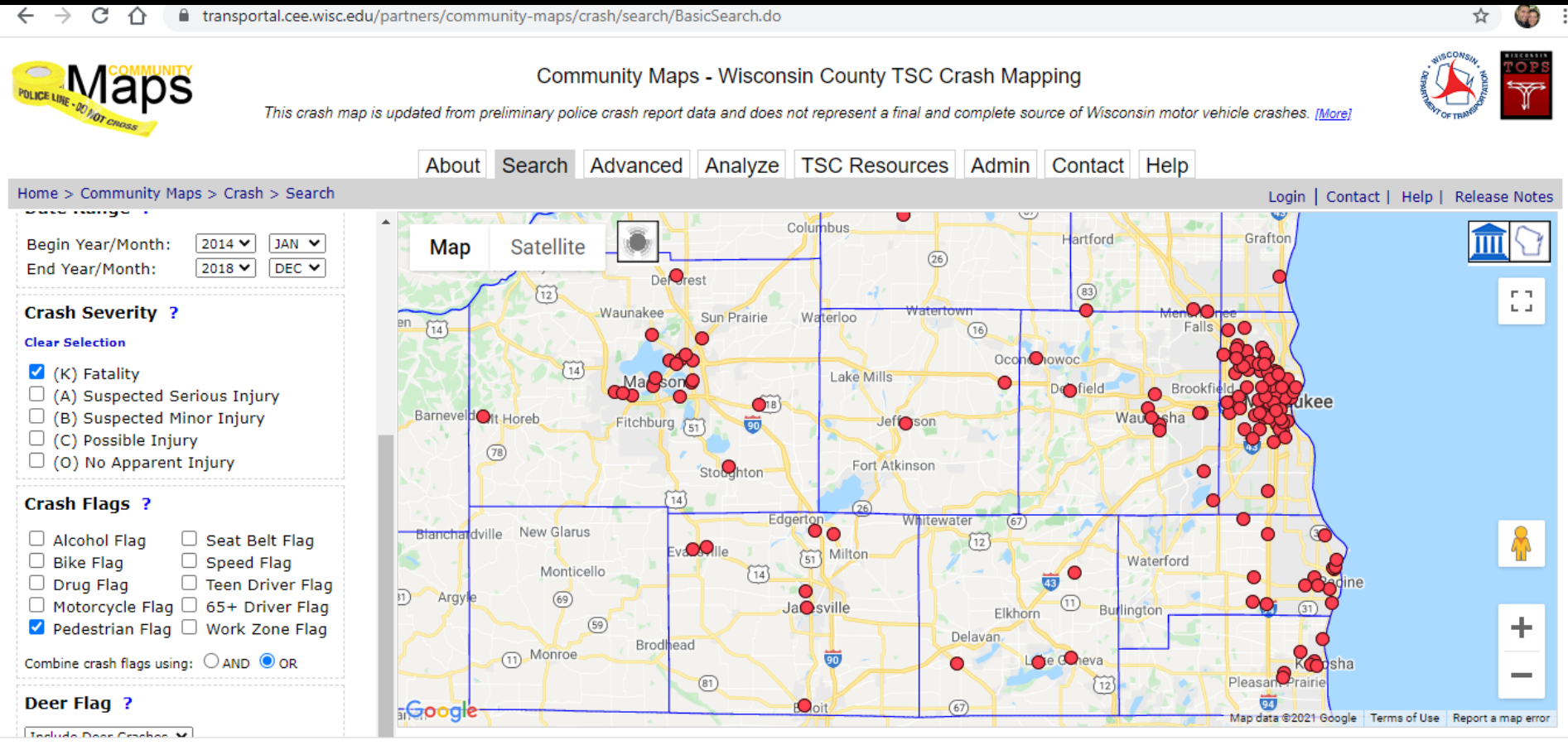
Community Maps



Source: Wisconsin Traffic Operations and Safety Lab. Community Maps - Wisconsin County TSC Crash Mapping, https://transportal.cee.wisc.edu/partners/community-maps/, 2021.

2: Multi-Use Trail Crossing Crash Model

How many trail user crashes do we expect per year at a crossing with certain characteristics?

Schneider, R.J., A. Schmitz, G. Lindsey, and X. Qin. "Exposure-Based Models of Trail User Crashes at Roadway Crossings," Transportation Research Record: Journal of the Transportation Research Board, https://doi.org/10.1177/0361198121998692, 2021.

SE WI Region Trails

(Existing trails in RED)

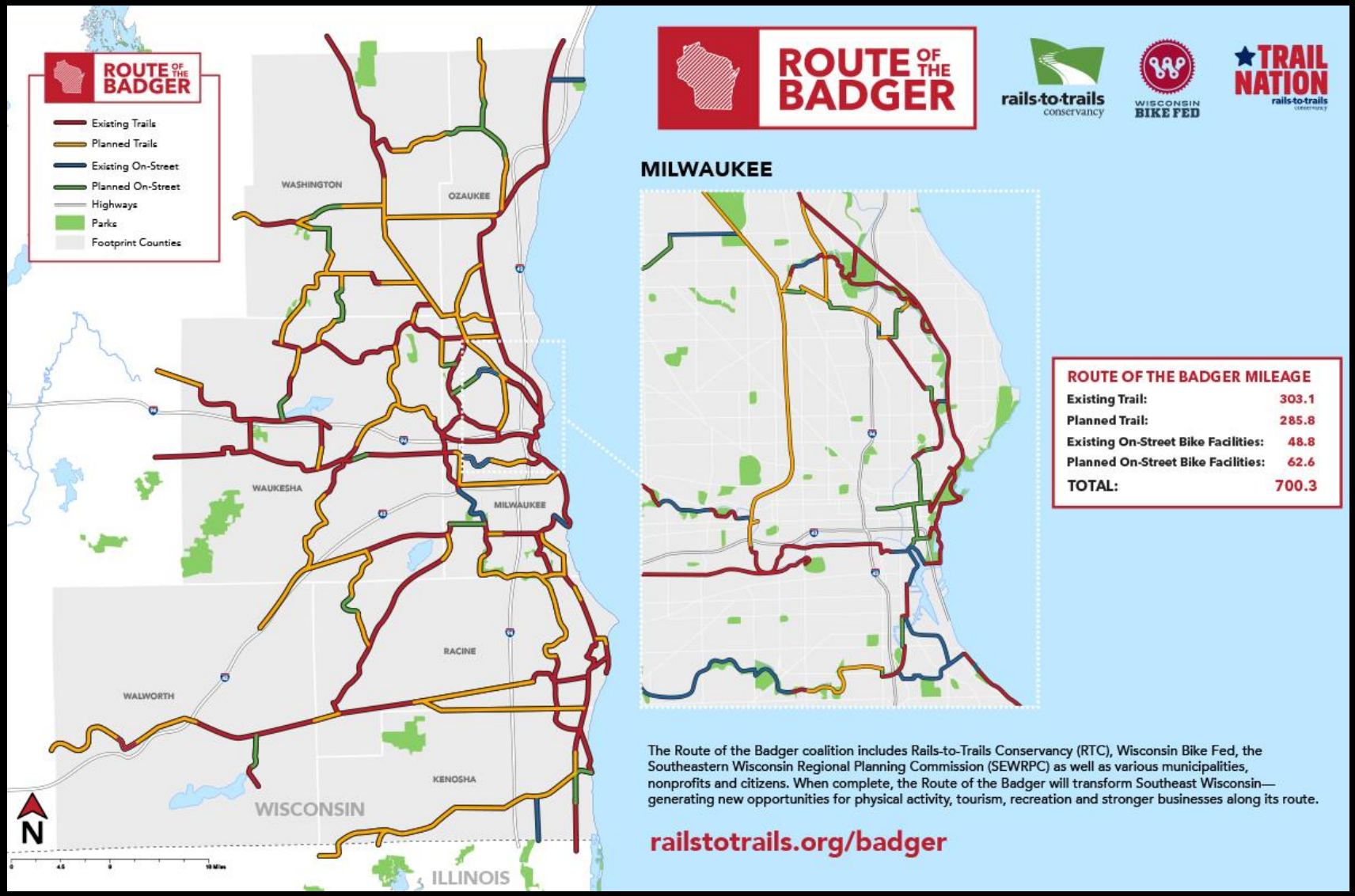


Image Source: Rails-To-Trails Conservancy, Route of the Badger, 2019.
https://www.railstotrails.org/our-work/trailnation/route-of-the-badger/explore-the-badger-route/

