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5-30-2014

## GIS Tools for Bicycle Network Analysis and Planning

Mike Lowry  
*University of Idaho*

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# **GIS Tools for Bicycle Network Analysis and Planning**

***Friday Transportation Seminar, May 30, 2014***  
**Mike Lowry, University of Idaho**



**Tool 1: Calculate Bicycle Level of Service**

**Tool 2: Calculate Community-wide Bikeability**

**Tool 3: Estimate Bicycle Volumes**

**Tool 4: Assess Dangerous Situation Exposure**



Tool 1

# **CALCULATE BICYCLE LEVEL OF SERVICE**

# Background

- **Bicycle Suitability**

Perceived comfort and safety of a segment of street or pathway

- **Bikeability**

Perceived comfort and safety of network connectivity for accessing important destinations

- **Bicycle Friendliness**

Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community

| <b>Name of Method</b>                      | <b>Acronym</b> | <b>Author</b>      | <b>Date</b> |
|--|----------------|--------------------|-------------|
| <b>Bicycle Safety Index Rating</b>         | BSIR           | Davis              | 1987        |
| <b>Bicycle Stress Level</b>                | BSL            | Sorton and Walsh   | 1994        |
| <b>Road Condition Index</b>                | RCI            | Epperson           | 1994        |
| <b>Interaction Hazard Score</b>            | HIS            | Landis             | 1994        |
| <b>Bicycle Suitability Rating</b>          | BSR            | Davis              | 1995        |
| <b>Bicycle Level of Service</b>            | BLOS           | Botma              | 1995        |
| <b>Bicycle Level of Service</b>            | BLOS           | Dixon              | 1996        |
| <b>Bicycle Suitability Score</b>           | BSS            | Turner et al       | 1997        |
| <b>Bicycle Compatibility Index</b>         | BCI            | Harkey et al       | 1998        |
| <b>Bicycle Suitability Assessment</b>      | BSA            | Emery and Crump    | 2003        |
| <b>Rural Bicycle Compatibility Index</b>   | RBCI           | Jones              | 2003        |
| <b>Compatibility of Roads for Cyclists</b> | CRC            | Noel et al         | 2003        |
| <b>Bicycle Level of Service</b>            | BLOS           | Zolnik             | 2007        |
| <b>Bicycle Level of Service</b>            | BLOS           | Jensen             | 2007        |
| <b>Bicycle Level of Service</b>            | BLOS           | Petritsch et al    | 2007        |
| <b>Bicycle Environmental Quality Index</b> | BEQI           | SFDPH              | 2009        |
| <b>Bicycle Quality Index</b>               | BQI            | Birk et al         | 2010        |
| <b>Bicycle Level of Service</b>            | BLOS           | HCM                | 2011        |
| <b>Bicycle Levels of Traffic Stress</b>    | LTS            | Mekuria and Furth  | 2012        |
| <b>Protected Lane Level of Service</b>     | PL-LOS         | Foster and Monsere | Today       |

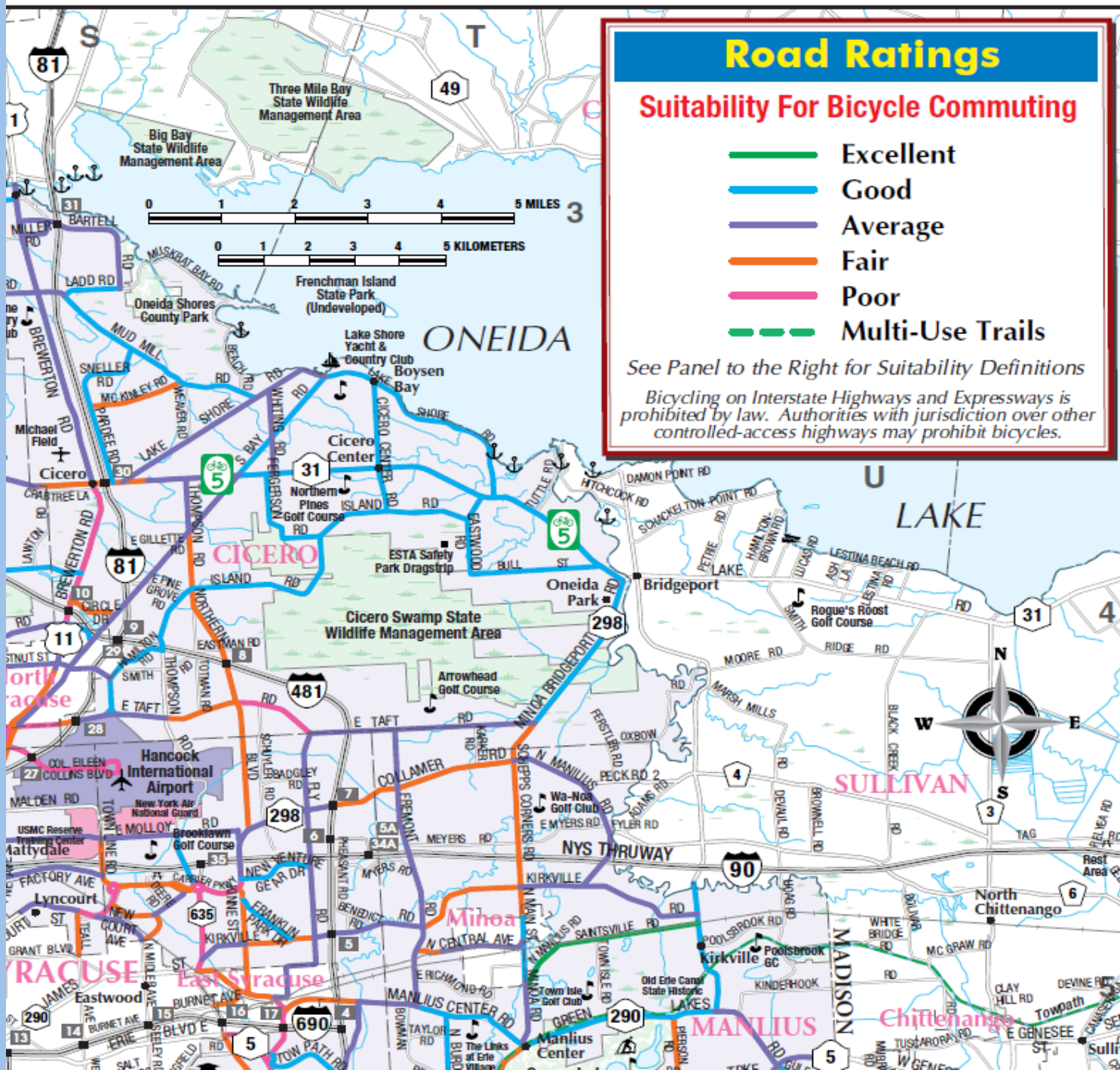
# Road Ratings

## Suitability For Bicycle Commuting

- Excellent
- Good
- Average
- Fair
- Poor
- Multi-Use Trails

See Panel to the Right for Suitability Definitions

Bicycling on Interstate Highways and Expressways is prohibited by law. Authorities with jurisdiction over other controlled-access highways may prohibit bicycles.



| Attribute                 | Method |     |     |     |      |
|---------------------------|--------|-----|-----|-----|------|
|                           | BSL    | BSS | BCI | BSA | BLOS |
| width of outside lane     | X      | X   | X   | X   | X    |
| width of bike lane        |        |     | X   | X   | X    |
| width of shoulder         |        | X   | X   | X   | X    |
| on-street parking         |        |     | X   | X   | X    |
| presence of curb          |        |     |     | X   | X    |
| vehicle traffic volume    | X      | X   | X   | X   | X    |
| number of lanes           |        |     |     | X   | X    |
| speed limit               | X      | X   | X   | X   | X    |
| percent heavy vehicles    |        |     | X   |     | X    |
| pavement condition        |        | X   |     | X   | X    |
| elevation grades          |        |     |     | X   |      |
| adjacent land use         |        |     | X   | X   |      |
| storm drain grate         |        |     |     | X   |      |
| physical median           |        |     |     | X   |      |
| turn lanes                |        |     | X   | X   |      |
| frequent curves           |        |     |     | X   |      |
| restricted sight distance |        |     |     | X   |      |
| numerous driveways        |        |     |     | X   |      |
| presence of sidewalks     |        |     |     | X   |      |



## Equation

$$\begin{aligned}
 \text{Bicycle Level of Service} = & 0.76 + [-0.005((w_{ol} + w_{bl} + w_{os})(2 - 0.005v) + (w_{bl} + w_{os} - 20p_{pk}) - 1.5c)^2] \\
 & + 0.507 \ln\left(\frac{v}{4N_{th}}\right) \\
 & + 0.199[1.119 \ln(S - 20) + 0.8103](1 + 0.1038P_{HV})^2 + 7.066\left(\frac{1}{P_c^2}\right)
 \end{aligned}$$

## Input

| Attribute | Description   |
|-----------|---|
| wol       | width of outside lane (ft)  |
| wbl       | width of bike lane (ft)   |
| wos       | width of outside shoulder including parking and gutter (ft)                                       |
| ppk       | estimated proportion of on-street parking that would be occupied during analysis period (decimal) |
| c         | curb present (yes = 1, no = 0)  |
| v         | directional analysis period vehicle volume (vph)  |
| Nth       | number of through lanes (#)   |
| S         | average vehicle speed (mph)   |
| PHV       | percent heavy vehicles (decimal)  |
| Pc        | pavement condition (poor-excellent) (0-5)   |

## Output

| BLOS      | Letter Grade |
|-----------|--------------|
| ≤ 2.00    | A            |
| 2.00-2.75 | B            |
| 2.75-3.50 | C            |
| 3.50-4.25 | D            |
| 4.25-5.00 | E            |
| >5.00     | F            |



## Equation

$$\text{Bicycle Suitability Score} = \text{Traffic Volume Factor Score} + \text{Shoulder Width Factor Score} + \text{Speed Limit Factor Score} + \text{Pavement Factor Score}$$

## Input

| Traffic Volume (ADT per lane) | Shoulder Width [If no shoulder, Curb Lane Width] (ft) | Speed Limit (mph) | Pavement Condition (HPMS rating) | Factor Score |
|-------------------------------|---|-------------------|----------------------------------|--------------|
| ≤ 1,000                       | ≥ 6 [≥ 15]  | ≤ 40              | 4-5                              | 2            |
| 1,000-1,999                   | 4-6 [14-15]   | 49-50             | 3-4                              | 1            |
| 2,000-4,999                   | 2-4 [12-14]   | 50-59             | 3                                | 0            |
| 5,000-9,999                   | 0-2 [12]  | 60-69             | 2-3                              | -1           |
| ≥ 10,000                      | 0 [≤ 12]  | ≥ 70              | 1-2                              | -2           |

## Output

| Score Range | Interpretation  |
|-------------|---|
| 6 to 8      | All four suitability factors have greater than minimum desirable values. The physical characteristics of the roadway are most likely desirable by intermediate to experienced bicyclists.   |
| -1 to 5     | At least three of the four suitability factors have minimum desirable or greater than minimum desirable values. One suitability factor may have less than desirable values. The physical characteristics of the roadway could be desirable by intermediate to experienced bicyclists. |
| -2 to -5    | At least two of the four suitability factors have less than minimum desirable values. One or two of the suitability factors may have minimum desirable values. The physical characteristics of the roadway may not be desirable by intermediate to experienced bicyclists.            |
| -6 to -8    | All four of the suitability factors have less than the minimum desirable values. The physical characteristics of the roadway are most likely undesirable by intermediate to experienced bicyclists.   |

*Intended for state highways and intermediate or experienced bicyclists.*

|   |   |
|---|---|
| Date: <u>April 4, 2002</u>                  | Comments/Suggested Improvements:<br><br><b>BICYCLE SUITABILITY ASSESSMENT</b> |
| Data Collector Name: <u>Jim</u>             |   |
| Segment ID Number/Name: <u>101 - Sample</u> |   |
| Boundary streets: <u>Walnut / Tulip</u>     |   |

| A) General Road Factors   | Measures      |
|---|---------------|
| 1) Annual Avg. Daily Traffic (AADT)   | <u>16,500</u> |
| 2) Total number of through lanes  | <u>2</u>      |
| 3) Speed (mph)  | <u>35</u>     |
| 4) Outside lane width (e.g., 11.5')   | <u>12.5</u>   |
| 5) Bike lane or paved shoulder width (e.g., 4.5') (Note - a <b>marked</b> bike lane.) | <u>∅</u>      |

