08-04 to 2013-04-25

## Extent: San Diego County

### Extent in Longitude Latitude

**North** 33.604507
**West** -117.667622 **East** -115.994329
**South** 32.532300

### Extent in the item's coordinate system

**North** 2163584.000014
**West** 6129994.007521 **East** 6639515.011248
**South** 1776354.611853

## Description:

Point layer to show the location of areas and specific features such as buildings, mile markers, and mountain tops
Five layers of place data was combined to make this single layer into a single layer; those of: PLACES (Was SANGIS.PLACES renamed PLACES_OLD); SHERIFF_PLACE_NAMES (Sheriff's place name file for dispatch);PLACES_SG SANDAG Places layer; PLACE_NAMES (Geographic Names Information System /GNIS, assumed); PLACES_CASINOS Casinos.
In PLACES_CASINOS fields were added named ADDR and CITYNM and calculated equal to existing fields ADDRESS and CITY to facilitate the appending process.

PLACES and PLACES_SG initially contained MULTIPOINT features; TOOLBOX Feature to Point was used to make the features POINT. The working layers were then called PLACES_SG_FeatureToPoint and PLACES_OLD_FeatureToPoint.In the PLACES layer 3 fields were widened for consistency with similarly named fields in other layers. NAME was widened from 32 to 200; ADDR was widened from 32 to 75; TYPE was widened from 20 to 254. After 2 versions the layer was named PLACES_OLD_FeatureToPoint2. PLACES_OLD_FeatureToPoint2 (which was originally PLACES) was copied to a feature class named PLACES_COMBINED. The other 4 feature classes were then appended with the NOTEST option. The name of the original layers where each point resided is in an added field FEA_SRC.The geodatabase was then copied, renamed PLACES_OUTPUT_20100730 and unneeded intermediate results were deleted.The final result is the feature class PLACES_COMBINED in the geodatabase PLACES_OUTPUT_20100730.
For the most part, the attribute fields align with the original 5 datasets that were used to create Places. However, some fields were deleted, as they did not apply to the other datasets. Other fields were assigned an attribute domain. These include: CityNm, CommunityNm, EntityType, and Fea_Src. The CityNm is comprised of the 18 incorporated cities within the County, as well as S.D. County. CommunityNm was a field that was added, since data entered under the CityNm field were actually communities. This domain includes 184 community and neighborhood names. The EntityType domain was taken directly from Bing's entity types and descriptions. The Fea_Src domain lists the 5 original data sources, plus Bing as a future data source.

## Credits:

County of San Diego, Planning and Development Services, LUEG-GIS Service, SANDAG, San Diego County Sheriff, U.S. Board on Geographic Names

## Use Limitation:



## Topics and Keywords

Topic Categories: Location Structure Transportation

Themes:

Places, Place Names

Places:

County of San Diego, California, County of San Diego, California, buildings, building, administration, aircraft, amusement, theme park, srea, structure,

burial place, burial ground, casino, body of water, public worship, College, University, College/University, cliff, cliffs, cliff(s), correctional, instituteions, County Road Station, Couriers, courcts, barrier, water, department, stores, depressions, education, insurance, instruction, exectutive, offices, fire, protection, station, forest, forests, gap, hospitals, medica, surgical, golf, government, harbor, sick, injured, hotel, industrial, site, books, media, public, attraction, major employer, mall, metereological, meterorological station, station, manufacturing, mile marker, mine, mines, landform, mountaains, arts, sciences, museum, national security, natural, gas, distribution, nature, parks, publishers, office, support, overfalls, scenic, recreation, plain, plains, team, sports, police, protection, athletic events, populated, postal, radio, television, wireless, communicaiton, equipment, sports, regulation, transportation, research, development, physical engineering, life sciences, reservoir, reservoirs, hut, house, apartment, retail, center, retail, center, ridge, ridges, section, populated, ship, spring, springs, stream, path, track, route, subterranean, passageway, wastewater, hole, zoo, zoos, botantical, garden, gardens

## Resource Details:

Status: On Going
Type: Vector
Update Frequency: Irregular
Next Update: Not specified

## Spatial Reference System:

Type: Projected
Reference: GCS_North_American_1983
Projection: NAD_1983_StatePlane_California_VI_FIPS_0406_Feet

Identifier: 2230
Codespace: EPSG
Version: 7.11.2

## Contacts:

### Point of Contact

Fred McCamic, GIS Analyst
County of San Diego, Planning & Development Services, LUEG-GIS Service
5510 Overland Ave, Suite 310
San Diego, California. 92123

Fred.Mccamic@sdcounty.ca.gov
(858) 505-6347

### Distributor

SanGIS
5510 Overland Ave, Suite 230
San Diego, California. 92123
SanGIS

webmaster@sangis.org
(858) 874-7000

## Distribution Ordering Instructions:

Refer to SanGIS website (http://www.sangis.org/services/index.html) to obtain further information on mapping and data extraction services available from SanGIS.