City of Minneapolis Trails

(Existing trails in GREEN)

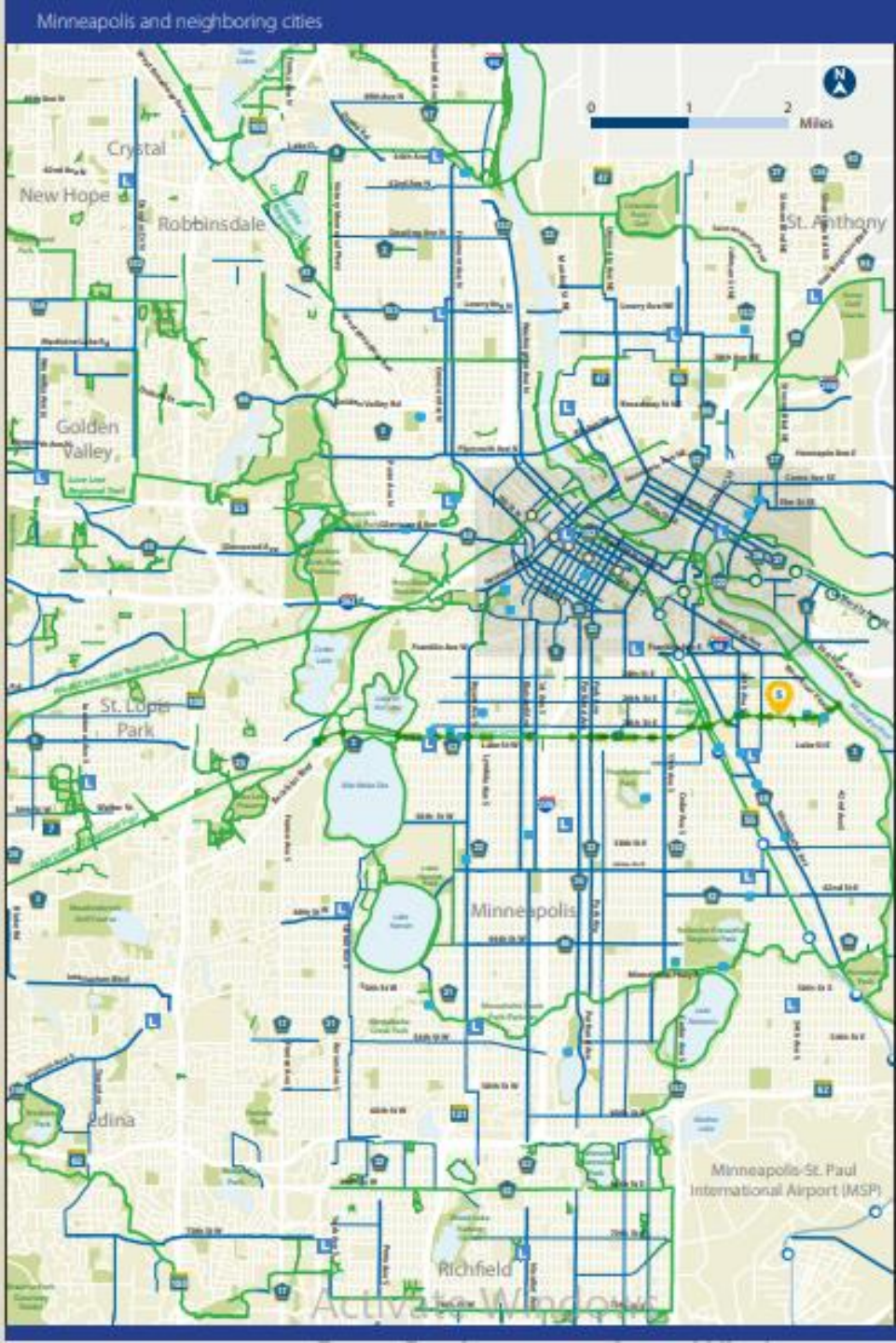


Image Source: Hennepin County Bike Map, 2019. https://www.hennepin.us/-/media/hennepinus/residents/transportation/biking/2019-bike-map.pdf

Crossing Type: Midblock

New Berlin Trail at Sunnyslope Road, New Berlin

Image Source: Google Earth, 2018

Crossing Type: One leg of 4-way intersection

Oak Leaf Trail Crossing of W. Good Hope Road at N 91st St., Milwaukee

Image Source: Google Earth, 2018

Crossing Type: Perpendicular crossing, 3-way

Ozaukee Interurban Trail Crossing of S. Spring Street (WI 32) at W Portview Dr., Port Washington

Image Source: Google Earth, 2018

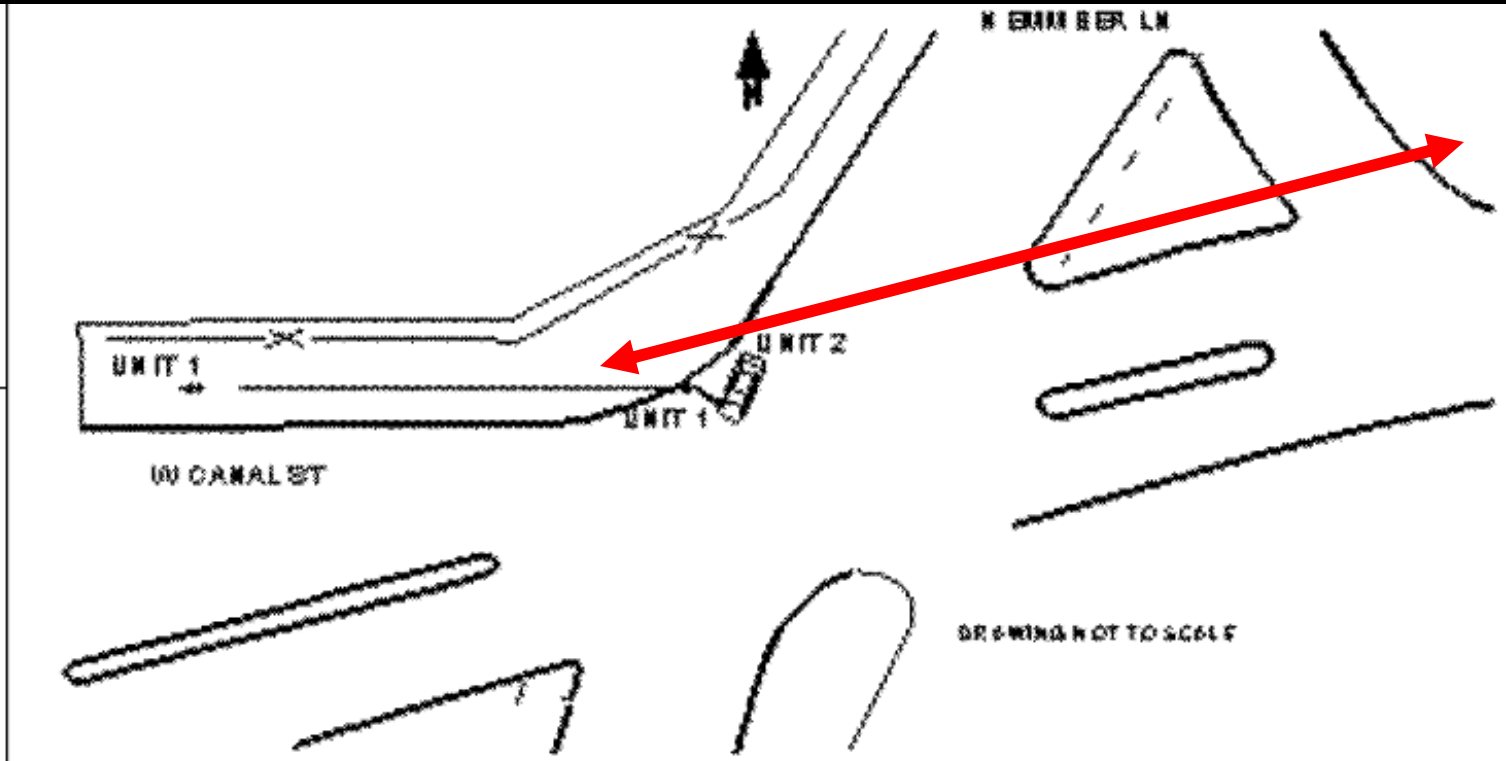
Crossing Type: Parallel crossing, 3-way

Trail Crossing of Zenith Avenue N along Theodore Wirth Parkway, Minneapolis

Image Source: Google Earth, 2019

Data: Pedestrian & Bicycle Crashes

DIAGRAM AND NA



UNIT 1, A BICYCLE, WAS TRAVELING E/B ON W CANAL ST APPROACHING N EMBER LN WHEN IT COLLIDED WITH UNIT 2, WHICH WAS TRAVELING S/B ON N EMBER LN AT W CANAL ST.

