3. DATA COLLECTION

It is important to note that the studies identified above target key non-motorized infrastructure/built environment features that are correlated with increased transit usage. However, since both transit ridership and mode share are strongly influenced by other factors – including the area's demographics, household income, car ownership patterns, etc. – this type of non-transportation data were also collected. This chapter summarizes the data the project team collected from the US Census bureau, Puget Sound Regional Council (PSRC), King County, and local jurisdictions within the study area. These data are listed in **Table 2** below:

Table 2: Regression Model Variables

Data	***Scale***	***Source***
Households	Census block group	American Community Survey
Employment	Traffic analysis zone	PSRC
Household income	Census block group	American Community Survey
Household size	Census block group	American Community Survey
Auto ownership	Census block group	American Community Survey
Transit ridership	Transit stop; transit line	KC, ST
Slope	20 foot contour	King County Data Portal
Street centerline	Entire study area	King County Data Portal; Snohomish County, City of Tacoma
Street lights	Entire study area	Jurisdictions
Sidewalks – existing and planned	Entire study area	Jurisdictions
Bike lanes – existing and planned	Entire study area	Jurisdictions
Off-street trails and cycletracks – existing and planned	Entire study area	Jurisdictions
Bike routes and sharrows – existing and planned	Entire study area	Jurisdictions
Signalized arterial crossings – existing and planned	Entire study area	Jurisdictions

As noted above, much of the detailed data were collected from local jurisdictions within the study area. To ensure that the most recent and relevant data were collected, the project team contacted staff in each jurisdiction in November 2013 and requested the most recent non-motorized connectivity data. A list of the jurisdictions contacted by the project team is shown below.

- Everett
- Auburn
- Bellevue
- Burien
- Des Moines
- Edmonds
- Federal Way
- Issaquah
- Kent
- Kirkland
- Lynnwood
- Mountlake Terrace
- Mukilteo
- Redmond
- Renton
- SeaTac
- Seattle
- Shoreline
- Tacoma
- Tukwila

With the exception of street light data, the jurisdictions generally had all the data listed in **Table 2**. Street lights proved to be a difficult item to collect since street lights are owned by a variety of organizations including cities, power providers, and local improvement district organizations. The streetlight data were not consistently organized across the study area, and much of the data were missing. Therefore, street lighting as a connectivity variable was dropped from this study. In a handful of cases, other connectivity data were not available in GIS and the team entered the following information in by hand:

- Edmonds – Sidewalk and bike lane data
- Everett – Sidewalk data
- Renton – Sidewalk data
- Tacoma – Sidewalk data
- Snohomish County – Arterial classifications

4. DATA PREPARATION

After receiving the transportation network data from the local jurisdictions, an initial inspection indicated that the project team would have to prepare or "clean" the data for the GIS network analysis. As described in this chapter, the primary issues were as follows:

> Coding and data management practices for sidewalks, paths, and bicycle facilities
> Each jurisdiction tends to have a unique system for coding non-motorized facilities. In addition, jurisdictions vary on how much non-motorized facility information they collect and how they manage that information in GIS. The project team created a "uniform" data coding system for all study area variables to facilitate the analysis. This dataset was "snapped" to the street centerline network to facilitate connectivity analysis.
>
> Gaps/discontinuities in the street and trail network
> These gap errors prevent the connectivity analysis tools from working properly since they mistakenly appear as barriers to access. The project team developed a process to identify and fix these errors utilizing GIS topology editor scripts.
>
> Bicycle Stress
> Bicycle stress evaluation is an emerging practice that assesses the quality of bicycle facilities for different types of users. The jurisdictions' datasets do not tend to have the bike stress input data stored in a common manner. The project team developed a set of bike stress variables across the entire study area and appended this information to the centerline file to facilitate this analysis.

INITIAL CLEANING OF THE ROADWAY CENTERLINE NETWORK

The primary transportation network utilized for this study is the King County *trans_network* GIS dataset[2]. The Snohomish County TIGER centerline and Tacoma street network GIS shapefiles supplemented the King County network. The Snohomish County and Tacoma datasets were manually merged with the King County network. Our review of the King County network found that roadway functional classification and speed limits