## Online Ordering Description:

Downloadable as a Shapefile from http://www.sangis.org/download/index.html

## Fields:

### Overview:

Layer showing the location of areas and specific features as point features.
Attribute item NAME is:Name of feature.
Attribute item ADDR is:Address
Attribute item CITYNM is:Incorporated City Name or S.D. County
Attribute item ZIP is:Zipcode
Attribute item TYPE is:Place type
Attribute item MSG is:Message
Attribute item LATITUDE is: Latitude, in decimal degrees
Attribute item LONGITUDE is: Longitude, in decimal degrees
Attribute item DESCRIP is:Description
Attribute item COMMUNITYNM is:Community Name
Attribute item EDIT is: Date the point was last edited

### Citation:

For the most part, the attribute fields align with the original 5 datasets that were used to create Places. However, some fields were deleted, as they did not apply to the other datasets. Other fields were assigned an attribute domain. These include: CityNm, CommunityNm, EntityType, and Fea_Src. The CityNm is comprised of the 18 incorporated cities within the County, as well as S.D. County. CommunityNm was a field that was added, since data entered under the CityNm field were actually communities. This domain includes 184 community and neighborhood names. The EntityType domain was taken directly from Bing's entity types and descriptions. The Fea_Src domain lists the 5 original data sources, plus Bing as a future data source.

**__FID (OID)**
Internal feature number.

**Shape (Geometry)**
Feature geometry.

**NAME (String)**
Name of site

**ADDR (String)**
Address

**CITYNM (String)**
Incorporated City Name or S.D. County

**ZIP (Double)**
Zipcode

**TYPE (String)**
Place type

**MSG (String)**
Message

**LATITUDE (Double)**
Latitude, in decimal degrees

**LONGITUDE (Double)**
Longitude, in decimal degrees

**DESCRIP (String)**
Description

**FEA_SRC (String)**
Feature Source

**COMMUNITYN (String)**
**EDIT (Date)**
Date the point was last edited

## Metadata Last Update: 2015-04-21

Regional GIS Data Warehouse (RGDW) Publication Stylesheet 1.4

# Appendix B

**Network Dataset Settings**

## Name: LTS_1_ND

Type: Shapefile-Based Network Dataset

Sources:
  Edge Sources:
    LTS_1

Turns:
  <Global Turns>

Connectivity:
  Group 1:
    Edge Connectivity:
      LTS_1 (Any Vertex)

Elevation Model: None

Attributes:
  Oneway:
    Usage Type: Restriction
    Data Type: Boolean
    Units Type: Unknown
    Use by Default: True
    Parameters:
      Restriction Usage (Double) = Prohibited
    Source Attribute Evaluators:
      LTS_1 (From-To): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "TF", "T": restricted = True
          End Select
        Expression: restricted
      LTS_1 (To-From): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "FT", "F": restricted = True
          End Select
        Expression: restricted
    Default Attribute Evaluators:
      Default Edges: Constant = Ignore Restriction
      Default Junctions: Constant = Ignore Restriction
      Default Turns: Constant = Ignore Restriction
  Length:

Usage Type: Cost
Data Type: Double
Units Type: Feet
Use by Default: True
Source Attribute Evaluators:
LTS_1 (From-To): Field
Language: VBScript
Expression: [Shape]
LTS_1 (To-From): Field
Language: VBScript
Expression: [Shape]
Default Attribute Evaluators:
Default Edges: Constant = 0
Default Junctions: Constant = 0
Default Turns: Constant = 0

Directions:
Directions Ready: No
-Length Attribute Required

Build errors:
SourceName: LTS_1, ObjectID: 4, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1, ObjectID: 69374, The edge feature is too small to participate in snapping and may not be connected to other features.