OPERATOR OF UNIT 2 STATED THAT HE WAS TRAVELING S/B ON N EMBER LN AND STOPPED AT THE STOP LIGHT AT W CANAL ST. HE STATED THAT HE WAS LOOKING FOR CROSS TRAFFIC WHEN UNIT 1 COLLIDED WITH HIM. HE STATED THAT HE SAW UNIT 1 TRAVELING E/B ON THE SIDEWALK ON W CANAL ST. I SPOKE TO THE OPERATOR OF UNIT 1 WHO STATED THAT SHE WAS TRAVELING E/B ON W CANAL ST APPROACHING N EMBER LN, ON HER BICYCLE, WHEN SHE NOTICED UNIT 2 TRAVELING S/B ON N EMBER LN AT W CANAL ST. SHE STATED THAT SHE SAW UNIT 2 STOP BUT AS SHE APPROACHED N EMBER LN UNIT 2 PULLED FORWARD INTO THE CROSSWALK JUST AS SHE ENTERED THE CROSSWALK. SHE STATED THAT SHE COULD NOT STOP IN TIME AND SHE COLLIDED WITH UNIT 2.

Source: WisTransPortal Database

Data: Trail User & MV Volumes

- Trail User Counts, collected 2014-2017
  - SEWRPC Regional Nonmotorized Count Program
  - City of Minneapolis Trail Counting Program
- Motor Vehicle Counts, collected 2014-2018
  - WisDOT (TC Map)
  - MnDOT & City of Minneapolis

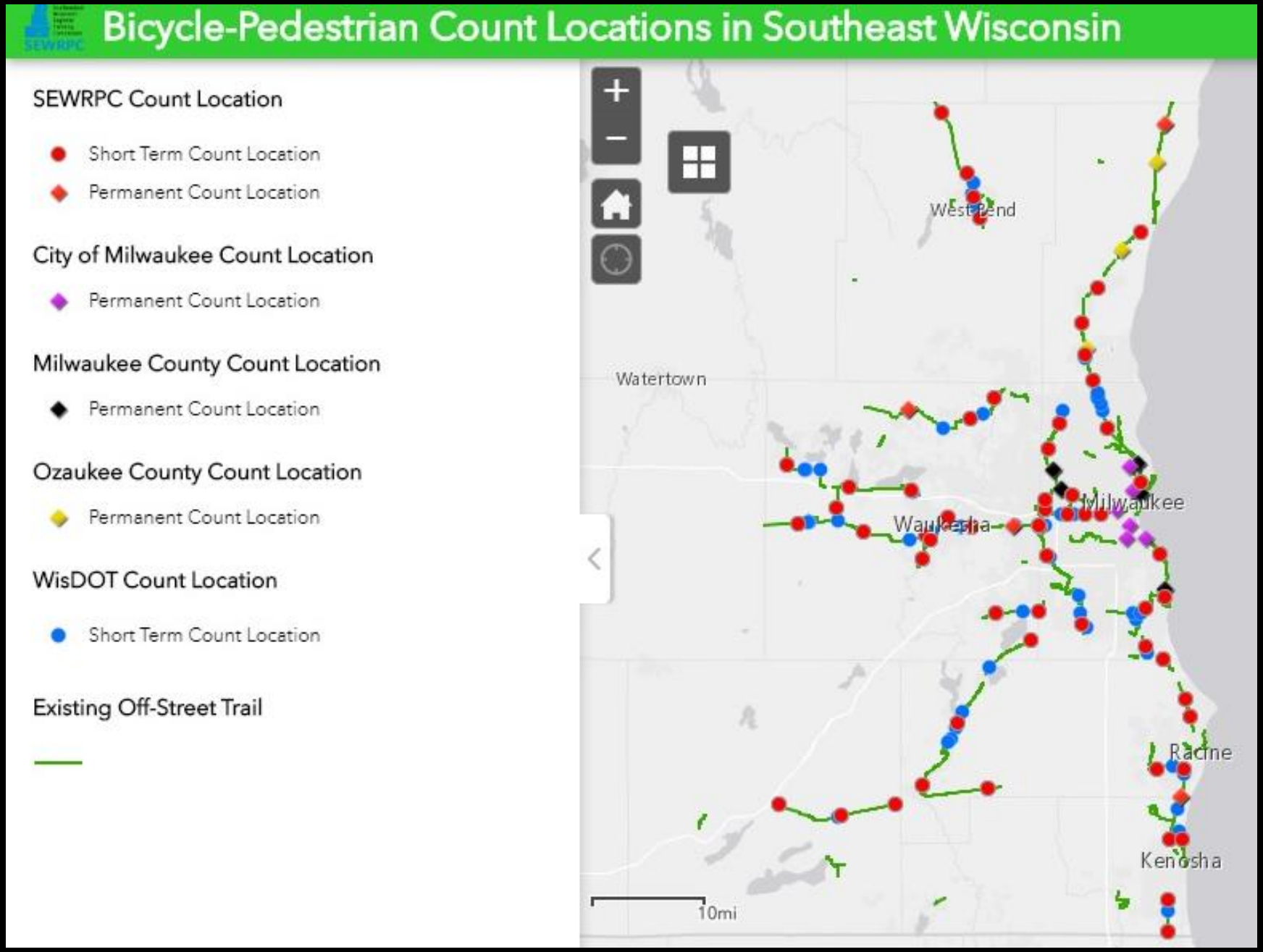
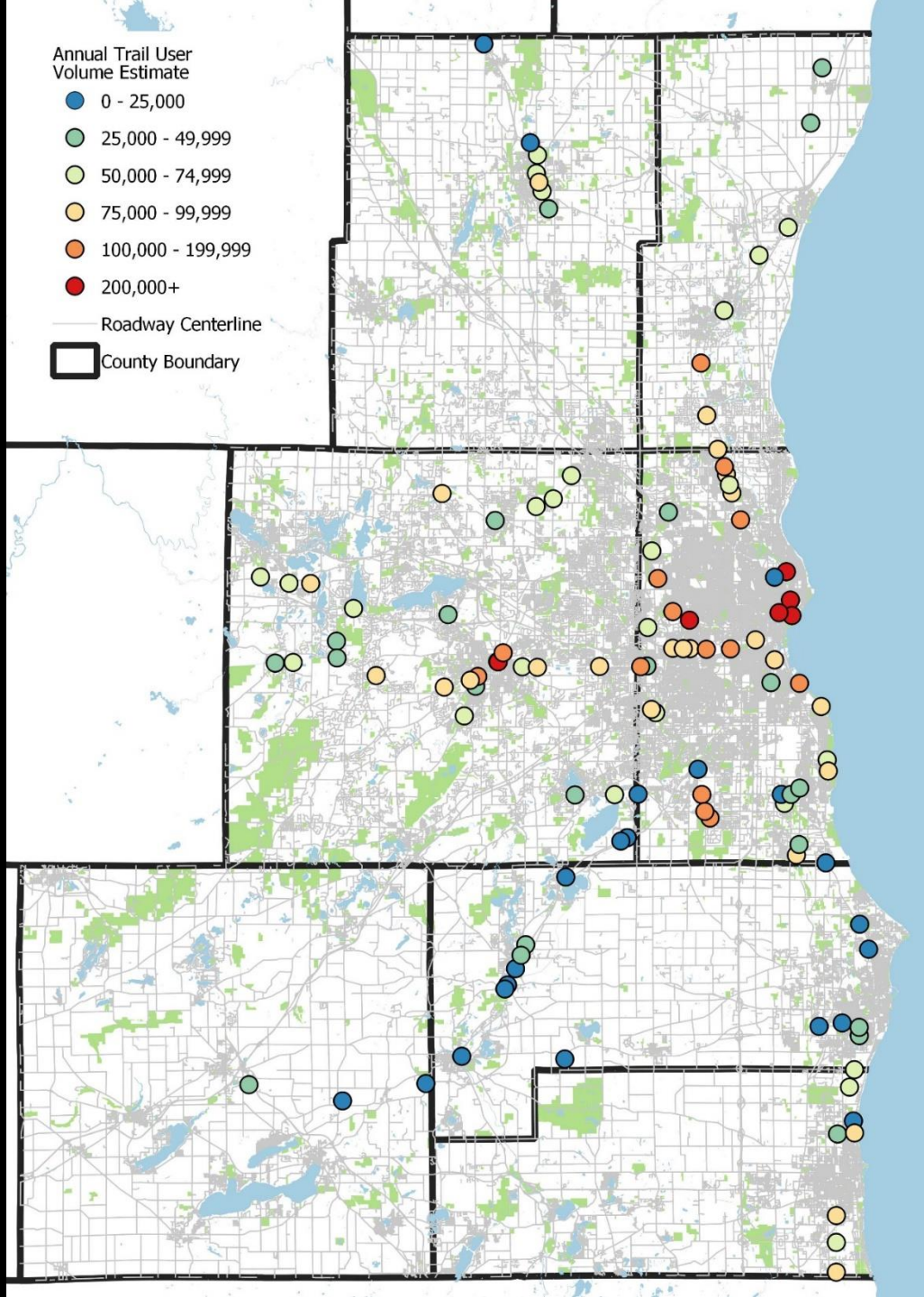