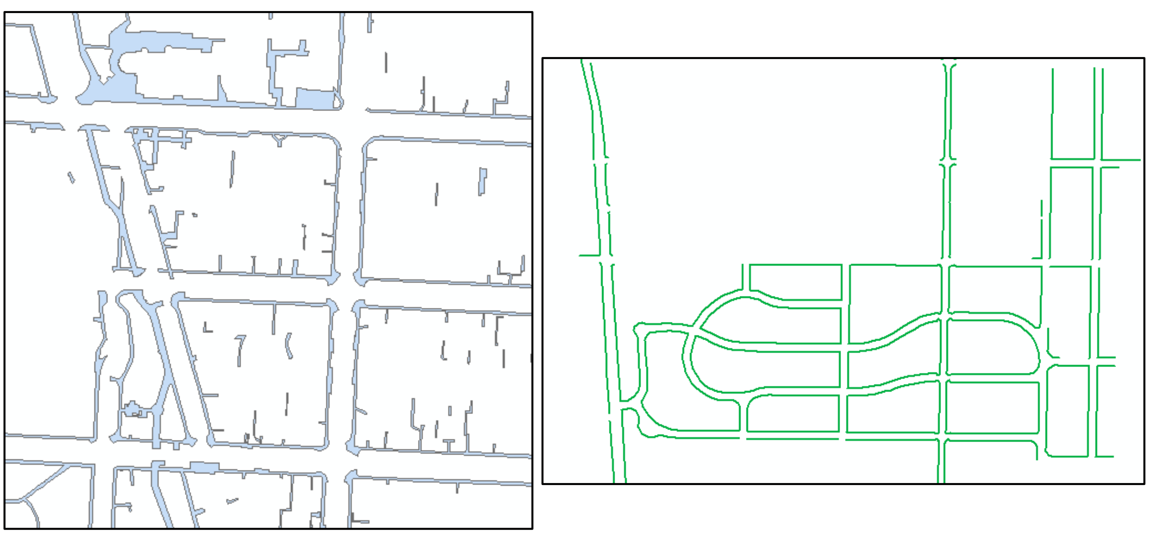
[2] KCGIS Center. *King County GIS Data Portal*. 2013. http://www5.kingcounty.gov/gisdataportal/Default.aspx

were coded accurately; however, these attributes were not consistent in the Snohomish County network, so we manually adjusted the segments within the study area. Additional filtering removed all network elements that were coded as freeways and other non-pedestrian/bicycle links such as private roads[3], railroads, alleys, and transit-only guideways.

NON-MOTORIZED ATTRIBUTE CODING

Each jurisdiction tends to gather and manage non-motorized network data in a unique way. For example, the City of Issaquah uses polygons to identify where sidewalks are, while Burien uses lines. See **Figure 2** below. Issaquah's data denote only the presence of the sidewalk, while Burien's dataset includes attributes such as sidewalk width and condition (e.g., new, broken/poor condition), although some segments are missing these data. Similar differences exist for the bicycle network data across the region.

Figure 2: Issaquah (left) and Burien (right) Sidewalk GIS Files



The lack of uniformity in how jurisdictions collect and organize information posed a problem for our analysis since we needed to ensure that all non-motorized facility data were consistently defined. Additionally, the connectivity analysis requires that network

[3] Private access roads typically do not provide consistent non-motorized access

analyst[4] be run on the non-motorized network, which means that the non-motorized data needs to be attached to a complete and connected network, like the street centerline file.

To create this standardized analysis file, the individual jurisdiction pedestrian and bicycle GIS files were first converted to GIS line formats containing standardized attribute data. The attribute data included length, facility type, and coverage (one or two sides of street if the data was available). An automated process was developed to "snap" the sidewalk and bicycle facility attributes to the street network. The bicycle network data was composed of simple lines while the sidewalk layers did not have a consistent format to allow for accurate snapping to local streets. Since the research indicated that sidewalks on local streets were not strongly correlated with access to transit (e.g., people will tend to walk along low-volume streets with or without sidewalks in order to access transit), we developed a sidewalk layer that included local streets as well as sidewalks along arterials and collectors[5].

After the automated snapping process was completed, the project team reviewed the results in detail and corrected errors manually. Off-street trails that were not included in the King County transportation network were also joined to the standardized network.

NETWORK GAPS AND DISCONTINUITIES

With the standardized network developed, we next evaluated the connectivity of the network to ensure the new GIS file accurately represented the connections between different links. For example, the project team looked to ensure that there were not connections between cul-de-sacs and nearby roads and there were accurate connections between trails and the street network. The testing included using GIS topology analysis to identify nodes and links that lacked a connection to the network, as shown in **Figure 3** below. Testing also involved sample routing analysis to confirm accurate connectivity with the links to the bus stop and transit station locations. This type of routing identified

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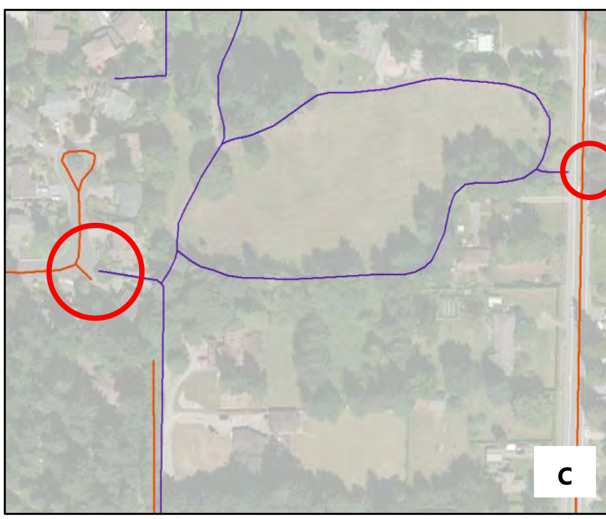
[4] Network Analyst is a GIS tool that can evaluate distance travelled along a specified network between two points.