Record these measures in the formula below

| B) Pavement Factors                  | Score             |
|--------------------------------------|-------------------|
| 1) (circle one pavement description) | (record score)    |
| Very Good = 0.25                     |                   |
| Good = <u>0.75</u>                   | <u>0.75</u>       |
| Fair = 1.50                          |                   |
| Poor = 2.25                          |                   |
| Very Poor = 3.75                     |                   |
| 2) Presence of a Curb <u>Y</u> N     | Yes = <u>0.25</u> |
| 3) Rough RR Crossing Y <u>N</u>      | Yes = 0.50        |
| 4) Storm Drain Grate <u>Y</u> N      | Yes = <u>0.75</u> |
| <b>TOTAL Scores</b>                  |                   |
| Record score in formula below        | <u>1.75</u>       |

| C) Location Factors           | Yes/No (circle) | Score for "Yes" |
|-------------------------------|-----------------|-----------------|
| 1) Angle Parking              | Y <u>N</u>      | 0.75            |
| 2) Parallel Parking           | <u>Y</u> N      | <u>0.50</u>     |
| 3) Right-Only Turn Lanes      | <u>Y</u> N      | <u>0.25</u>     |
| 4) Center (Both) Turn Lane    | Y <u>N</u>      | -0.25           |
| 5) Physical Median            | Y <u>N</u>      | -0.50           |
| 6) Paved Shoulder             | Y <u>N</u>      | -0.75           |
| 7) Marked Bike Lane           | Y <u>N</u>      | -1.00           |
| 8) Severe Grades              | Y <u>N</u>      | 0.50            |
| 9) Moderate Grades            | <u>Y</u> N      | <u>0.25</u>     |
| 10) Frequent Curves           | <u>Y</u> N      | <u>0.25</u>     |
| 11) Restricted Sight Distance | <u>Y</u> N      | <u>0.50</u>     |
| 12) Numerous Driveways        | <u>Y</u> N      | <u>0.50</u>     |
| 13) Numerous Intersections    | Y <u>N</u>      | 0.75            |
| 14) Difficult Intersections   | Y <u>N</u>      | 1.00            |
| 15) Industrial Land Use       | Y <u>N</u>      | 0.50            |
| 16) Commercial Land Use       | <u>Y</u> N      | <u>0.25</u>     |
| 17) Sidewalk Only One Side    | <u>Y</u> N      | <u>0.25</u>     |
| 18) Sidewalks do not exist    | Y <u>N</u>      | 0.50            |
| <b>TOTAL all "YES" points</b> |                 | <u>2.75</u>     |
| Record score in formula below |                 |                 |

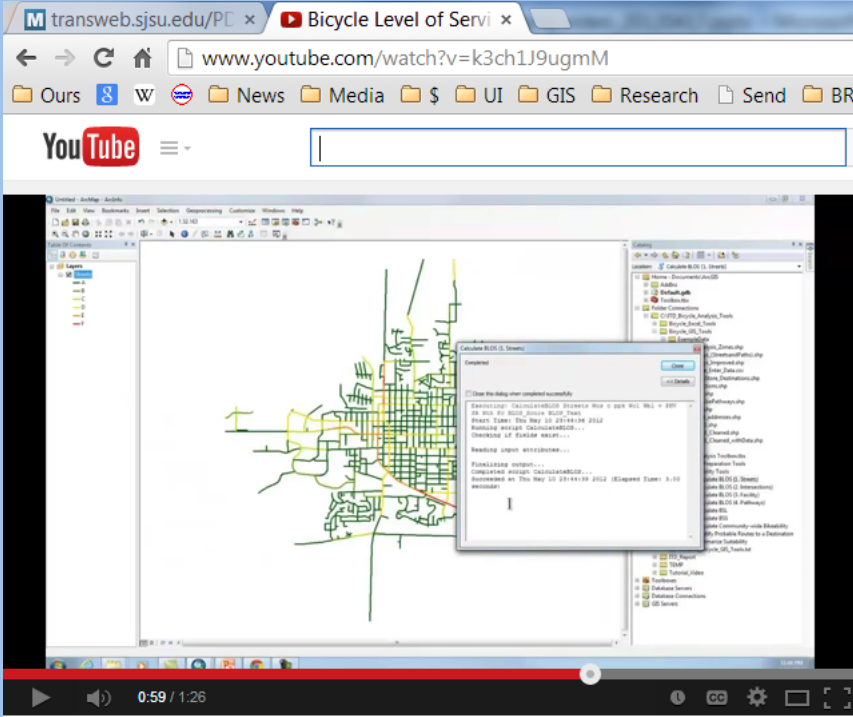
$$\frac{16,500}{2 \times 2500} + \frac{35}{35} + \frac{14 - 12.5 - \emptyset}{2} + 1.75 + 2.75 = 9.6$$

AADT: 16,500  
 Speed (mph): 35  
 Outside Lane Width: 12.5  
 Bike Lane or Paved Shoulder Width: ∅  
 Pavement Factors: 1.75  
 Location Factors: 2.75  
 Bicycle Suitability Score: 9.6

# of thru Lanes: 2

# [BLOS Demonstration video]

<http://www.youtube.com/watch?v=k3ch1J9ugmM>



The screenshot shows a web browser window with a YouTube video player. The browser tabs include 'transweb.sjsu.edu/PL' and 'Bicycle Level of Servi'. The address bar shows the YouTube video URL. The video player shows a map with a network of roads and a dialog box with the following text:

```
Calculate BLOS (s) Overlays  
Completed  
Clear the dialog when completed successfully  
WARNING: Calculated Bicycle BLOS for all BLS = 200  
on May 10 2014 10:00:00 AM  
START TIME: Thu May 10 2014 10:00:00 AM  
WARNING MESSAGE: Calculated BLOS...  
Checking if BLOS result...  
Reading input attributes...  
Finalizing output...  
COMPUTED BLOS: CALCULATED BLOS...  
Completed on Thu May 10 2014 10:00:00 AM (Elapsed Time: 0:00)  
Completed
```

**Bicycle Level of Service GIS Tool**

Dr. Mike Lowry · 10 videos

15 views

Like About Share Add to

Published on Jan 24, 2014  
Purchase tools: <https://marketplace.uidaho.edu/C20272...>  
Full video: [http://www.youtube.com/watch?v=eba\\_h9...](http://www.youtube.com/watch?v=eba_h9...)  
These tools are based the 2010 Highway Capacity Manual (HCM)



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Layers



Catalog

Location: C:\ITD\_Bicycle\_Analysis\_Tools

- Home - Documents\ArcGIS
  - AddIns
  - Default.gdb
  - Toolbox.tbx
- Folder Connections
  - ITD\_Bicycle\_Analysis\_Tools
    - Bicycle\_Excel\_Tools
    - Bicycle\_GIS\_Tools
    - ExampleData
      - Big\_Analysis\_Zones.shp
      - Bikeways\_(StreetsandPaths).shp
      - Bikeways\_Improved.shp
      - Example\_Enter\_Data.csv
      - GroceryStore\_Destinations.shp
      - Intersections.shp
      - Parcels.shp
      - SharedUsePathways.shp
      - Streets.shp
      - Student\_addresses.shp
      - zip83301.shp
      - zip83301\_Cleaned.shp
      - zip83301\_Cleaned\_withData.shp
    - ToolData
      - Bicycle Analysis Toolbox.tbx
        - 1 Data Preparation Tools
        - 2 Suitability Tools
          - Calculate BLOS (1. Streets)
          - Calculate BLOS (2. Intersections)
          - Calculate BLOS (3. Facility)
          - Calculate BLOS (4. Pathways)
          - Calculate BSL
          - Calculate BSS
          - Calculate Community-wide Bikeability
          - Identify Probable Routes to a Destination
          - Summarize Suitability
    - README\_Bicycle\_GIS\_Tools.txt
    - ITD\_Report
    - TEMP
    - Tutorial\_Video
- Toolboxes
- Database Servers
- Database Connections
- GIS Servers



| BLOS | Current Conditions | Proposed Improvement Scenario 1 | Proposed Improvement Scenario 2 |
|------|--------------------|---------------------------------|---------------------------------|
| A    | 70                 | 78                              | 84                              |
| B    | 7                  | 8                               | 5                               |
| C    | 10                 | 8                               | 5                               |
| D    | 7                  | 3                               | 3                               |
| E    | 3                  | 1                               | 1                               |
| F    | 3                  | 2                               | 2                               |

**Great Bicycle Suitability...**  
**...But does it go anywhere?**



## Tool 2

# CALCULATE COMMUNITY-WIDE BIKEABILITY

- **Bicycle Suitability**

Perceived comfort and safety of a segment of street or pathway

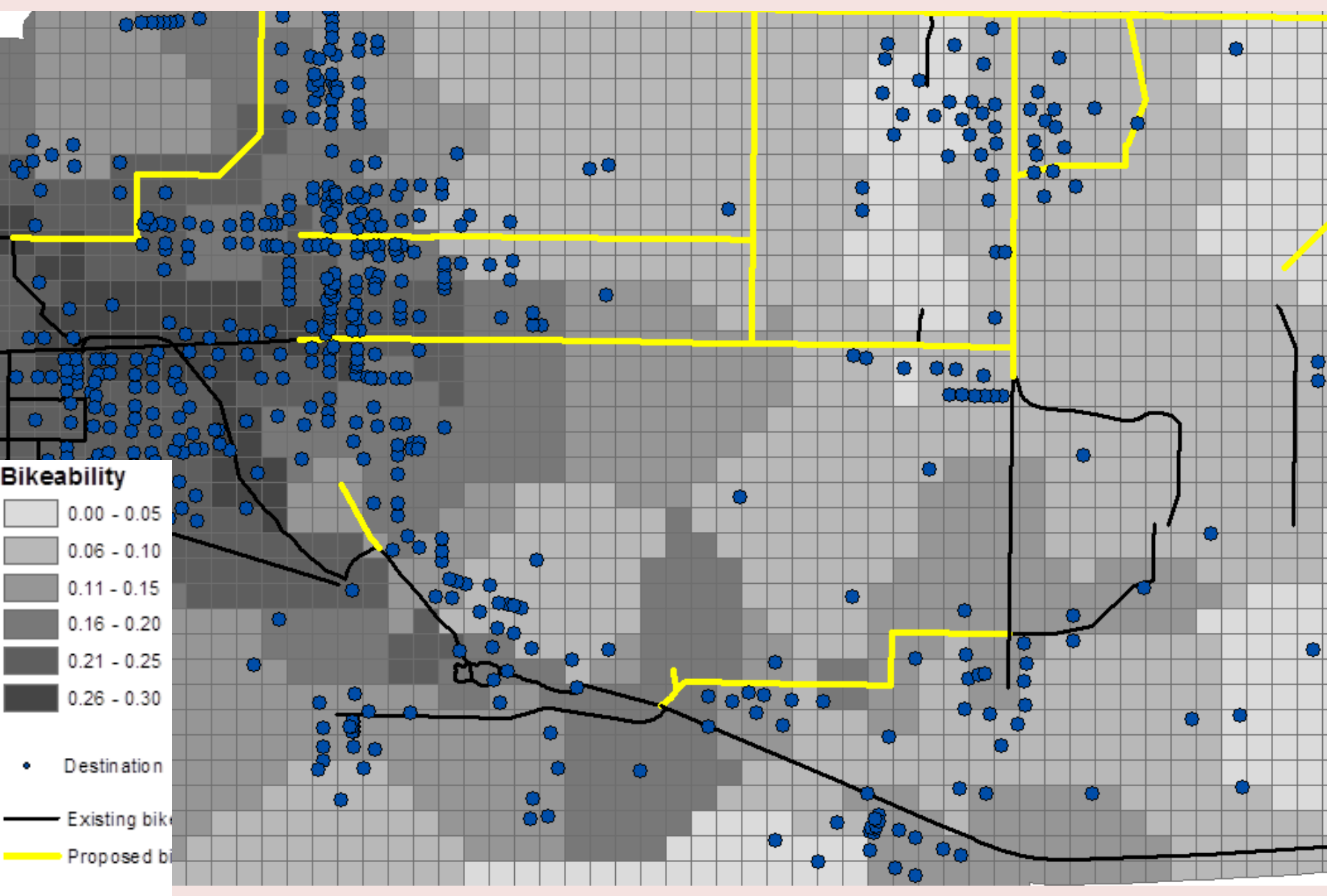
- **Bikeability**

Perceived comfort and safety of network connectivity for accessing important destinations

- **Bicycle Friendliness**

Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community





# [Bikeability Demonstration video]

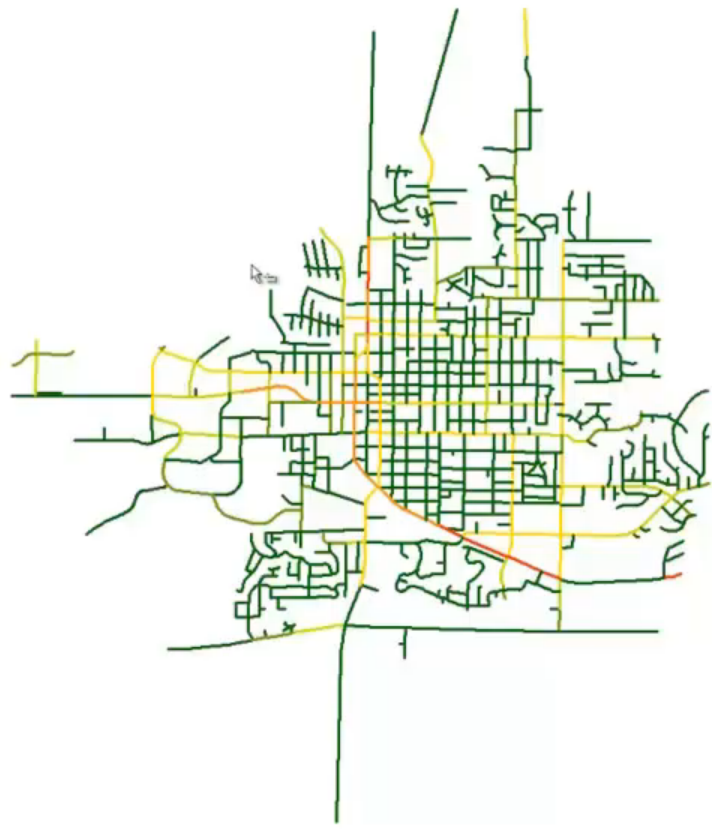
<http://www.youtube.com/watch?v=2Wi14vy7ZU4>

The screenshot shows a web browser window displaying a YouTube video. The browser's address bar shows the URL [www.youtube.com/watch?v=2Wi14vy7ZU4](http://www.youtube.com/watch?v=2Wi14vy7ZU4). The browser's tab is titled "Bikeability GIS Tool - x". The browser's address bar also shows a search bar and a list of folders: Ours, News, Media, \$, UI, GIS, Research, Send, and BRC. The YouTube logo is visible in the top left corner of the browser window. The video player shows a screenshot of a GIS application. The application window is titled "ArcMap - ArcView". The main map area displays a grayscale map of a city area with a grid overlay. The map is titled "Catalan Community with Bikeability". The left sidebar shows a "Layers" panel with a tree view of the map's layers. The right sidebar shows a "Catalog" panel with a list of data sources and layers. The video player shows a progress bar at 3:10 / 5:58. Below the video player, the video title "Bikeability GIS Tool" is displayed. The video is by "Dr. Mike Lowry - 10 videos". There is a "Subscribe" button with a "7" next to it. The video has "9 views". Below the video player, there are icons for "Like", "About", "Share", "Add to", and "Print". The video was published on Jan 24, 2014.