Image Source: Southeastern Wisconsin Regional Planning Commission, Bicycle-Pedestrian Count Locations in SE WI, 2019. http://sewrpc1.maps.arcgis.com/apps/webappviewer/index.html?id=f04c5692b52c4467a8dee067901fe340

SE Wisconsin Annual Trail User Volume Estimates



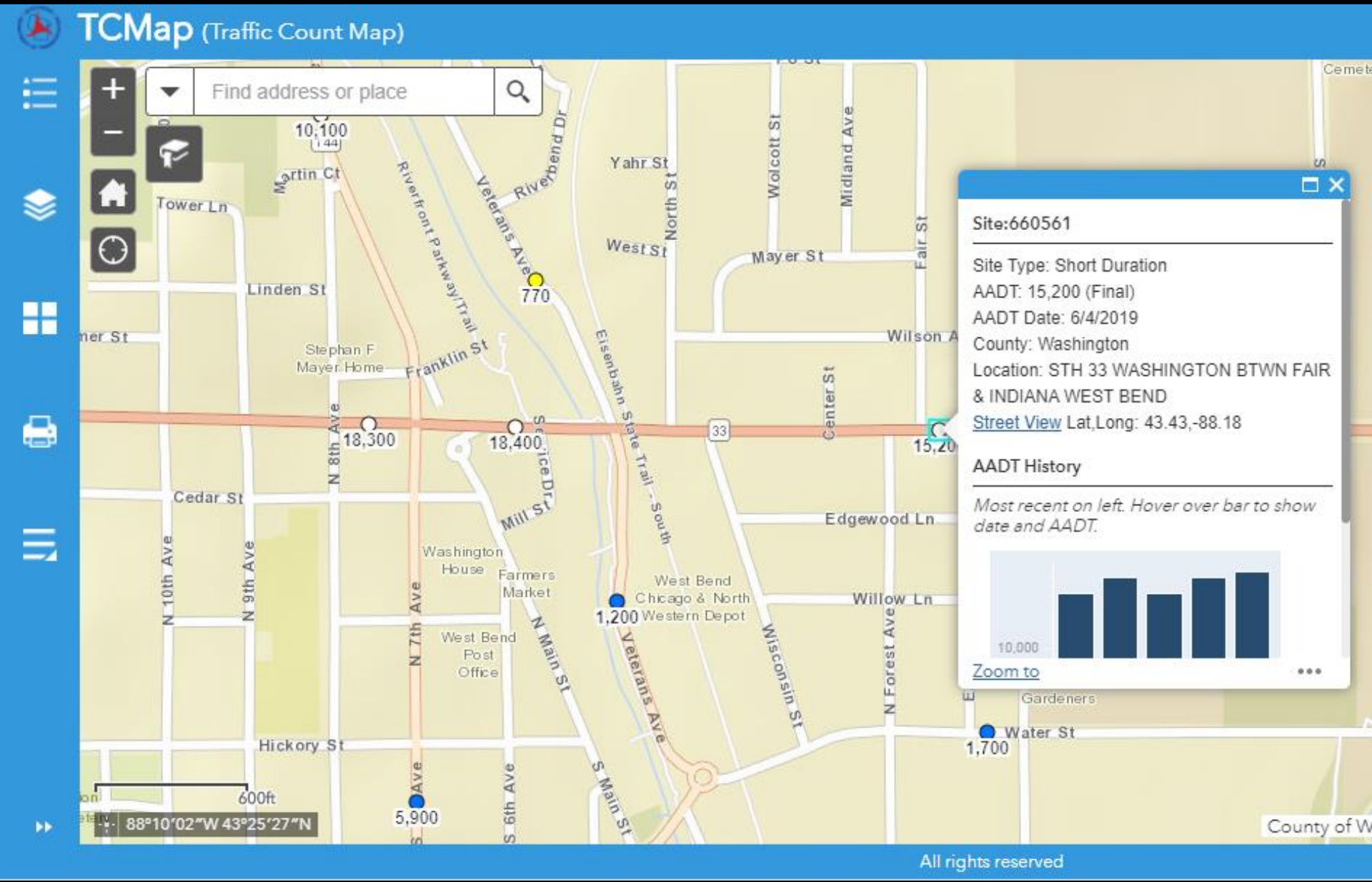


Image Source: Wisconsin Department of Transportation, TCMap (Traffic Count Map), 2020.
https://wisdot.maps.arcgis.com/apps/webappviewer/index.html?id=2e12a4f051de4ea9bc865ec6393731f8

Data: Trail Crossing Characteristics

- Crossing type and exposure
- Geometric
  - Crossing distance, curb extensions, medians, number of lanes, angled crossing
- Control & Flow
  - Traffic signal, stop sign, speed limit, one-way
- Sign & Marking
  - Warning signs, in-street signs, RFBs, other beacons, XW marking type, pavement markings
- Visibility
  - Clear distance, street lights, on-street parking

Data: Trail Crossing Characteristics

Sources: Google Maps/Earth & Google Street View, 2011-2018

Image Source: Google Maps

Trail Crossing Crash Model

	Poisson-Gamma Model (Negative Binomial)			Poisson-Lognormal Model[1]		
Variable	Beta	Std. Err.	Sig.[2]	Mean	Std. Dev.	Sig.[2,3]
Constant	-9.287	1.538	**	-9.922	1.471	**
Natural log of AADTT (trail users)	0.663	0.136	**	0.670	0.130	**
Natural log of AADTT (motor vehicles)	0.479	0.162	**	0.509	0.147	**
Mid-block crossing (base)	n/a	n/a	n/a	n/a	n/a	n/a
Crossing one 4-way intersection leg (1 = yes; 0 = no)	0.102	0.460	ns	0.134	0.427	ns
Crossing leg parallel to mainline at 3-way intersection (1 = yes; 0 = no)	-0.663	0.862	ns	-0.957	0.910	ns
Crossing leg perpendicular to mainline at 3-way intersection (1 = yes; 0 = no)	0.905	0.468	*	0.908	0.446	**
Traffic signal control (1 = yes; 0 = no)	0.536	0.446	ns	0.486	0.426	ns
Crosswalk length (m)	0.036	0.020	*	0.037	0.018	**
Clear distance: driver ~50m from the crossing can see less than 5m of the trail on at least one side of the roadway (1 = yes; 0 = no)	0.303	0.347	ns	0.373	0.341	ns
Clear distance: driver ~50m from the crossing can see more than 20m of the trail on both sides of the roadway (1 = yes; 0 = no)	-0.395	0.234	ns	-0.378	0.312	ns
sigma	n/a	n/a	n/a	0.771	0.185	**
Sample size (n)	197			197		
Log-likelihood[4]	-165.3			n/a		
AIC[4]	350.6			n/a		
BIC[4]	383.5			n/a		

1) Poisson-lognormal model parameter estimates are based on a simulation using 100,000 iterations.
2) ** indicates $p < 0.05$; * indicates $p < 0.10$; ns = indicates not significant.
3) Significance for the Poisson-lognormal model parameter estimates is determined by their percentile va
same; * indicates that the 5% and 95% parameter signs are the same).
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Implications for Crossing Design

- Reduce trail crossing distances
  - Curb extensions
  - Median islands
  - Reduce # of lanes
- Flag trails that cross 3-way intersections perpendicular to main traffic
  - Leading pedestrian intervals
  - High-visibility markings and signs
- Remove obstructions from trail approaches
  - Improve sight lines between drivers and trail users
  - Advance warning markings and signs

