

# Criteria and Guidelines for Three-Lane Road Design and Operation

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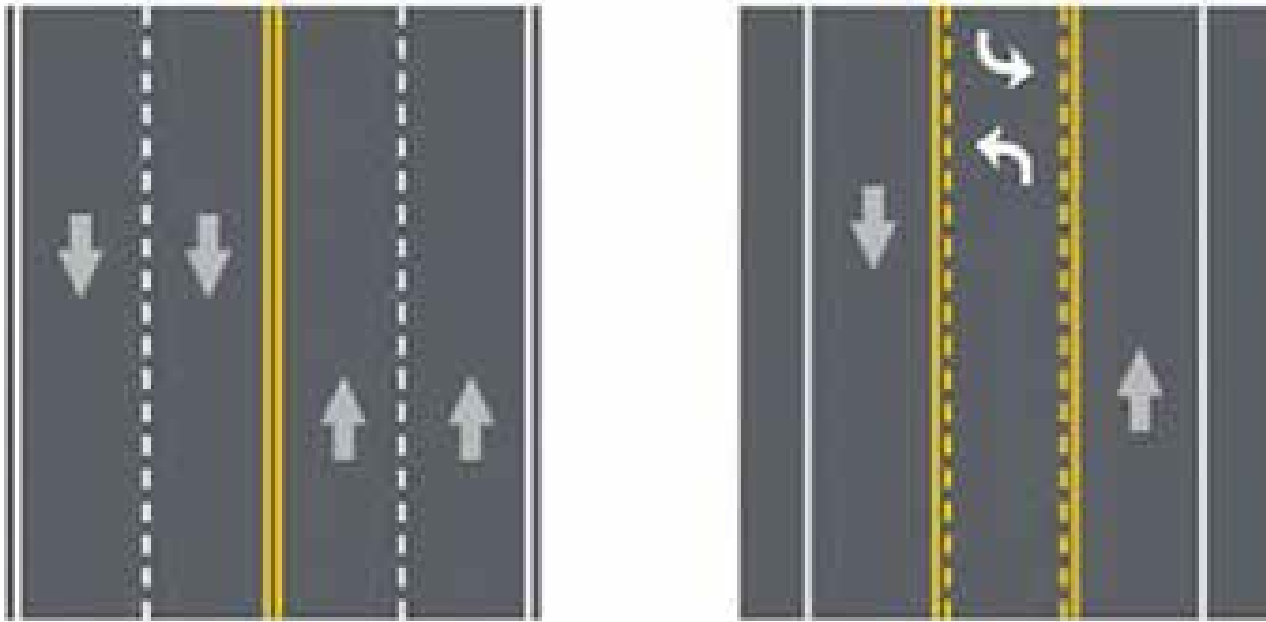
Minnesota Traffic Observatory

University of Minnesota

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# Typical 4-3 'Road-Diet'



“Proven” crash reduction countermeasure

Space for parking or bike lanes

Easier ped crossing

Livability improvements



# Review Literature and Identify Knowledge Gaps

36 design features identified

47+ sources identified

Summary table compiled

Features survey identified as important

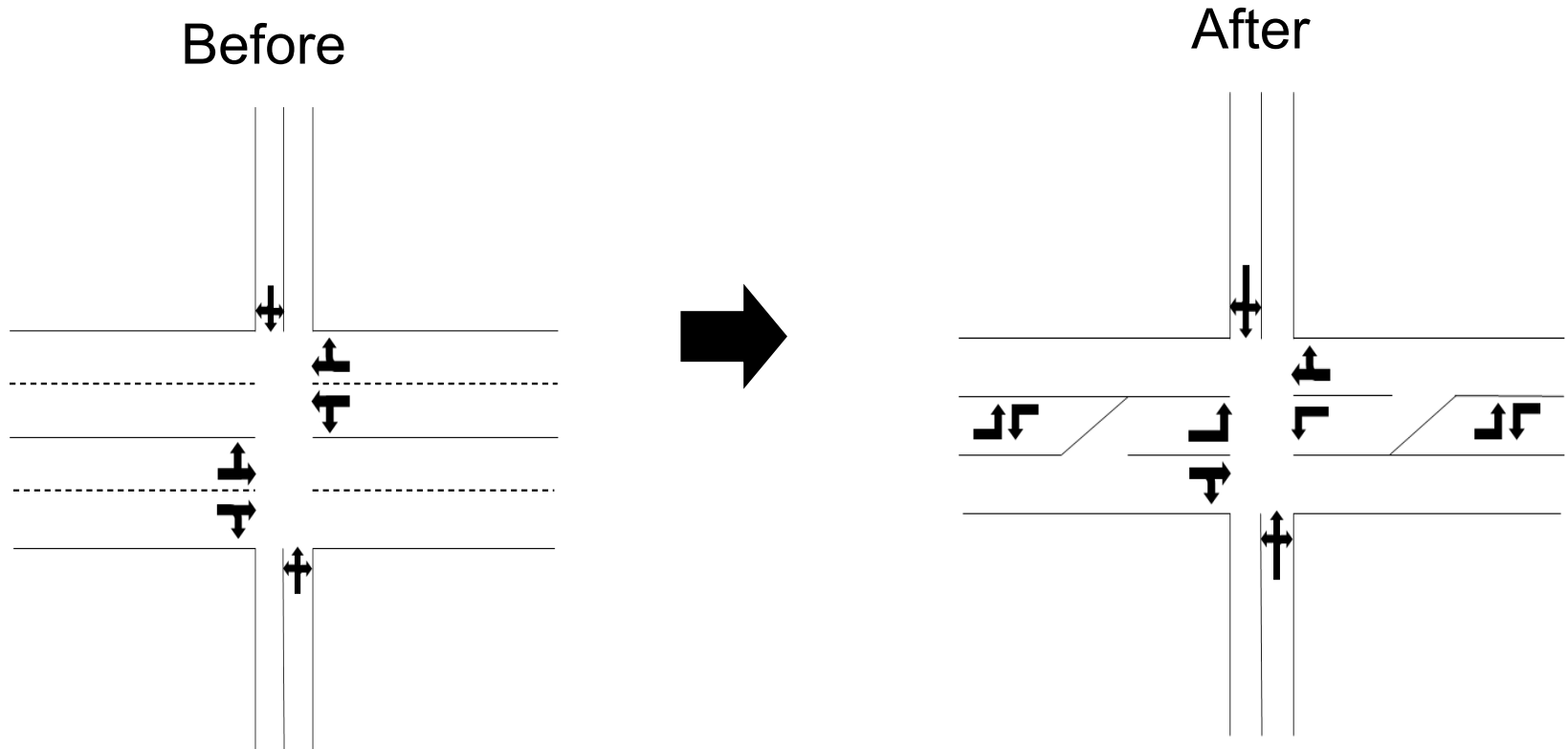
- Pedestrian Islands
- Lane Widths
- Operating Speeds
- Main Road Traffic Volume