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      - B
      - C
      - D
      - E
      - F
  - SharedUsePathways
    - B
    - C
  - FacilityOutput
    - D
  - Streets**
    - A
    - B
    - C
    - D
    - E
    - F



Catalog

- Location: Calculate BLOS (1. Streets)
- Home - Documents\ArcGIS
  - AddIns
  - Default.gdb
  - Toolbox.tbx
- Folder Connections
  - C:\ITD\_Bicycle\_Analysis\_Tools
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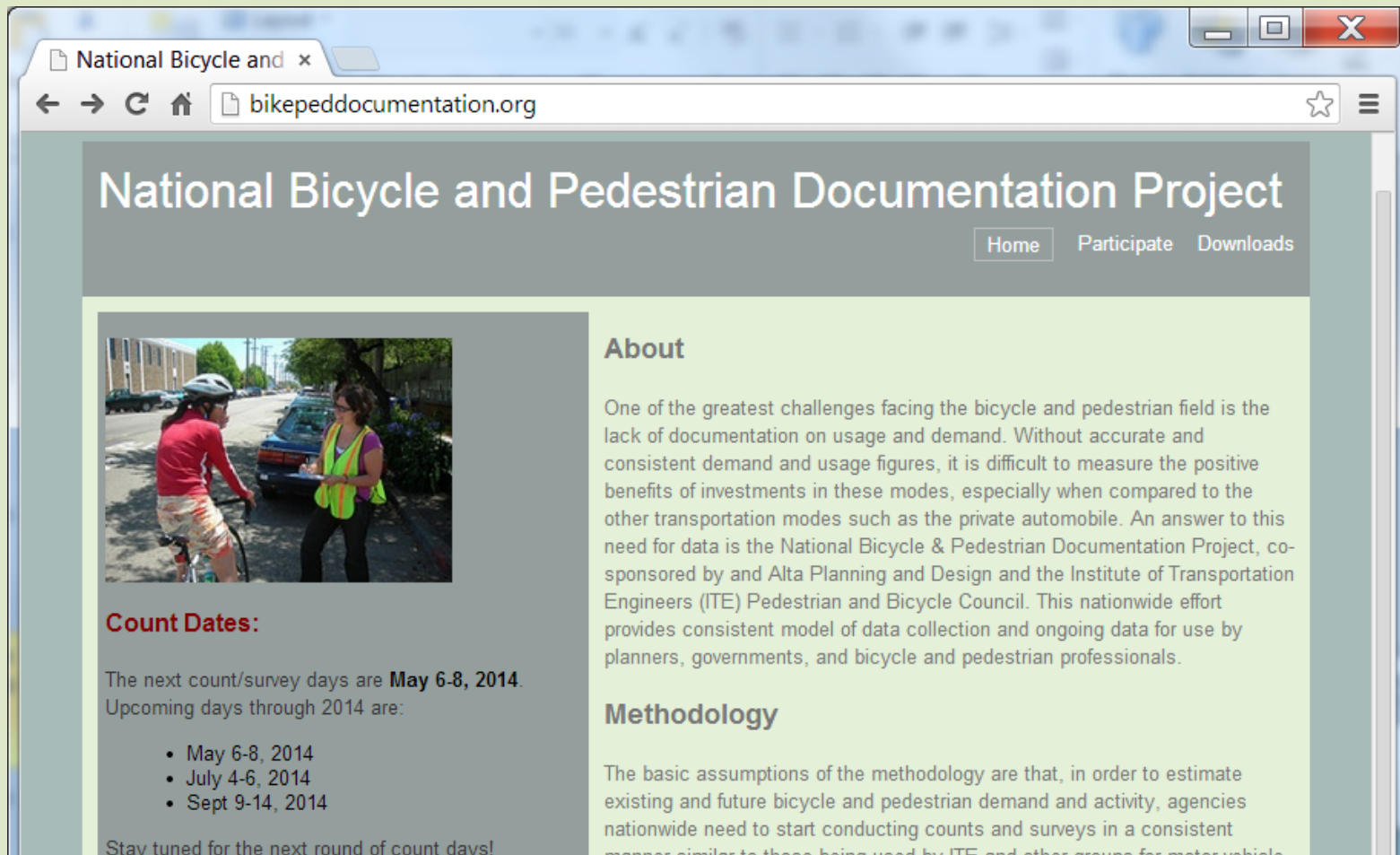


Tool 3

# ESTIMATE BICYCLE VOLUMES

# Background

## Citizen-volunteer count programs



The image shows a screenshot of a web browser displaying the website for the National Bicycle and Pedestrian Documentation Project. The browser's address bar shows the URL [bikepeddocumentation.org](http://bikepeddocumentation.org). The website's main heading is "National Bicycle and Pedestrian Documentation Project", with navigation links for "Home", "Participate", and "Downloads".

**Count Dates:**

The next count/survey days are **May 6-8, 2014**.  
Upcoming days through 2014 are:

- May 6-8, 2014
- July 4-6, 2014
- Sept 9-14, 2014

Stay tuned for the next round of count days!

**About**

One of the greatest challenges facing the bicycle and pedestrian field is the lack of documentation on usage and demand. Without accurate and consistent demand and usage figures, it is difficult to measure the positive benefits of investments in these modes, especially when compared to the other transportation modes such as the private automobile. An answer to this need for data is the National Bicycle & Pedestrian Documentation Project, co-sponsored by Alta Planning and Design and the Institute of Transportation Engineers (ITE) Pedestrian and Bicycle Council. This nationwide effort provides consistent model of data collection and ongoing data for use by planners, governments, and bicycle and pedestrian professionals.

**Methodology**

The basic assumptions of the methodology are that, in order to estimate existing and future bicycle and pedestrian demand and activity, agencies nationwide need to start conducting counts and surveys in a consistent manner similar to those being used by ITE and other groups for motor vehicle

# Instructions

The other dates were selected to provide a representative sampling of activity during a typical spring (May) and winter (January) period. The 4<sup>th</sup> of July period was selected because it will afford both a typical summer weekday and what is typically the busiest holiday period and activity period for recreational facilities and activities.

Having an official count week is also important for generating enthusiasm around the date. Much like nationwide Bike to Work Weeks, we hope that the National Documentation Project Week in September will become a much-anticipated annual event in localities around the nation.

## Times

Based on our research, we are recommending (see below). However, if you have been doing using these same time periods for all future

### RECOMMENDED

Weekday, 5-7  
Saturday, 12-2

### SECONDARY

Weekday, 7-9  
Saturday, 7-9

## Rationale for Time Periods

Time periods are more important for counts than for other types of data collection. Time periods were chosen since the afternoon and evening periods are the most important for bicyclists, with commuters, school children, and recreational riders. Counts conducted during these periods will provide a good picture of bicycling during the peak periods of the day. Actual local peak periods may differ from the national count time periods but the national count time periods are chosen based on periods if it is determined that this period

## Automatic Machines

While the NBPD is based on manual counting, we encourage localities to consider conducting counts to consider conducting counts in their community. These machines will give information on usage, benefits and other information.

## Weather

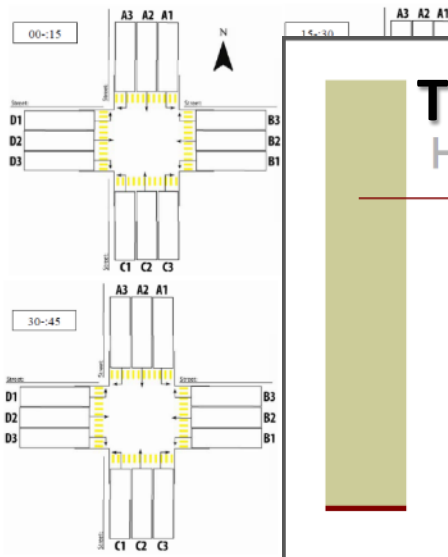
Weather may be a determinant in selecting count locations and surveyors, but a particular location or unusual during the count period

# Forms

www.nbpd.org

Please fill in your name, count location, date, time period, and weather conditions (fair, rainy, very cold). Count all bicyclists crossing through the intersection under the appropriate categories.

- Count for two hours in 15-minute increments.
- Count bicyclists who ride on the sidewalk.
- Count the number of people on the bicycle, not the number of bicycles.
- Use one intersection graphic per 15-minute interval.



# Training Presentation

## How do you count this?



The National Bicycle and Pedestrian Documentation Project  
and the Institute of Transportation Studies

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# Citizen Volunteer Counts

2012 WASHINGTON STATE BICYCLE AND PEDESTRIAN DOCUMENTATION PROJECT

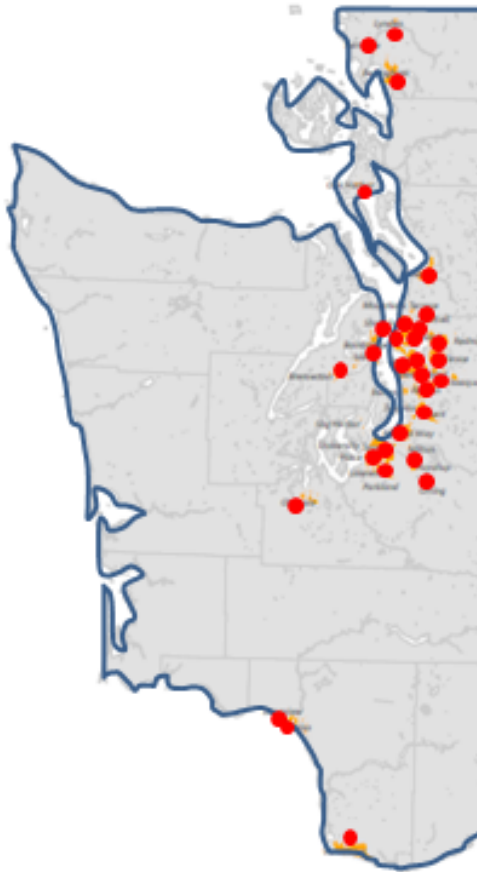


Table 2: Count cities and locations by year

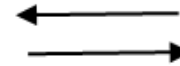
| City              | 2008 |    | 2009 |    | 2010 |    | 2011 |    | 2012 |    |
|-------------------|------|----|------|----|------|----|------|----|------|----|
|                   | AM   | PM | AM   | PM | AM   | PM | AM   | PM | AM   | PM |
| Bainbridge Island | 0    | 0  | 0    | 0  | 0    | 5  | 1    | 1  | 5    | 4  |
| Bellevue          | 4    | 3  | 13   | 13 | 13   | 13 | 5    | 7  | 7    | 8  |
| Bellingham        | 6    | 6  | 12   | 12 | 17   | 17 | 18   | 18 | 18   | 18 |
| Bothell           | 5    | 6  | 6    | 4  | 6    | 3  | 6    | 5  | 6    | 5  |
| Bremerton         | 6    | 6  | 6    | 4  | 6    | 5  | 1    | 3  | 6    | 5  |
| Burien            | 0    | 0  | 4    | 9  | 9    | 9  | 9    | 9  | 10   | 10 |
| Ellensburg        | 6    | 4  | 5    | 4  | 2    | 3  | 3    | 5  | 4    | 4  |
| Everett           | 6    | 6  | 9    | 9  | 8    | 5  | 10   | 9  | 11   | 11 |
| Federal Way       | 0    | 0  | 0    | 0  | 0    | 0  | 0    | 0  | 1    | 5  |
| Ferndale          | 1    | 1  | 0    | 0  | 1    | 0  | 0    | 0  | 0    | 0  |
| Gig Harbor        | 0    | 0  | 0    | 0  | 0    | 0  | 0    | 0  | 1    | 1  |
| Issaquah          | 0    | 0  | 6    | 4  | 7    | 3  | 6    | 3  | 6    | 6  |
| Kelso             | 0    | 0  | 5    | 7  | 8    | 8  | 0    | 1  | 2    | 0  |