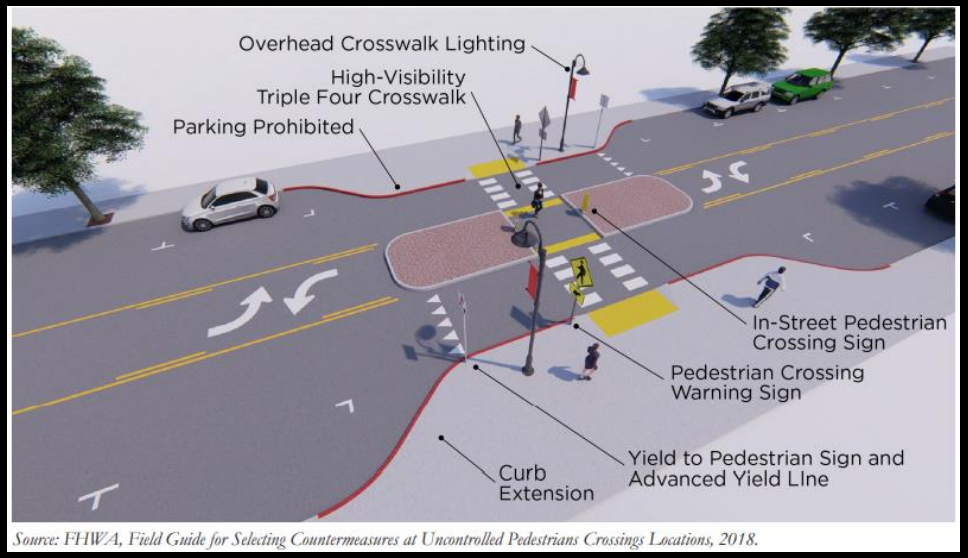


Image Source: City of Sacramento, CA. 2021 Pedestrian Crossing Design Guidelines.

Trail Crossing Safety Performance Function

- Average number of crashes predicted in 8 years at all SE Wisconsin crossings = 0.47

- Highest-risk crossing in SE Wisconsin
  - Oak Leaf Trail crossing of W. North Ave. at Menomonee River Pkwy. = 3.9 crashes/8 yrs
    - (It experienced 0 crashes during 2011-2018)

Oak Leaf Trail Crossing of W North Ave at Menomonee River Pkwy

Image Source: Google Earth, 2018

Application: High-Risk Crossings

Crossing Location	Predicted Crashes (8-year period)
Oak Leaf Trail Crossing of W North Ave at Menomonee River Pkwy, Wauwatosa	3.9
Lake Country Trail Crossing of WI 67 (Summit Ave) at Oconomowoc Pkwy, Oconomowoc	2.9
Oak Leaf Trail Crossing of W Silver Spring Dr at 107th St, Milwaukee	2.7
Oak Leaf Trail Crossing of W Good Hope Rd at N 91st St, Milwaukee	1.7
Oak Leaf Trail Crossing of N Swan Blvd at Menomonee River Pkwy, Wauwatosa	1.7
Hank Aaron State Trail Crossing of S Emmber Ln at W Canal St, Milwaukee	1.5
Oak Leaf Trail Crossing of W Burleigh St at Menomonee River Pkwy, Milwaukee	1.3
New Berlin Trail Crossing of WI 59/164 (Les Paul Pkwy) (mid-block S of Lincoln Ave), Waukesha	1.3

Example: Design Comparison

- Crossing 1
  - Midblock, uncontrolled crossing
  - 350 trail users and 6,500 AADT
  - **20m crossing distance**
  - **Limited clear distance (<5m on one approach)**
  - **Prediction = 0.68 crashes in 8 years**

Example: Reduce crossing distance with curb extensions & increase visibility

- Crossing 2
  - Midblock, uncontrolled crossing
  - 350 trail users and 6,500 AADT
  - **10m crossing distance**
  - **Extensive clear distance (>20m on both approaches)**
  - **Prediction = 0.21 crashes in 8 years**

Source: FHWA, Field Guide for Selecting Countermeasures at Uncontrolled Pedestrians Crossings Locations, 2018.

Image Source: City of Sacramento, CA. 2021 Pedestrian Crossing Design Guidelines.

Project Report

Pedestrian Exposure Data for the Wisconsin State Highway System: WisDOT Southeast Region Pilot Study

Prepared by
Robert J. Schneider, PhD, Associate Professor, UW-Milwaukee Department of Urban Planning
Andrew Schmitz, Masters Student, UW-Milwaukee Department of Urban Planning
Xiao Qin, PhD, Professor, UW-Milwaukee Department of Civil & Environmental Engineering

Prepared for
Wisconsin Department of Transportation (WisDOT), Bureau of Transportation Safety (BOTS)

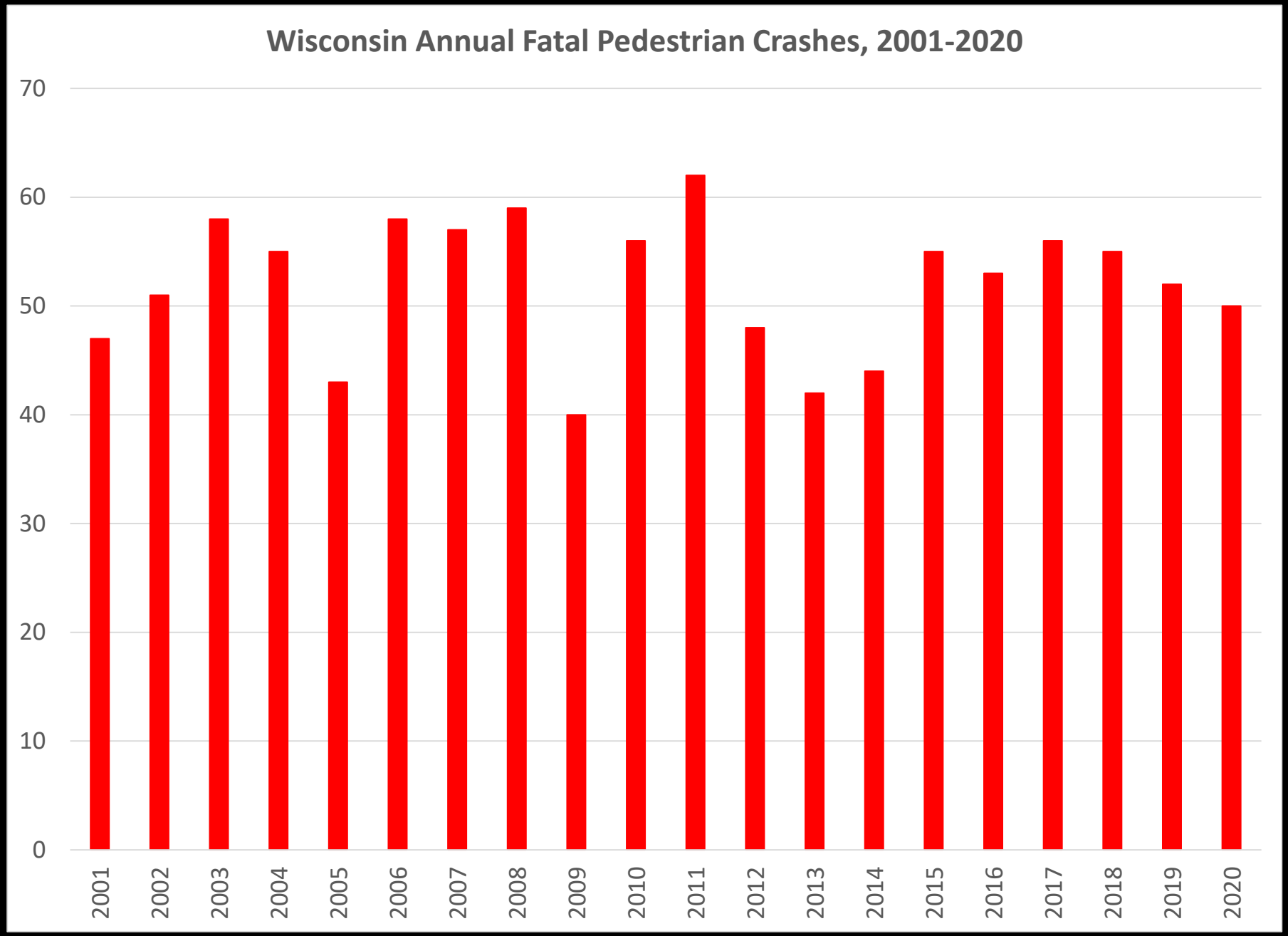
June 2021

https://wisconsindot.gov/Documents/safety/education/pedestrian/wistudy-pedcount.pdf

Questions & Discussion

Robert Schneider, PhD, UW-Milwaukee, Department of Urban Planning
Xiao Qin, PhD, UW-Milwaukee Department of Civil & Environmental Engineering
Andrew Schmitz, Masters Student, UW-Milwaukee, Department of Urban Planning
E-mail: rjschnei@uwm.edu





Source: UW-Madison Traffic Operations and Safety Lab. WisTransPortal Database, 2021.