## Name: LTS_12_ND

Type: Shapefile-Based Network Dataset

Sources:
  Edge Sources:
    LTS_12

Turns:
  <Global Turns>

Connectivity:
  Group 1:
    Edge Connectivity:
      LTS_12 (Any Vertex)

Elevation Model: None

Attributes:
  Oneway:
    Usage Type: Restriction
    Data Type: Boolean
    Units Type: Unknown
    Use by Default: True
    Parameters:
      Restriction Usage (Double) = Prohibited
    Source Attribute Evaluators:
      LTS_12 (From-To): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "TF", "T": restricted = True
          End Select
        Expression: restricted
      LTS_12 (To-From): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "FT", "F": restricted = True
          End Select
        Expression: restricted
    Default Attribute Evaluators:
      Default Edges: Constant = Ignore Restriction
      Default Junctions: Constant = Ignore Restriction
      Default Turns: Constant = Ignore Restriction
  Length:

Usage Type: Cost
Data Type: Double
Units Type: Feet
Use by Default: True
Source Attribute Evaluators:
LTS_12 (From-To): Field
Language: VBScript
Expression: [Shape]
LTS_12 (To-From): Field
Language: VBScript
Expression: [Shape]
Default Attribute Evaluators:
Default Edges: Constant = 0
Default Junctions: Constant = 0
Default Turns: Constant = 0

Directions:
Directions Ready: No
-Length Attribute Required

Build errors:
SourceName: LTS_12, ObjectID: 6, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_12, ObjectID: 7, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_12, ObjectID: 60263, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_12, ObjectID: 115414, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_12, ObjectID: 115415, The edge feature is too small to participate in snapping and may not be connected to other features.

## Name: LTS_123_ND

Type: Shapefile-Based Network Dataset

Sources:
  Edge Sources:
    LTS_123

Turns:
  <Global Turns>

Connectivity:
  Group 1:
    Edge Connectivity:
      LTS_123 (Any Vertex)

Elevation Model: None

Attributes:
  Oneway:
    Usage Type: Restriction
    Data Type: Boolean
    Units Type: Unknown
    Use by Default: True
    Parameters:
      Restriction Usage (Double) = Prohibited
    Source Attribute Evaluators:
      LTS_123 (From-To): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "TF", "T": restricted = True
          End Select
        Expression: restricted
      LTS_123 (To-From): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "FT", "F": restricted = True
          End Select
        Expression: restricted
    Default Attribute Evaluators:
      Default Edges: Constant = Ignore Restriction
      Default Junctions: Constant = Ignore Restriction
      Default Turns: Constant = Ignore Restriction
  Length:

Usage Type: Cost
Data Type: Double
Units Type: Feet
Use by Default: True
Source Attribute Evaluators:
LTS_123 (From-To): Field
Language: VBScript
Expression: [Shape]
LTS_123 (To-From): Field
Language: VBScript
Expression: [Shape]
Default Attribute Evaluators:
Default Edges: Constant = 0
Default Junctions: Constant = 0
Default Turns: Constant = 0

Directions:
Directions Ready: No
-Length Attribute Required

SourceName: LTS_123, ObjectID: 8, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_123, ObjectID: 9, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_123, ObjectID: 78251, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_123, ObjectID: 78252, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_123, ObjectID: 150168, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_123, ObjectID: 150169, The edge feature is too small to participate in snapping and may not be connected to other features.

## Name: LTS_1234_ND

Type: Shapefile-Based Network Dataset

Sources:
  Edge Sources:
    LTS_1234

Turns:
  <Global Turns>

Connectivity:
  Group 1:
    Edge Connectivity:
      LTS_1234 (Any Vertex)

Elevation Model: None

Attributes:
  Oneway:
    Usage Type: Restriction
    Data Type: Boolean
    Units Type: Unknown
    Use by Default: True
    Parameters:
      Restriction Usage (Double) = Prohibited
    Source Attribute Evaluators:
      LTS_1234 (From-To): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "TF", "T": restricted = True
          End Select
        Expression: restricted
      LTS_1234 (To-From): Field
        Language: VBScript
        Prelogic:
          restricted = False
          Select Case UCase([ONEWAY])
            Case "N", "FT", "F": restricted = True
          End Select
        Expression: restricted
    Default Attribute Evaluators:
      Default Edges: Constant = Ignore Restriction
      Default Junctions: Constant = Ignore Restriction
      Default Turns: Constant = Ignore Restriction
  Length:

Usage Type: Cost
Data Type: Double
Units Type: Feet
Use by Default: True
Source Attribute Evaluators:
LTS_1234 (From-To): Field
Language: VBScript
Expression: [Shape]
LTS_1234 (To-From): Field
Language: VBScript
Expression: [Shape]
Default Attribute Evaluators:
Default Edges: Constant = 0
Default Junctions: Constant = 0
Default Turns: Constant = 0

Directions:
Directions Ready: No
-Length Attribute Required

SourceName: LTS_1234, ObjectID: 8, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1234, ObjectID: 9, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1234, ObjectID: 79788, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1234, ObjectID: 79789, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1234, ObjectID: 153138, The edge feature is too small to participate in snapping and may not be connected to other features.
SourceName: LTS_1234, ObjectID: 153139, The edge feature is too small to participate in snapping and may not be connected to other features.