Table 2: Count cities and locations by year

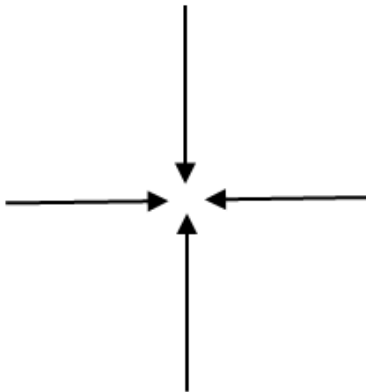
| City              | 2008 |    | 2009 |     | 2010 |     | 2011 |     | 2012 |     |
|-------------------|------|----|------|-----|------|-----|------|-----|------|-----|
|                   | AM   | PM | AM   | PM  | AM   | PM  | AM   | PM  | AM   | PM  |
| Bainbridge Island | 0    | 0  | 0    | 0   | 0    | 5   | 1    | 1   | 5    | 4   |
| Bellevue          | 4    | 3  | 13   | 13  | 13   | 13  | 5    | 7   | 7    | 8   |
| Bellingham        | 6    | 6  | 12   | 12  | 17   | 17  | 18   | 18  | 18   | 18  |
| Bothell           | 5    | 6  | 6    | 4   | 6    | 3   | 6    | 5   | 6    | 5   |
| Bremerton         | 6    | 6  | 6    | 4   | 6    | 5   | 1    | 3   | 6    | 5   |
| Burien            | 0    | 0  | 4    | 9   | 9    | 9   | 9    | 9   | 10   | 10  |
| Ellensburg        | 6    | 4  | 5    | 4   | 2    | 3   | 3    | 5   | 4    | 4   |
| Everett           | 6    | 6  | 9    | 9   | 8    | 5   | 10   | 9   | 11   | 11  |
| Federal Way       | 0    | 0  | 0    | 0   | 0    | 0   | 0    | 0   | 1    | 5   |
| Ferndale          | 1    | 1  | 0    | 0   | 1    | 0   | 0    | 0   | 0    | 0   |
| Gig Harbor        | 0    | 0  | 0    | 0   | 0    | 0   | 0    | 0   | 1    | 1   |
| Issaquah          | 0    | 0  | 6    | 4   | 7    | 3   | 6    | 3   | 6    | 6   |
| Kelso             | 0    | 0  | 5    | 7   | 8    | 8   | 0    | 1   | 2    | 0   |
| Yakima            | 3    | 3  | 1    | 1   | 1    | 2   | 2    | 3   | 1    | 1   |
| Total             | 91   | 92 | 152  | 149 | 184  | 182 | 191  | 176 | 202  | 207 |
|                   | 183  |    | 301  |     | 366  |     | 367  |     | 409  |     |



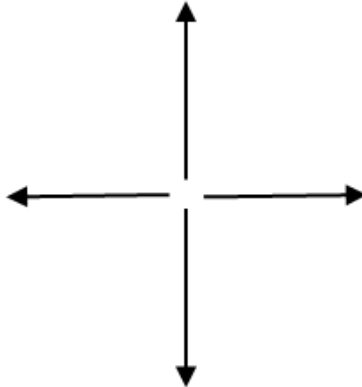
2 Movement  
Screenline



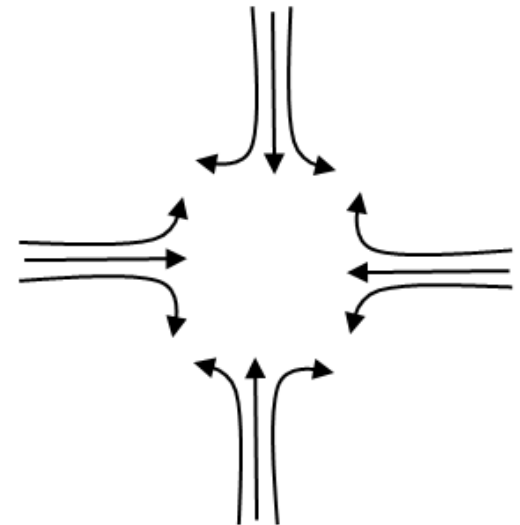
4 Movement  
Toward Intersection



4 Movement  
Leaving Intersection



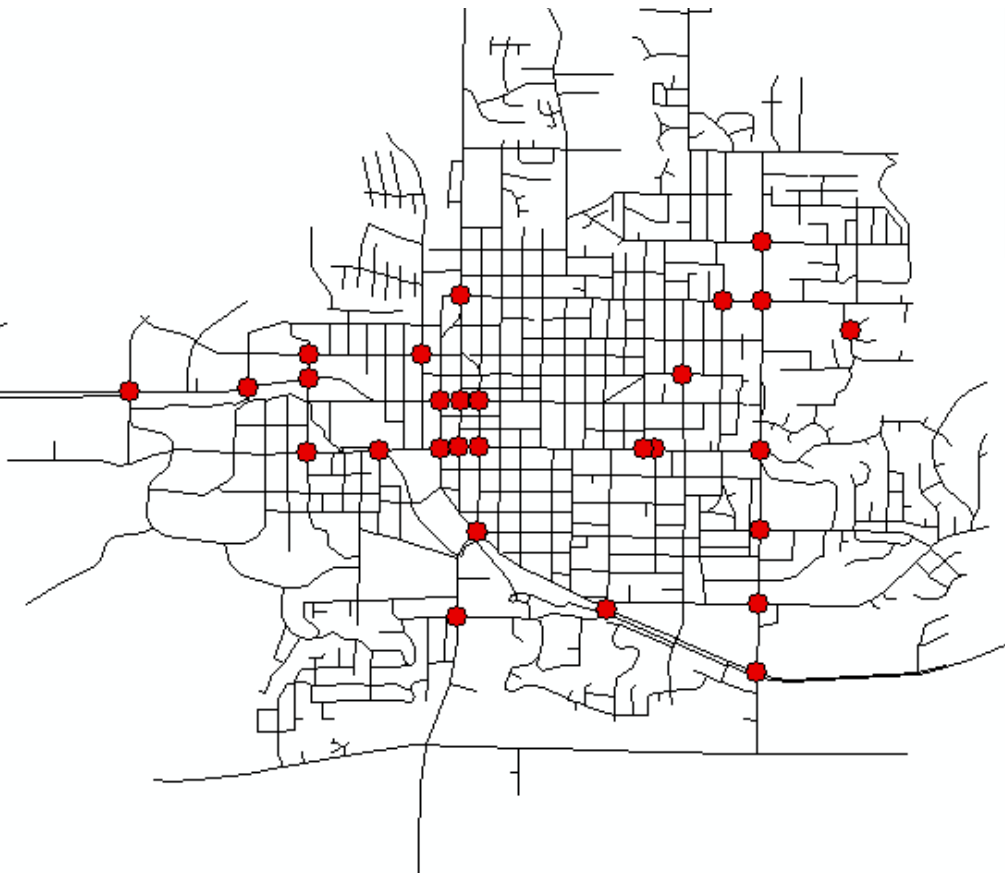
12 Movement





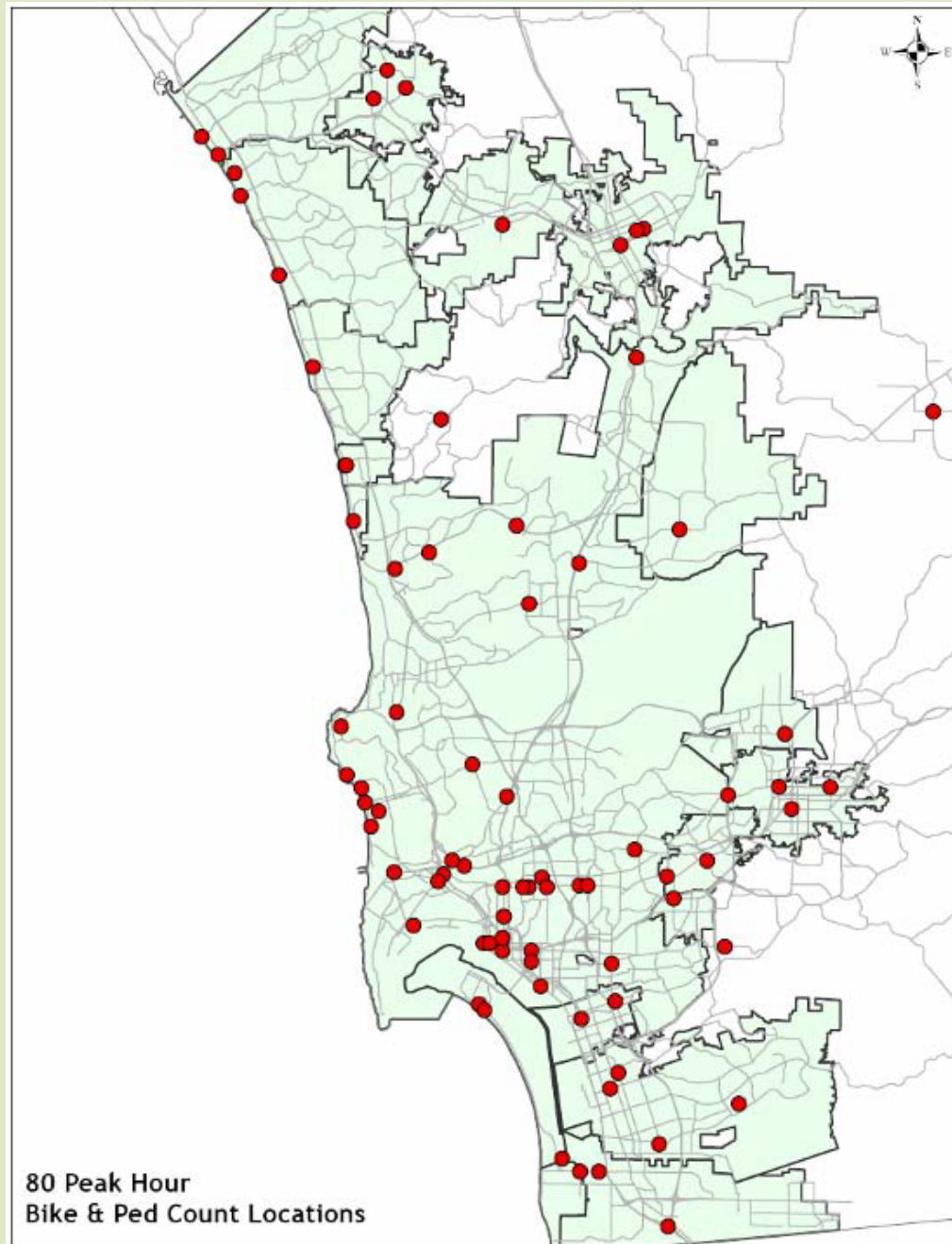
**How can citizen-volunteer  
count data be used?**

## **Snap shot of volumes**

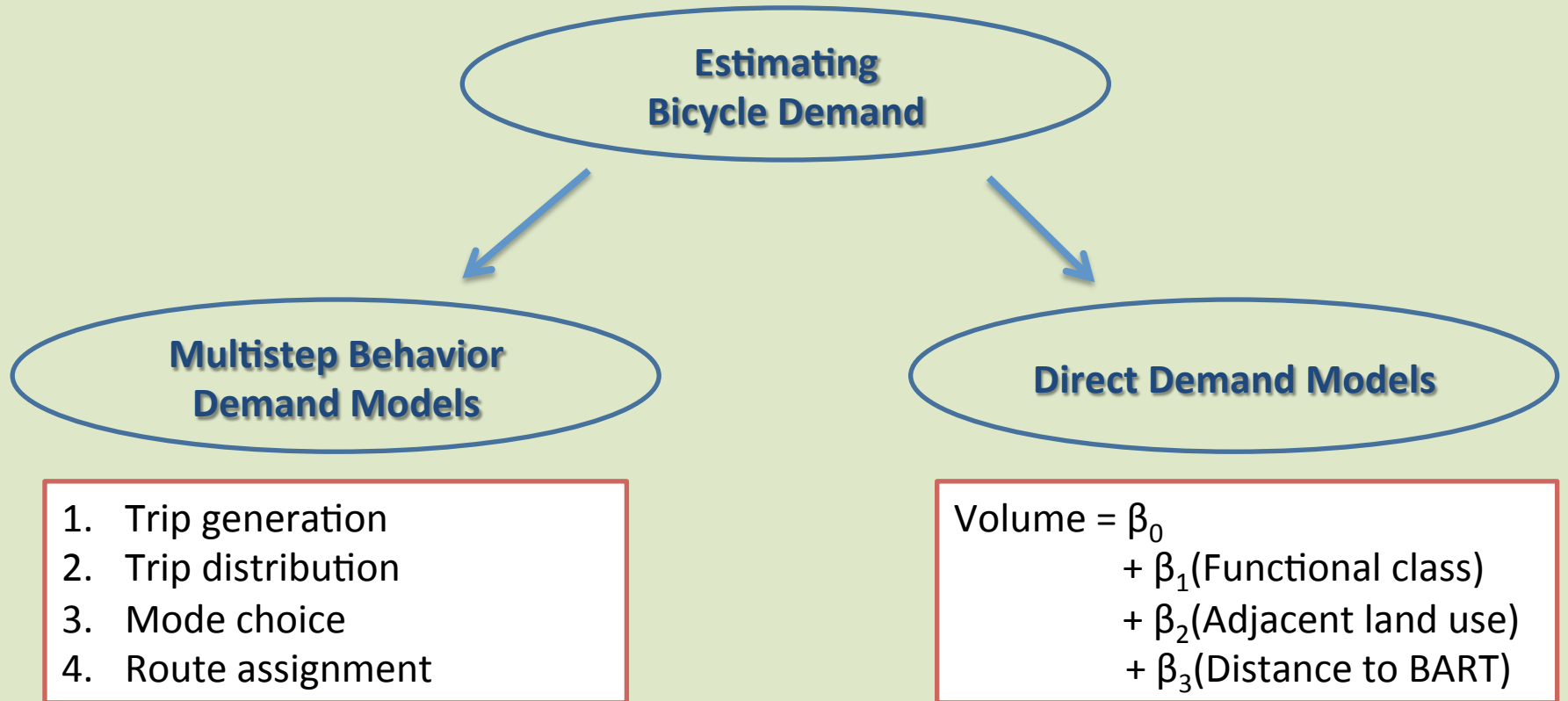


- **26 Locations**
- **2011, 2012, 2013**
- **7:00 – 9:00 AM**
- **4:00 – 6:00 PM**