Pedestrian Count Screening Process

- Removed counts with the following characteristics:
  - Not located/geocoded
  - Not on a major roadway (e.g., intersections of two local roadways)
  - 3-leg and 5-leg intersections
  - Freeway ramps
  - Minor driveways (e.g., driveways to single-family homes)
  - Taken on days with rain or snow
  - Taken between November and March (more variability)
  - Zero pedestrians (either erroneous or in locations where pedestrian volumes are too low to predict reliably)
  - *Round 2: Annual volumes <1,000 and >2,000,000*

Trail Crossings Studied

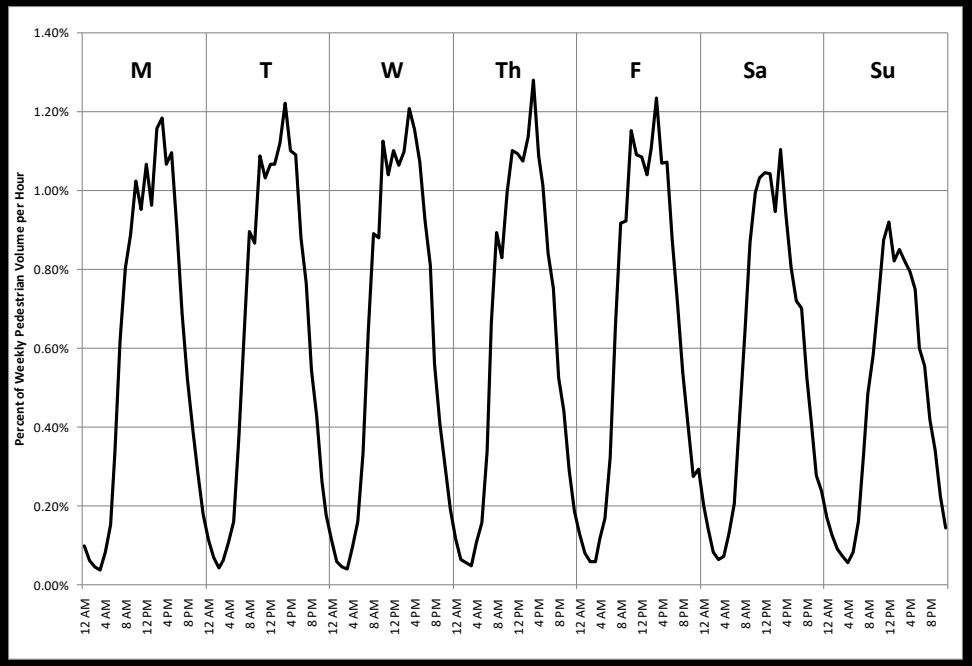
- 197 Trail Crossings in SE Wisconsin & Minneapolis
  - 89 crossings in 7-county SE WI Region
    - Most at-grade crossings were suburban and rural
  - 108 crossings in City of Minneapolis
    - Most at-grade crossings were urban
  - Other trail crossings were excluded:
    - Driveway, alley, and private street crossings
    - Trail constructed after 2015 (study period: 2011-2018)
    - Trail count unavailable or unlikely to be accurate (different paths through intersection; trail split prior to intersection)
  - Thanks to Greg Lindsey, University of Minnesota

Data: Pedestrian & Bicycle Crashes

- Police-reported crashes, 2011-2018
- Only included crashes associated with the trail crossing
  - Initially gathered crashes within 100m of each crossing
  - Reviewed crash narratives (WI) & crash type/actions/circumstances (MN)
  - Excluded other crashes at intersections
- 60 of 197 crossings had trail user crashes
  - 34 had 1 crash, 15 had 2 crashes, & 11 had 3+ crashes
  - 85% of the 117 *crashes* involved bicyclists

Expanded Short Counts to Annual

- Created comparable annual volumes from counts taken on different days at different times
  - Hour to weekday factor
  - Weekday to week factor
  - Week to year factor



Expanded short counts to annual volumes…

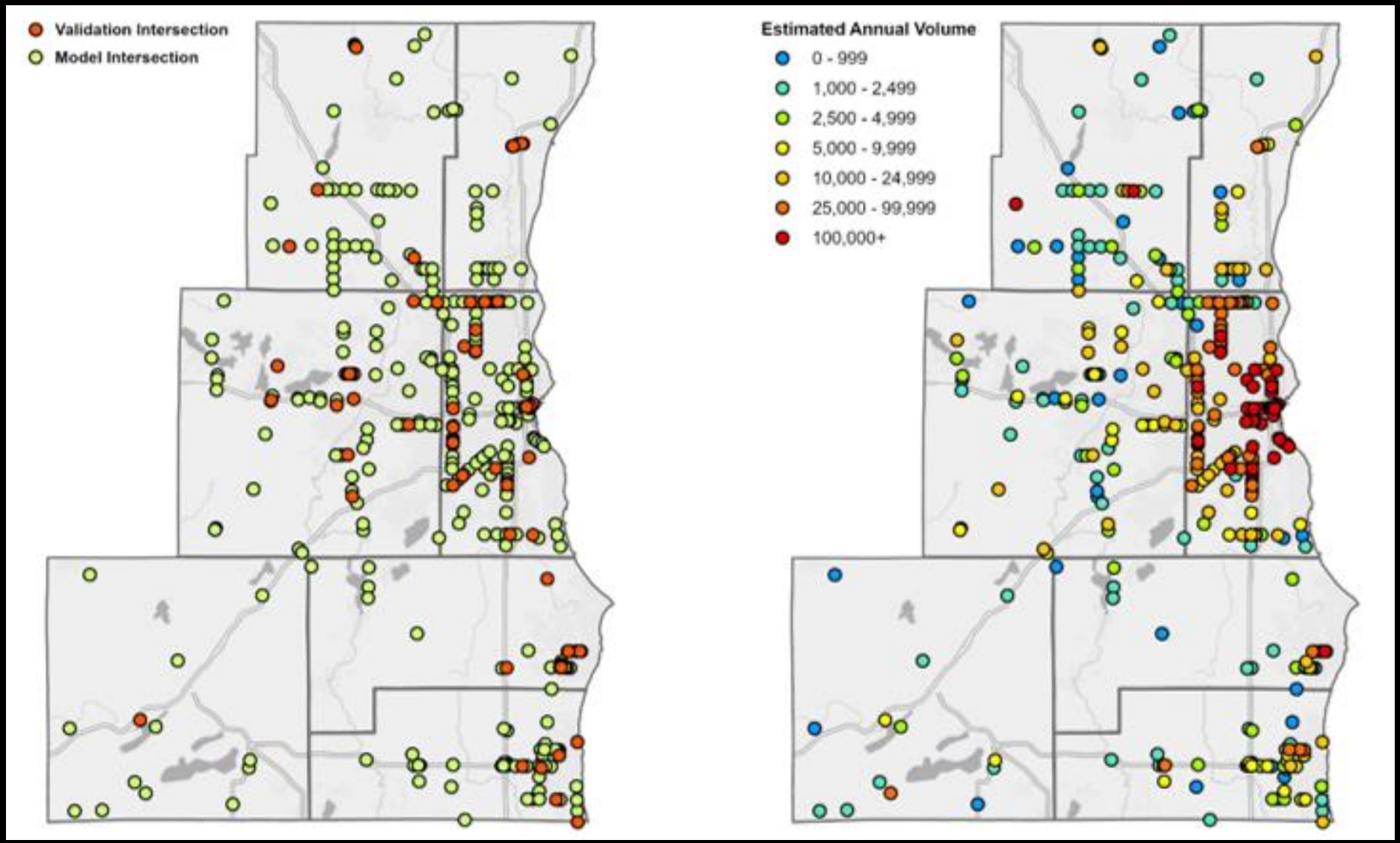
Example automated counter location in Oakland, CA