[5] See page 6. Source: NCHRP Project 08-78a Estimating Bicycling and Walking for Planning and Project Development: Practitioner Guidebook, *Renaissance Planning Group et. al., Transportation Research Board, August 2013.*

missing connections and erroneous connections in the network. Based on the results of the routing analysis, manual corrections were made to the standardized GIS network.

Figure 3: Examples of Network Gaps and Discontinuities



Connectivity break identified in the red circle (inset A) and the actual gap of less than a foot (inset B).

Gaps between trails and the street network (red circles in inset C) that required manual modification.

BICYCLE STRESS

Bicycle stress is a measure of how safe, secure, and comfortable cyclists feel when traveling along a given route or between different locations. The concept of bicycle stress was developed by the Mineta Transportation Institute, which leveraged previous work from the Florida DOT, the HCM 2010 Multimodal level-of-service methodology, and the Bicycle Compatibility Index developed through the FHWA[6]. Additionally, the Mineta researchers evaluated Dutch cycling standards and measurement techniques in order to guide the development of a “Bike Stress Index” scoring system based on key “levels of traffic stress” indicators[7]. This methodology takes into account the varying nature of cyclists and their tolerance for traffic stress. There are four levels for the index. Level 1 is the lowest stress, which is a route that can accommodate all cyclist types. Level 4 is the highest, with stress levels only tolerated by cyclists characterized in previous studies as “strong and fearless.” The following list summarizes the various aspects present with each level as presented in the report:

- **Bike Stress Level 1:** Minimal traffic stress where cyclists are either physically separated from traffic or are in a slow and minimal traffic stream with no more than one lane per direction.
    - **Example:** Bike paths and low-volume residential streets.
- **Bike Stress Level 2:** Low traffic stress and suitable for most cyclists, but more demand for attention is required. Cyclists are either physically separated or are on a shared roadway with minimal traffic and low speed differentials.
    - **Example:** Bike lanes on collector streets, or lower volume streets with wide shoulders.
- **Bike Stress Level 3**: Higher stress due to multi-lane traffic and moderate speed differentials. While a bike lane may be provided, the conditions are not suitable for all cycling comfort levels due to speeds and volumes in the adjacent traffic lanes.
    - **Example**: Bike lanes on minor arterials under 35 mph.
- **Bike Stress Level 4**: Highest level of stress due to speed differential, lack of facilities and/or multi-lane traffic flow.
    - **Example**: No bike lanes on arterials or bike lanes on arterials above 35 mph.

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[6] DOT – Department of Transportation. HCM – Highway Capacity Manual. FHWA – Federal Highway Administration

[7] “Low Stress Bicycling and Network Connectivity”. Mineta Transportation Institute. 2012

For the non-motorized access analysis, a bike stress score was computed utilizing a modified version of the Mineta method due to data availability. Variables included:

- Street functional class as a proxy for the number of lanes and traffic flow
- Bike lane provision (bike lanes or other separated facilities such as cycletracks/off-street trails were included while sharrows or shared lanes were not included)
- Speed limit

The index then was computed based on a rubric, shown in **Table 3** below, and adopted from the Mineta method to appropriately score each street segment. If a street segment had no bike lane, the following metrics were utilized to apply a bike stress score to the segment. As shown in the table below, if a collector had a speed limit of 30 mph, the bike stress is 3. If a bike lane was present on a link that had a speed limit 35 mph or below, then the bike stress score would decrease by one unit.

Table 3: Bike/Level of Stress Calculation Matrix

	Speed Limit (MPH)			
	25	**30**	**35**	**40+**
Principal	4	4	4	4
Minor	3	4	4	4
Collector	2	3	4	4
Local	1	2	3	4
Off-Street Trail	1	1	1	1

On-Street Bicycle Lanes: The presence of striped on-street bicycle lanes reduces the LTS index by 1 when it is otherwise 2 or greater.

Source: Fehr & Peers, 2014

FINAL EXISTING CONDITIONS DATASET

With the network cleaning and consolidation described above complete, a final GIS dataset was prepared. The network was clipped to a three-mile buffer around the 544 study stations. The three miles is consistent with Federal Transit Administration guidelines regarding non-motorized access to transit. Key fields in the dataset include:

- **kc_fcc_id:** Street Functional Class:
  P – Primary Arterial, M – Minor Arterial, C – Collector Arterial, L – Local Street or path
- **speed_lim** – Speed limit of the link in miles-per-hour
- **sw_exists** – Boolean (1 = yes, 0 – no) if a sidewalk is present on an arterial (one or both sides); score is one for all local residential streets
- **bk_exists** – Boolean (1 = yes, 0 – no) if a bike lane is present on a street
- **bkstress_mod** – Bike stress index of the link (from 1: Low to 4: High)

Figure 4: Example Attributes of a Minor Arterial (left) and an Off-street Path (right) from the final