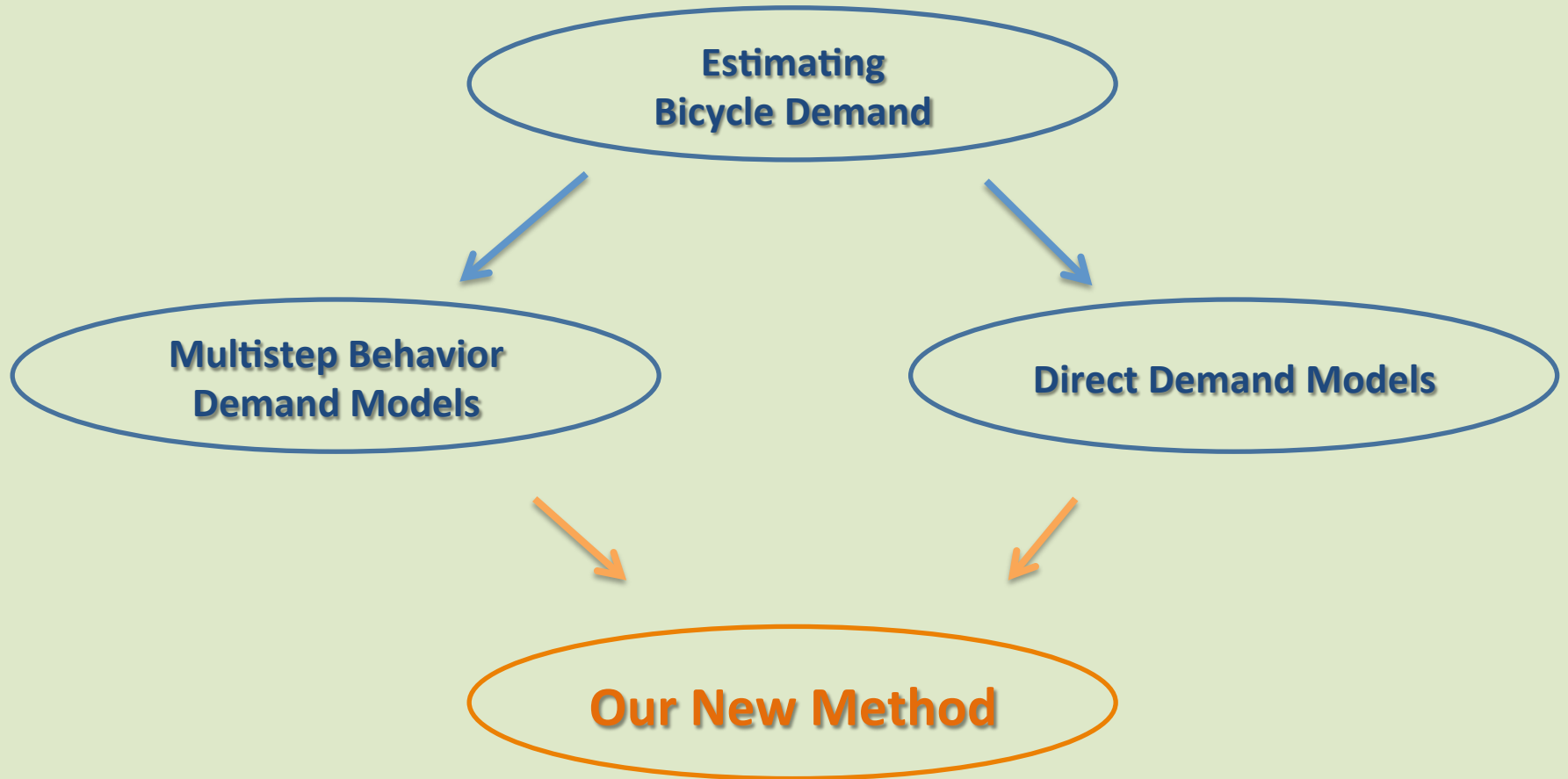
**80 locations!**

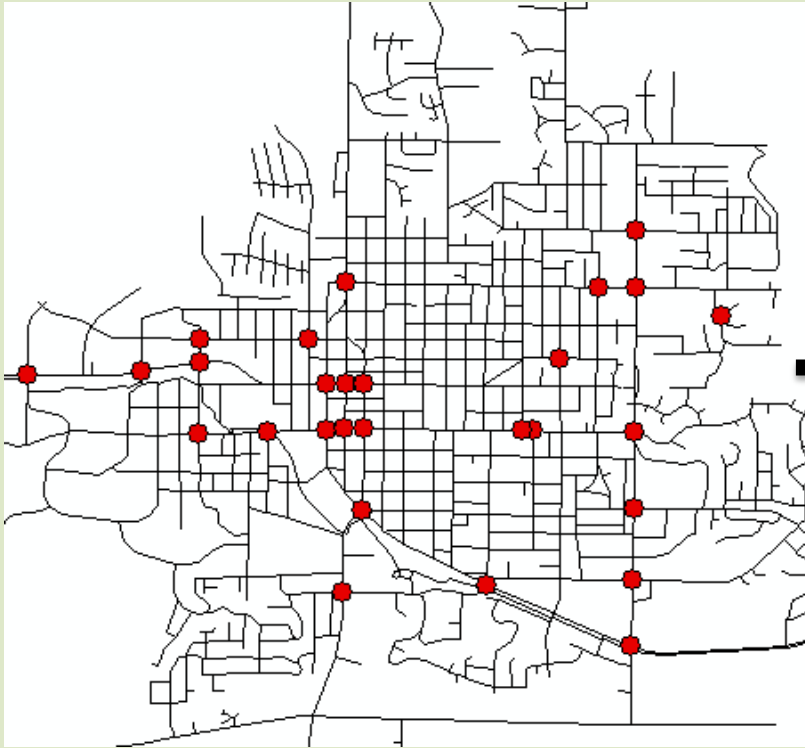


# Background

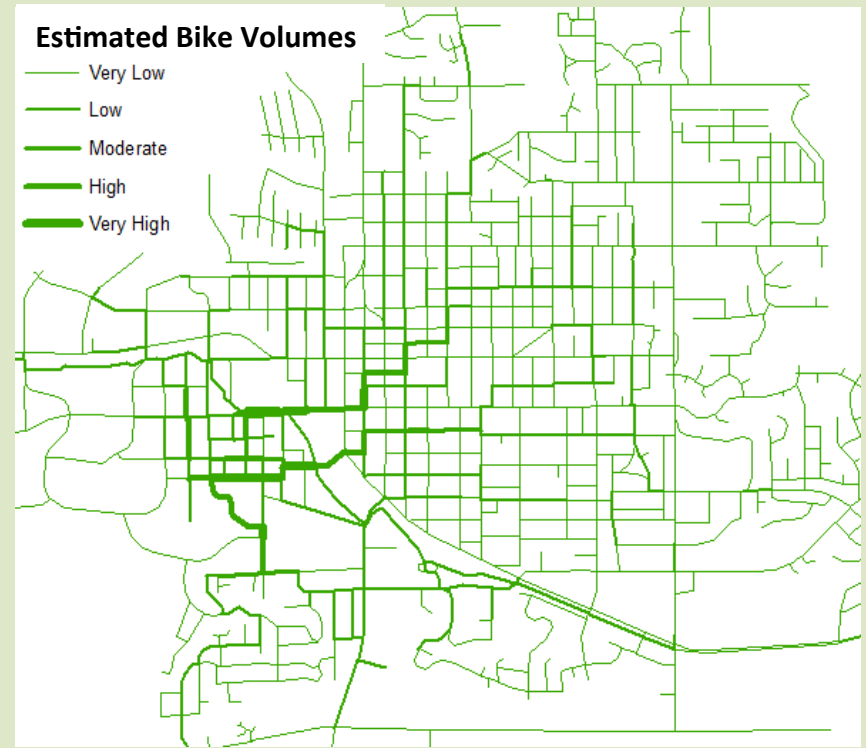


# Background



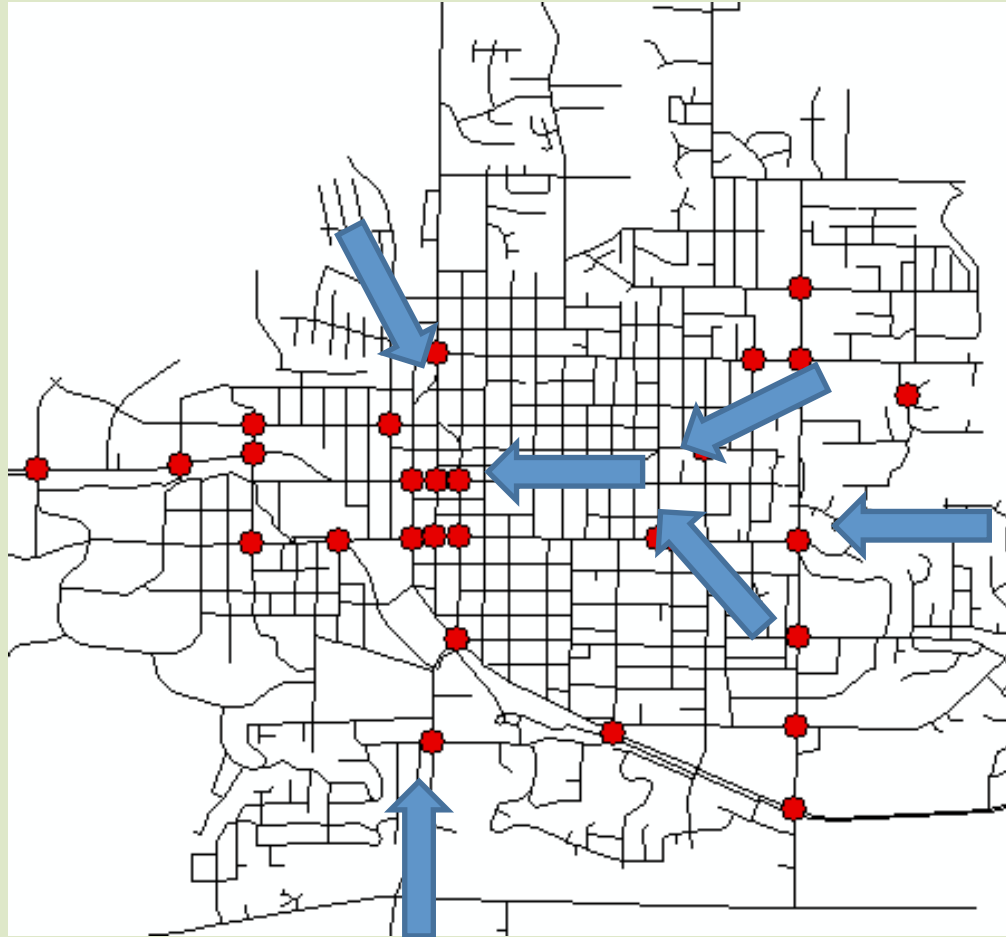


**Observed Count Points**



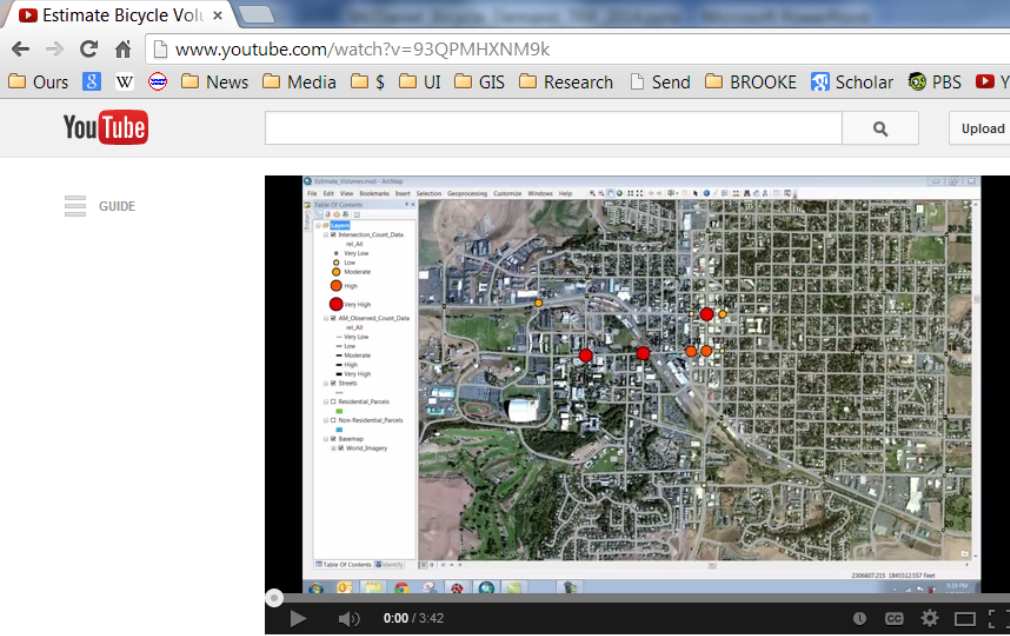
**Network-wide  
2 Hour Volume**

# Topological Flow



# [Volume Estimation Demonstration video]

<http://www.youtube.com/watch?v=dMp2XIQaykw>

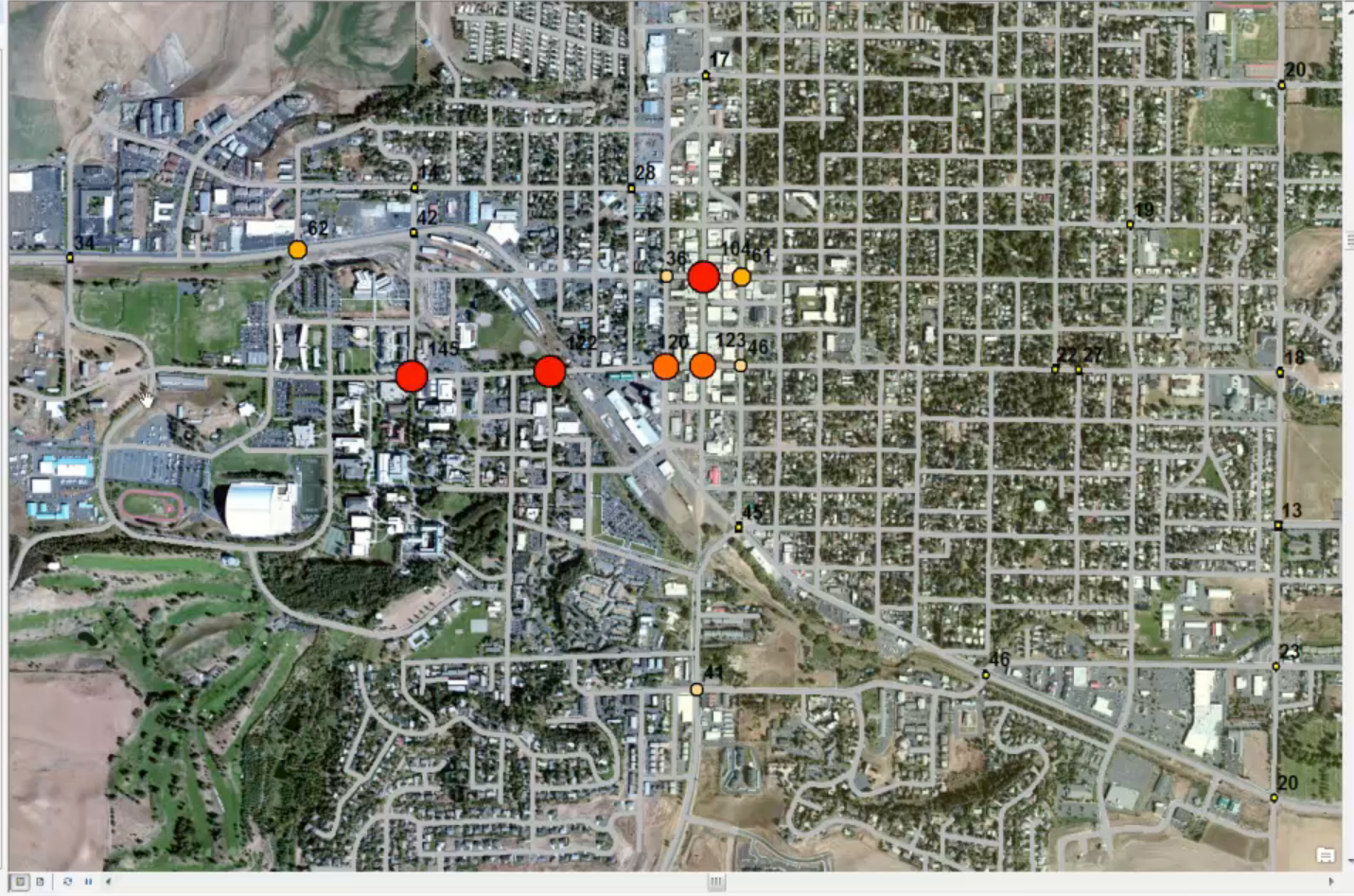


The screenshot shows a YouTube video player displaying a GIS software interface. The video title is "Estimate Bicycle Volume". The video content shows a map of a city area with several red and orange dots indicating estimated bicycle volume. A legend on the left side of the map shows the following categories: Very Low (blue dot), Low (yellow dot), Moderate (orange dot), High (red dot), and Very High (dark red dot). The video player interface includes a search bar, a "GUIDE" menu, and a video progress bar showing 0:00 / 3:42. Below the video player, the video title "Estimate Bicycle Volume" is displayed, along with the channel name "Dr. Mike Lowry" and 9 videos. The video has 3 views, 0 likes, and 0 dislikes. The video is published on Jan 9, 2014. The description of the video is: "GIS tool to estimate bicycle volumes. More information: McDaniel, S., Lowry, M., and Dixon, M. (2014). 'Using Origin-Destination Centrality to Estimate Directional Bicycle

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Layers

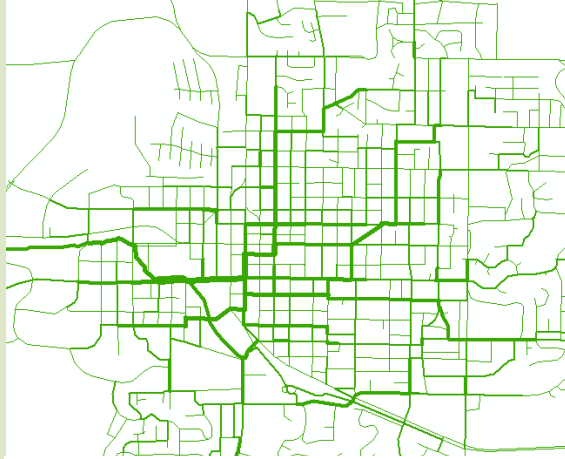
- Intersection\_Count\_Data
  - rel\_All
    - Very Low
    - Low
    - Moderate
    - High
    - Very High
- AM\_Observed\_Count\_Data
  - rel\_All
    - Very Low
    - Low
    - Moderate
    - High
    - Very High
- Streets
- Residential\_Parcels
- Non-Residential\_Parcels
- Basemap
  - World\_Imagery



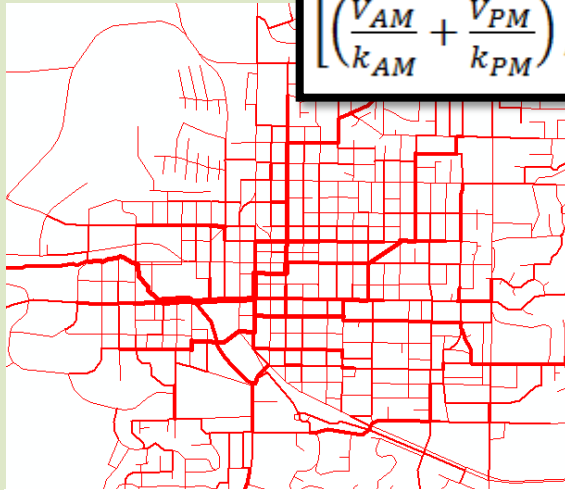
2306607.215 1845512.557 Feet



# Step 1. Spatially Extrapolate



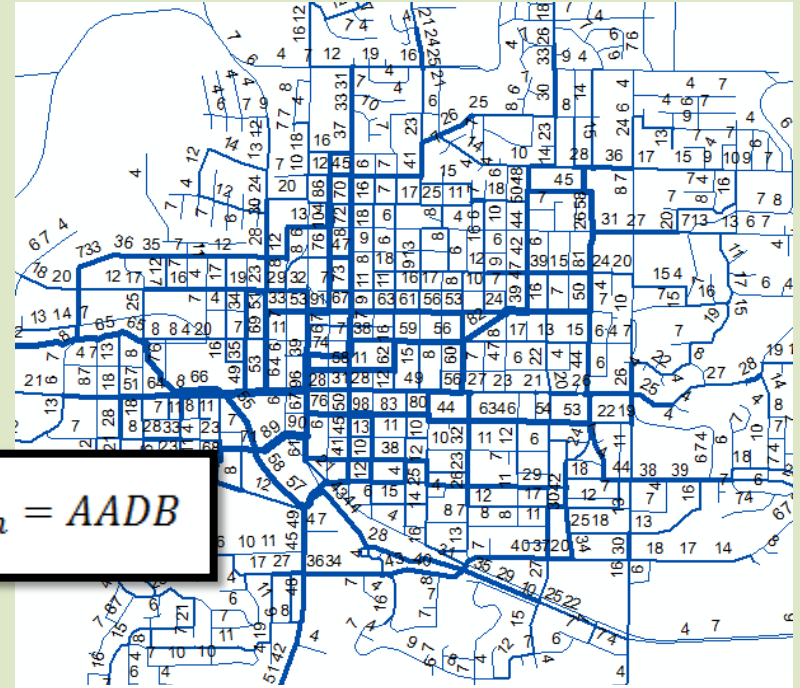
**AM 2 Hour Volume**



**PM 2 Hour Volume**

$$\left[ \left( \frac{V_{AM}}{k_{AM}} + \frac{V_{PM}}{k_{PM}} \right) / 2 \right] * F_{day} * F_{month} = AADB$$

# Step 2. Temporally Extrapolate



**AADB**

# Scenario Planning



# Scenario Planning

## Third Street Bicycle Volumes Existing and Forecasted

| Intersection<br>Cross Street | Existing<br>Conditions<br>(AADB) | Proposed<br>Scenario<br>(AADB) |
|------------------------------|----------------------------------|--------------------------------|
| Van Buren Street             | 24                               | 226                            |
| Harrison Street              | 28                               | 230                            |