Analysis & Validation Databases

Table 2. Annual Pedestrian Volume Estimates at Final Study Intersections

Annual Pedestrian Volume Estimate	Number of Count Locations (Model)	% of Count Locations (Model)	Number of Count Locations (Validation)	% of Count Locations (Validation)
More than 100,000	30	11.5%	5	11.1%
50,000 to 100,000	24	9.2%	5	11.1%
10,000 to 49,999	70	26.9%	16	35.6%
1,000 to 9,999	136	52.3%	19	42.2%
Less than 1,000	0	0.0%	0	0.0%
Total	**260**	**100.0%**	**45**	**100.0%**

Analysis & Validation Databases



Negative Binomial Model Structure

$$PedVolume_i = e^{(\beta 0 + \beta 1X1i + \beta 2X2i + \ldots + \beta jXji)}$$

where:
$PedVolume_i$ = estimated annual pedestrian crossings at intersection i,
X_{ij} = quantitative measure of each explanatory variable j associated with intersection i,
β_j = model coefficient for explanatory variable j to be determined by negative binomial regression, and
β_0 = constant to be determined by negative binomial regression.

Three Potential Models

Table 5. Final Annual Pedestrian Crossing Volume Models

	A. Base Model		B. Square Root Model		C. Cube Root Model	
Variable	**Beta**	**p-value**	**Beta**	**p-value**	**Beta**	**p-value**
Constant	8.334	0.000	7.629	0.000	7.071	0.000
PopDen400	0.000140	0.001				
SRPopDen400			0.019	0.000		
CRPopDen400					0.100	0.000
EmpDen400	0.000021	0.046				
SREmpDen400			0.00581	0.005		
CREmpDen400					0.036	0.003
BusStp100	0.336	0.000				
SRBusStp100			0.434	0.000		
CRBusStp100					0.477	0.001
Retail100	0.108	0.026				
SRRet100			0.375	0.000		
CRRet100					0.471	0.000
RestBar100	0.116	0.062				
SRReBa100			0.208	0.050		
CRReBa100					0.244	0.044
SchDum400	0.515	0.001	0.478	0.003	0.499	0.002
Pct0Veh400	5.307	0.000	4.184	0.001	4.330	0.000
Sample size (n)	260		260		260	
Log-likelihood[1]	-2792		-2774		-2772	
AIC[1]	5601		5565		5560	
BIC[1]	5629		5593		5588	

1) Lower absolute values of log-likelihood, AIC, and BIC indicate better overall model fit.

Example: Model B ("square root" model)

$$Y_i = \exp(7.63 + 0.019X_{1i} + 0.0058X_{2i} + 0.43X_{3i} + 0.38X_{4i} + 0.21X_{5i} + 0.48X_{6i} + 4.18X_{7i})$$

where:

- Y_i = estimated **annual pedestrian crossing volume** at intersection i
- X_{1i} = square root of the population density within 400m of intersection i
- X_{2i} = square root of the job density within 400m of intersection i
- X_{3i} = square root of number of bus stops within 100m of intersection i
- X_{4i} = square root of number of retail businesses within 100m of intersection i
- X_{5i} = square root of number of restaurant and bar businesses within 100m of intersection i
- X_{6i} = 1 if intersection i is within 400m of a school (0 otherwise)
- X_{7i} = Proportion of households without a motor vehicle within 400m of intersection i

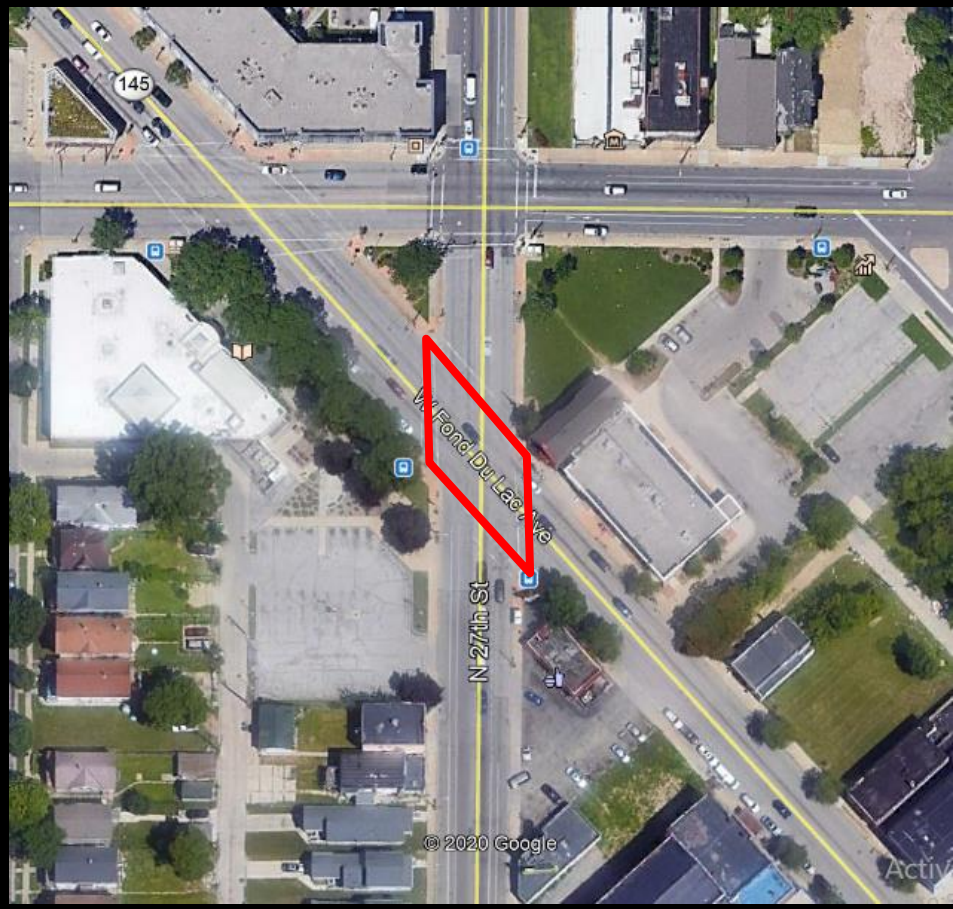
What is annual ped crossing volume?

Predicted annual volume at two example intersections (Model B)

Identical scale (Source: Google Earth, 2018: image height = 1000 feet)