| Tyler Street                 | 32                               | 230                            |
| Polk Street                  | 44                               | 253                            |
| Taylor Street                | 89                               | 239                            |
| Fillmore Street              | 127                              | 255                            |
| Pierce Street                | 146                              | 255                            |

**Increase of about  
200 bicyclists per day.**

**Increase of about  
150 bicyclists per day.**



**Tool 4**

# **ASSESS DANGEROUS SITUATION EXPOSURE**

# Background

## Challenge of Accident Analysis

1. Lack of Volume Data
2. Lack of Accident Data



# Dangerous Situations

## (Situational Antecedents to accidents)

| Dangerous Situation            | Description  | References   |
|--------------------------------|--|--|
| Mixed cycling in harsh traffic | Cycling in the vehicle travel lane on a road with high vehicle volume, speed, and/or percent heavy vehicle | Mapes, 2009; Teschke, 2012; Harkey and Stewart, 1997; Elvik et al., 2009; Moritz 1997; Tinsworth et al., 1994; Allen-Munley et al., 2004; Klop and Khattak, 1999; Vandebulcke 2013; Schepers et al., 2013; CROW 2007; Kim et al., 2007; Stone and Broughton, 2003; Carter et al., 2007; McCarthy and Gilbert, 1996 |
| Dedicated ROW in harsh traffic | Cycling in a dedicated right-of-way adjacent to high vehicle volume, speed, and/or percent heavy vehicle   | Reynolds et al., 2009; Pucher and Buehler, 2012.   |
| Separated cycling              | Physically separated on-street cycling, such as cycle tracks   | Lusk et al., 2011; Lusk et al., 2013; Kin et al., 2007; Wachtel and Lewiston, 1994; Schepers et al., 2011  |
| Cramped Space                  | Roads without a bike lane or shoulder, narrow travel lanes   | McCarthy and Gilbert, 1996; Vandebulcke 2011; Allen-Munley et al., 2004; Klop and Khattak, 1999; Harkey and Stewart, 1997  |
| Excessive space                | Roads with wide travel lanes, no bike lane, and at least moderate speed                                    | Allen-Munley et al., 2004; Hunter et al., 1999   |
| Dooring and vehicle parking    | Areas with on-street parking and high parking turnover   | Vandebulcke et al., 2013; Tilahun et al., 2007   |
| Frequent access points         | High frequency of driveways  | Allen-Munley et al., 2004; Emery and Crump, 2003   |

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| Frequent access points         | High frequency of driveways  | Allen-Munley et al., 2004; Emery and Crump, 2003  |



# Dangerous Situations

| Dangerous Situation       | Description  | References   |
|---------------------------|--|--|
| Crossing harsh traffic    | Crossing a road with high vehicle volume, speed, and/or percentage heavy vehicle | Summala et al., 1996; CROW, 2007; Schepers et al., 2011  |
| Complicated intersections | Navigating; e.g. five point intersections or roundabouts                         | Daniels et al., 2009; Brüde and Larsson, 2000; Schoon and Van Minnen, 1994; Vandenbulcke et al., 2013                          |
| Right hook                | Right-turning cars conflicting with through cyclist                              | McCarthy and Gilbert, 1996; Räsänen and Summala, 1998; Schimek, 2014; Weigand, 2008; Schepers et al., 2013; Furth et al., 2014 |
| Left sneak                | Cyclist sneaking across travel lanes to complete a left turn                     | Hunter et al., 1999  |
| Thru clip                 | Left turning vehicles conflict with through cyclist                              | Summala et al., 1996; Räsänen and Summala, 1998; Schimek, 2014; Shepers et al., 2014   |
| Gaps in bicycle network   | Discontinuity of bicycle the network   | Krizek and Roland, 2005; Mekuria et al., 2012  |
| Wrong-way riding          | Cycling the wrong-way on a one-way street.                                       | Wachtel and Lewiston, 1994; Räsänen and Summala, 1998; Schimek, 2014; Summala et al., 1996; Hunter et al., 1999;               |
| Sidewalk riding           | Cyclist utilizing sidewalks  | Schimek, 2014; Wachtel and Lewiston 1994;  |
| Infrequent cyclers        | Low cyclist volume   | Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007                                  |

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| Thru clip                 | Left turning vehicles conflict with through cyclist                              | Summala et al., 1996; Räsänen and Summala, 1998; Schimek, 2014; Shepers et al., 2014   |
| Gaps in bicycle network   | Discontinuity of bicycle the network   | Krizek and Roland, 2005; Mekuria et al., 2012  |
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| Sidewalk riding           | Cyclist utilizing sidewalks  | Schimek, 2014; Wachtel and Lewiston 1994;  |
| Infrequent cyclers        | Low cyclist volume   | Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007                                  |

# Step 1. Define Exposure Metrics



Community-specific metrics should be based on:

- **Public involvement**
- **Local experience**
- **Latest research**

| Dangerous Situation                | Metric  |
|------------------------------------|---|
| Separated cycling in harsh traffic | Bike lane<br>Vehicle volume > 8,000 AADT  |
| Mixed cycling in harsh traffic     | No bike lane<br>Vehicle volume > 3,000 AADT   |
| Cramped space                      | Vehicle lane width < 12 ft<br>Vehicle volume > 1,000 AADT<br>Vehicle speed limit > 20 mph |
| Parking maneuvers and dooring      | Parking turnover > 4 maneuvers per hr   |
| Frequent access points             | Access points > 30 per mile   |
| Steep grade                        | Grade > 4%  |
| Wrong-way riding                   | Wrong-way riding occurrence   |
| Unexpected cyclers                 | Cyclist volume < 50 AADB  |



# Step 2. Calculate Exposure

3. Calculate Dangerous Situation Exposure

Street Network

Bike Volume Field  
AADBS0

Functional Class Field  
Func

Speed Field  
carspeed

Car AADT Field  
Est\_AADT

Movement Field  
Movement

Bike Lane Width Field  
Bike\_S0

Wrong Way Field  
Wrong\_way

Slope Field  
Slope

Output Text File

OK Cancel Environments... Show Help >>

Table Of Contents

Layers

Bikeways\_Augmented\_2

AADBS1

0 - 23

24 - 54

55 - 80

81 - 117

Catalog

Location: 3. Calculate Dangerous Situation Exposure

Home - Documents\ArcGIS

Folder Connections

C:\Users\m\lowry\NIATTW500L3\Dropbox\Tools\_Shared\Volume\_

ExampleData

Input

Instructions

Output

ToolData

Volume Estimation Toolbox.tbx

0 Other Tools

1 Land Use Preparation Tools

2 Network Preparation Tools

3 Map Count Data Tools

4 Analysis Tools

1. Estimate AADT

2. Estimate AADB

3. Calculate Dangerous Situation Exposure

Toolboxes

Table Of Contents Identify

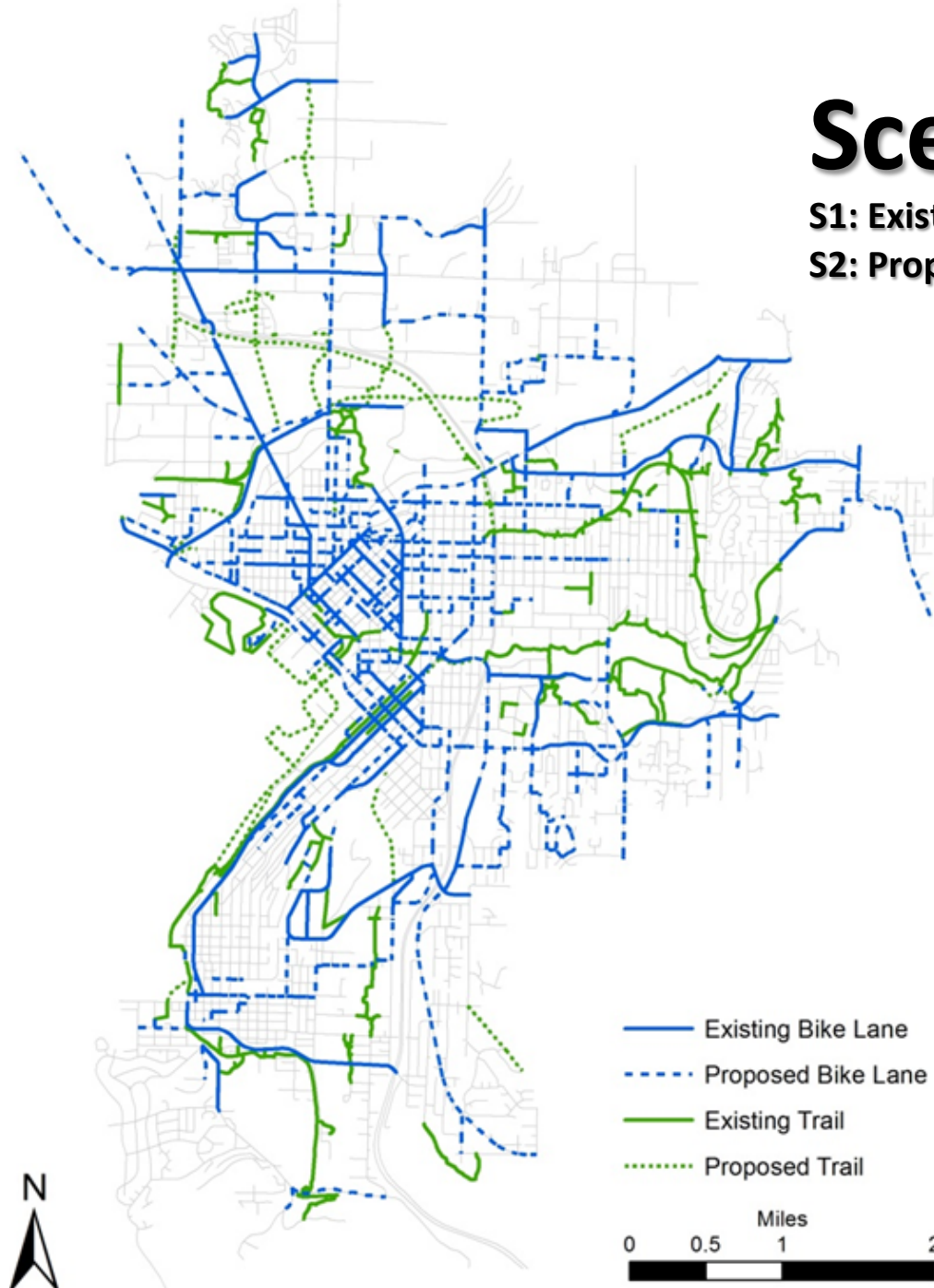
1249074.912 655679.755 Feet

10:45 PM  
2/26/2014

# Scenarios

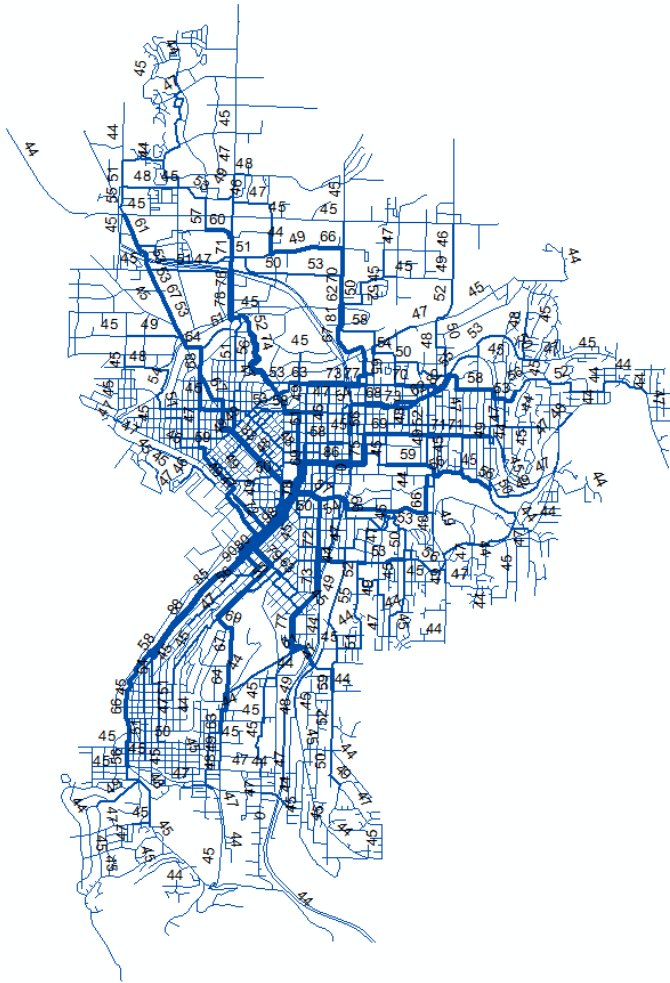
**S1: Existing Conditions**

**S2: Proposed Improvements**

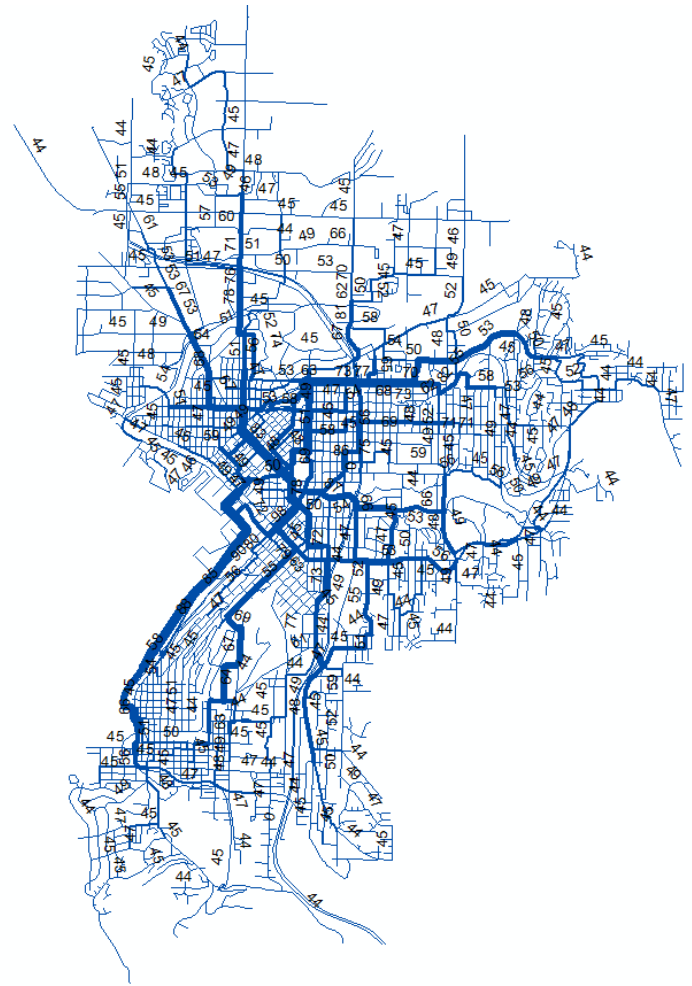


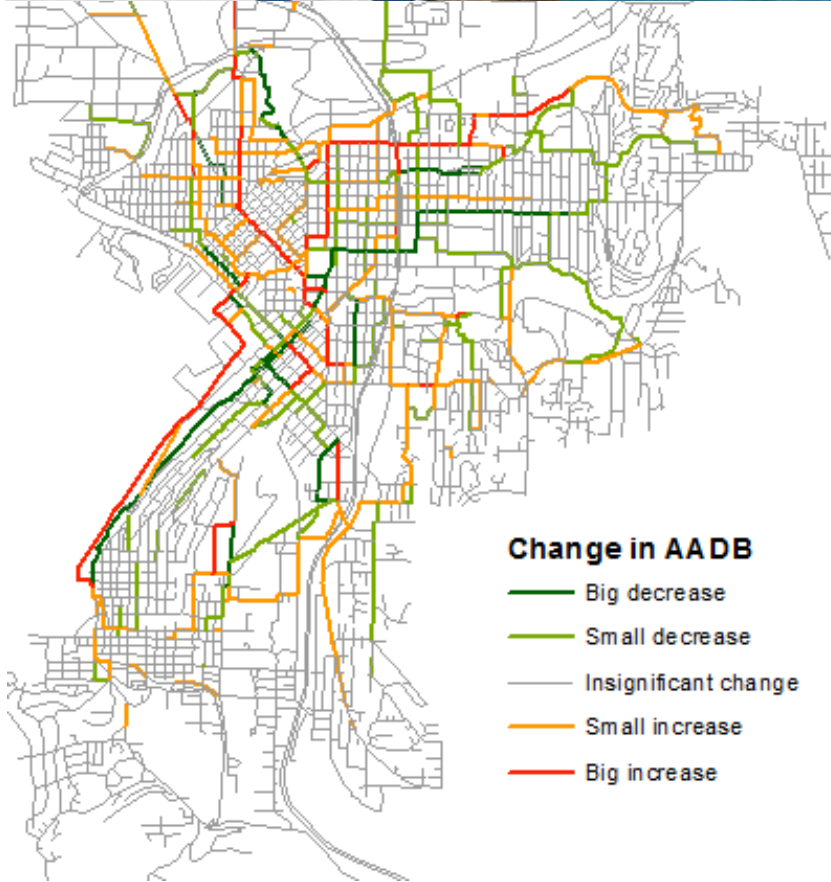
# AADB

Scenario 1 (Existing)