WI 190 & N 124th St, Brookfield

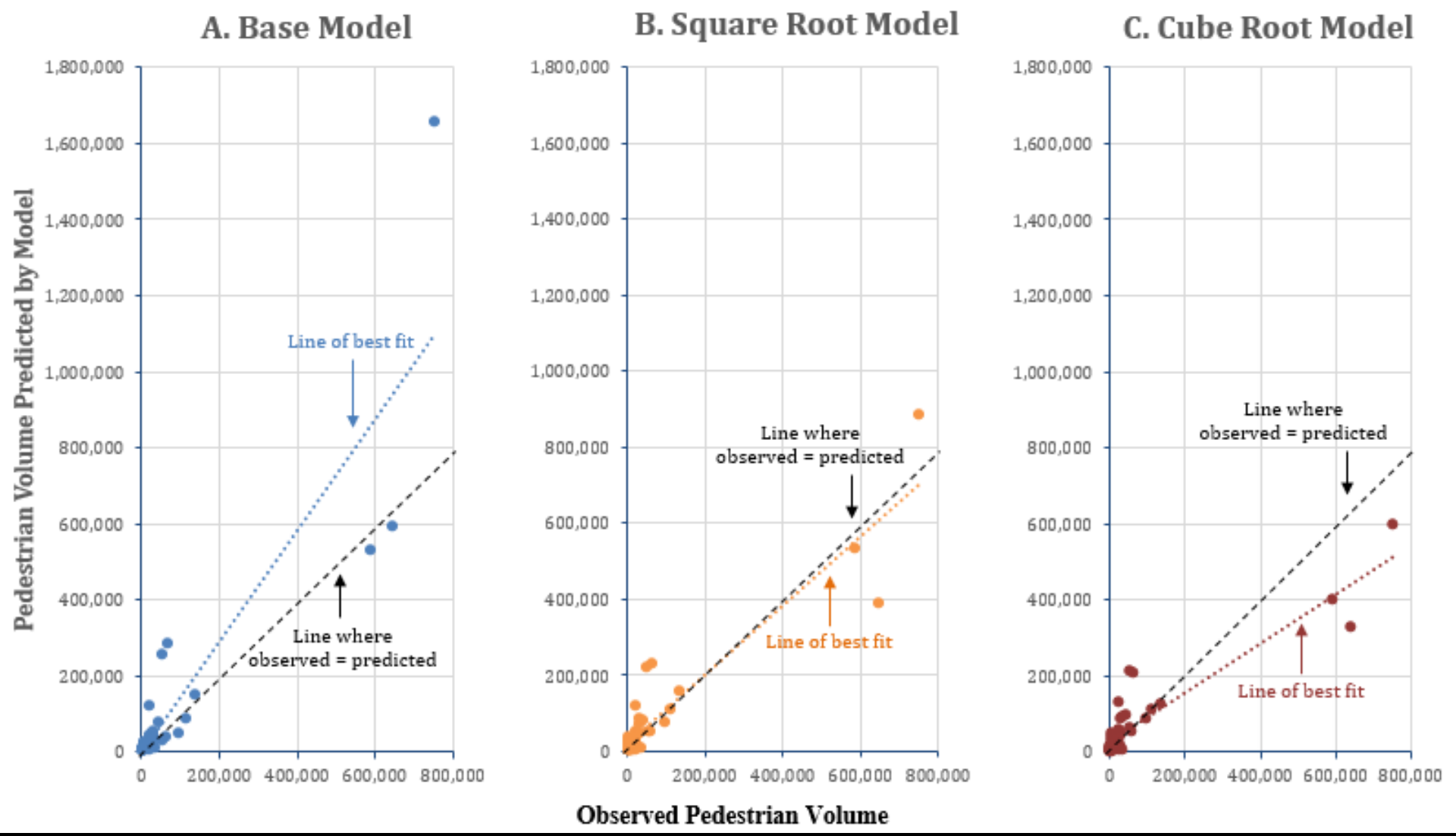
18,300 crossings/year



WI 145 & N 27th St, Milwaukee

786,000 crossings/year

Validation: How well do the models work?



Validation: How well do the models work?

Table 6. Comparison of Model Accuracy

	A. Base Model		B. Square Root Model		C. Cube Root Model	
MAE[1]	43724		31052		36959	
RMSE[1]	143987		60506		72975	
	A. Base Model		B. Square Root Model		C. Cube Root Model	
Ratio of Estimated to Observed Count	**Number of Intersections**	**% of Intersections**	**Number of Intersections**	**% of Intersections**	**Number of Intersections**	**% of Intersections**
> 3.00	9	20.0%	10	22.2%	10	22.2%
2.00 to 3.00	6	13.3%	4	8.9%	6	13.3%
1.50 to 1.99	3	6.7%	7	15.6%	7	15.6%
1.00 to 1.49	12	26.7%	8	17.8%	5	11.1%
0.67 to 0.99	6	13.3%	8	17.8%	8	17.8%
0.50 to 0.66	6	13.3%	6	13.3%	7	15.6%
0.33 to 0.49	2	4.4%	0	0.0%	0	0.0%
<0.33	1	2.2%	2	4.4%	2	4.4%
	A. Base Model		B. Square Root Model		C. Cube Root Model	
Ratio of Estimated to Observed Count	**Number of Intersections**	**% of Intersections**	**Number of Intersections**	**% of Intersections**	**Number of Intersections**	**% of Intersections**
0.67 to 1.49	18	40.0%	16	35.6%	13	28.9%
0.50 to 1.99	27	60.0%	29	64.4%	27	60.0%
Total Intersections	45		45		45	

1) Lower values of mean absolute error (MAE) and root mean squared error (RMSE) indicate better overall model prediction across all validation intersections.

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1) Lower values of mean absolute error (MAE) and root mean squared error (RMSE) indicate better overall model prediction across all validation intersections.

Application requires input data

Estimated **annual pedestrian crossing volume** at an intersection is a function of:

1) population density within 400m of intersection
   (US Census ACS population data by tract)
2) job density within 400m of intersection
   (US Census LEHD jobs by block)
3) number of bus stops within 100m of intersection
   (MPOs & transit agencies bus stop layers)
4) number of retail businesses within 100m of intersection
   (ESRI Business Analyst Infogroup Businesses)
5) number of restaurant and bar businesses within 100m of intersection
   (ESRI Business Analyst Infogroup Businesses)
6) school located within 400m
   (National Center for Education Statistics, Common Core of Data and Private School Survey)
7) % of households without a motor vehicle within 400m of intersection
   (US Census ACS household data by tract)

Progress: Automated Count Stations

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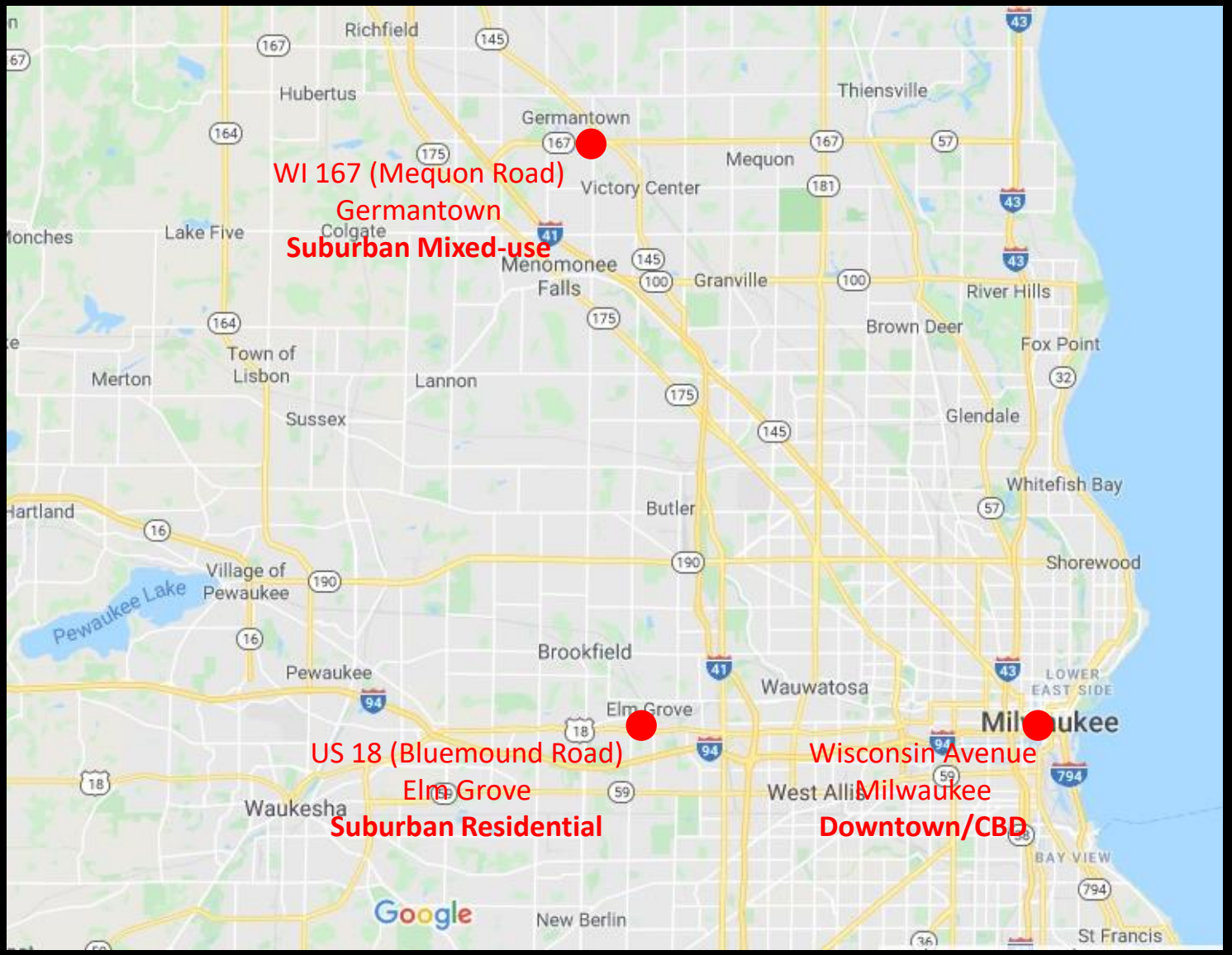

Map source: Google Maps, 2019