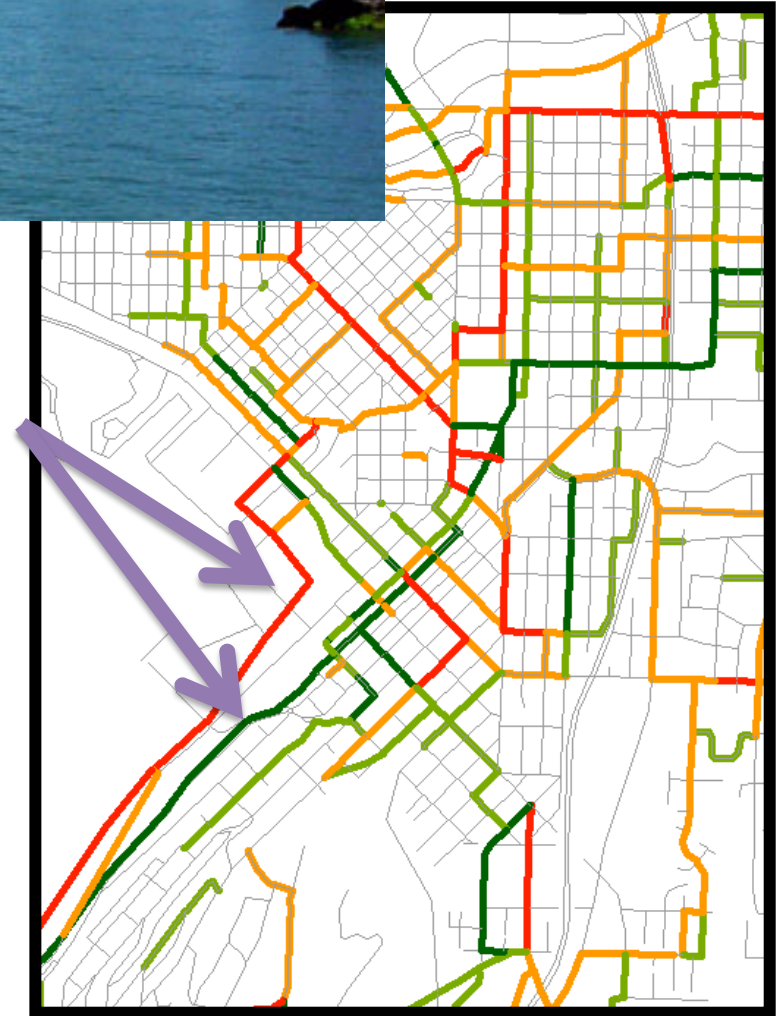
Scenario 2 (Proposed)





**Change in AADB**

- Big decrease
- Small decrease
- Insignificant change
- Small increase
- Big increase





# Exposure Along Street Segments

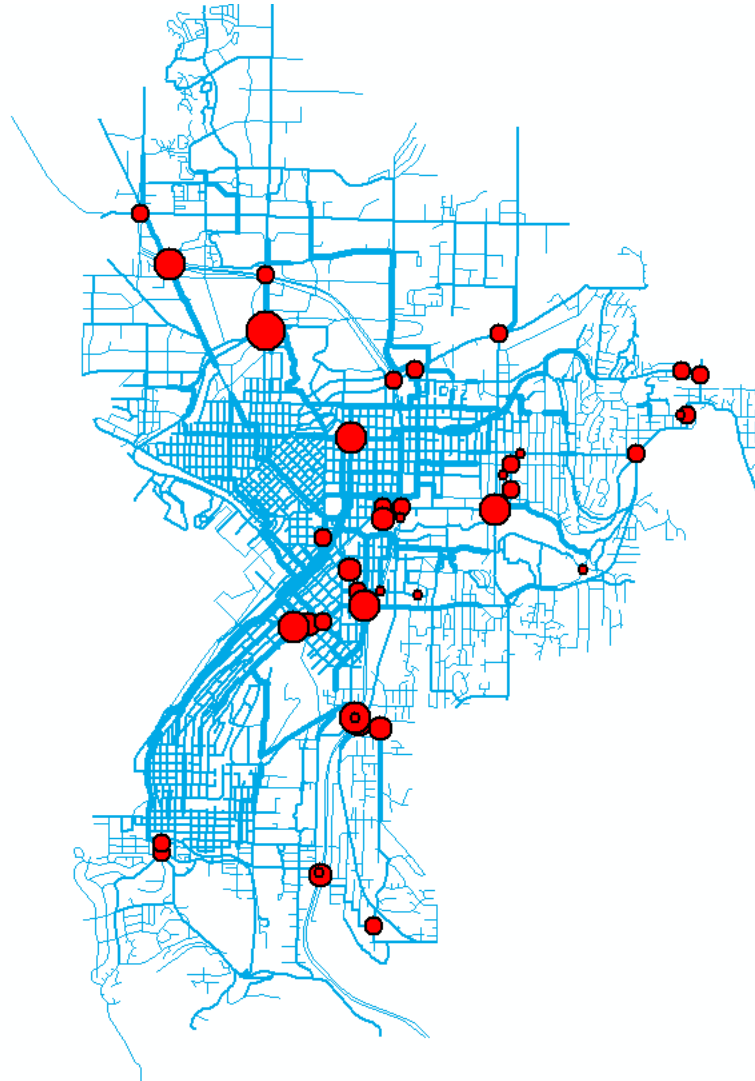
| Dangerous Situation            | Metric Conditions  | Scenario 1:<br>Existing<br>Conditions<br>(Annual BMT) | Scenario 2: w/<br>Proposed<br>Improvements<br>(Annual BMT) | Change<br>(Annual<br>BMT) | Percent<br>Change |
|--------------------------------|--|---|--|---------------------------|-------------------|
| Mixed cycling in harsh traffic | No bike lane<br>Vehicle volume<br>> 3,000 AADT   | 666,000   | 272,000  | -394,000                  | -59%              |
| Dedicated ROW in harsh traffic | Bike lane<br>Vehicle volume<br>> 8,000 AADT  | 97,000  | 250,000  | 153,000                   | 158%              |
| Cramped space                  | Veh. lane width < 12 ft<br>Vehicle volume<br>> 1,000 AADT<br>Vehicle speed limit<br>> 20 mph | 307,000   | 180,000  | -127,000                  | -41%              |
| Dooring and vehicle parking    | Vehicle parking<br>turnover > 4 per hr   | 2,646,000   | 2,746,000  | 100,000                   | 4%                |
| Frequent access points         | Access points<br>> 30 per mile   | 3,923,000   | 3,847,000  | -76,000                   | -2%               |
| Steep grade                    | Grade > 4%   | 197,000   | 197,000  | 0                         | 0%                |
| Wrong-way riding               | Wrong-way riding<br>occurrence   | 134,000   | 145,000  | 11,000                    | 8%                |
| Infrequent cyclers             | Cyclist volume < 15<br>AADB  | 1,151,000   | 1,096,000  | -55,000                   | -5%               |

# Exposure at Intersections

| Dangerous Situation          | Metric Conditions                              | Scenario 1:<br>Existing<br>Conditions<br>(Annual Bicyclists) | Scenario 2: w/Proposed<br>Improvements (Annual<br>Bicyclists) | Change (Annual<br>Bicyclists) | Percent<br>Change |
|------------------------------|--|--|---|-------------------------------|-------------------|
| Crossing harsh intersections | Cross street vehicle volume > 2,000 AADT       | 7,114,000  | 6,647,000   | -467,000                      | -7%               |
| Right hook                   | Vehicle right turns > 1,000 AADT               | 605,000  | 577,000   | -28,000                       | -5%               |
| Left sneak                   | Oncoming thru vehicle volume > 2,000 AADT      | 7,516,000  | 7,523,000   | 7,000                         | 0%                |
| Thru clip                    | Oncoming left-turn vehicle volume > 1,000 AADT | 615,000  | 613,000   | -2,000                        | 0%                |

# Hot Spot Analysis

**Right Hook  
Exposure**



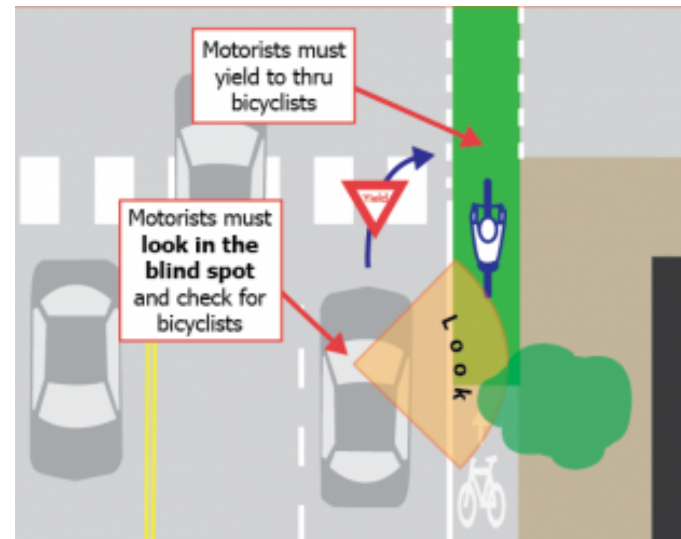
# Future Work

1. Create Safety Performance Functions (SPFs) based on exposure.

$$\text{Expected Number of Right Hook Accidents} = \beta_0 + \beta_1(\text{right hook exposure})$$

2. Create Crash Modification Factors (CMFs) to for improvements.

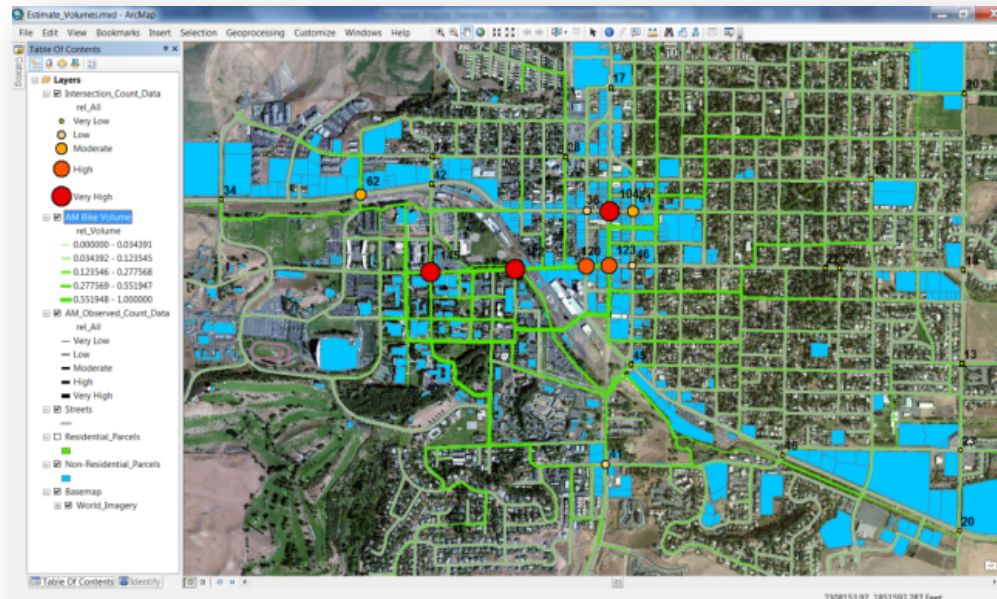
green paint => 12% reduction



# Conclusions

New tools are...

- Inexpensive and easy to use,
- Require commonly available GIS data, and
- Can produce very good results.



**Thank you...**

**...Questions??**

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## **Tool 1: Calculate Bicycle Level of Service**

Callister, D. and Lowry, M. (2013). "Tools and Strategies for Wide-scale Bicycle Level of Service Analysis." *ASCE Journal of Urban Planning and Development*, Vol. 139, No.4, p. 1-8.

## **Tool 2: Calculate Community-wide Bikeability**

Lowry, M., Callister, D., Gresham, M. and Moore, B. (2012). "Assessment of Communitywide Bikeability with Bicycle Level of Service." *Transportation Research Record: Journal of the Transportation Research Board*, 2314, pp. 41-48.

## **Tool 3: Estimate Bicycle Volumes**

McDaniel, S., Lowry, M., and Dixon, M. (In press). "Using Origin-Destination Centrality to Estimate Directional Bicycle Volumes." *Transportation Research Record: Journal of the Transportation Research Board*, Scheduled publication 2014.

## **Tool 4: Assess Dangerous Situation Exposure**

Cool, S. and Lowry, M. (Forthcoming). "Quantifying dangerous situation exposure for bicyclists" Scheduled Submission June, 2014.