**Main Road Traffic Volume selected as first priority**



# Literature on “Main Road Traffic Volume”

Simulation studies at signalized intersections



# Guidelines from Literature

- Iowa Study - Knapp & Giese (2001)
  - Converted to AADT
    - $\leq 15,000$  vpd (feasibility probable)
    - 15,000 to 17,500 vpd (exercise caution)
    - $\geq 17,500$  vpd (feasibility less likely)
- Kentucky Study - Stamatiadis et al. (2011)

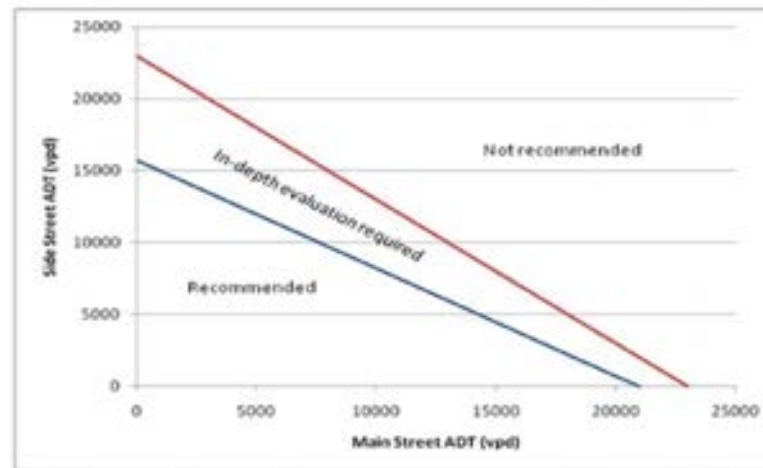


Figure 2 Operational performance guideline for road diet implementation

(Source: Stamatiadis et, al. (2011))



# Michigan Study – Lyles et al (2012)

- The ADT threshold for considering such road diets should be changed to 10,000.
- Detailed operational analysis should be done when ADTs are 10,000 or more OR when peak hour volumes exceed 1,000
- Because of the variation in intersection geometry, turning volumes, and signal timing from site to site, detailed operations analysis always be done.



## 3 Sites with AADT > 20,000

1. Lake Washington Blvd, Kirkland WA  
(Burden and Lagerway 1999)  
AADT = 23,000 (as high as 30,000)

2. Grand River Ave, East Lansing MI  
(Burden and Lagerway 1999)  
AADT = 23,000

3. Ocean Park Blvd, Santa Monica CA  
(FHWA 2015?)  
AADT = 23,000



# Lake Washington Blvd, Kirkland, WA



Mostly driveways





# Grand River Ave E. Lansing MI



Mostly Driveways



# Ocean Park Blvd Santa Monica



Less Clearcut



# Next Steps

## Findings so far:

- Signalized intersection capacity constrains 4-3 conversions
- AADTs > 20,000 feasible on roads with driveways but few signalized intersection
- Mainline speed reductions to be expected, benefit?

## Focus questions:

- Configurations supporting AADT > 15,000?
- Boundaries separating acceptable/unacceptable LOS

## 3 roads selected for simulation:

- 50<sup>th</sup> street (Minneapolis)
- Minnetonka Blvd (St. Louis Park)
- Baker Road (Minnetonka)



# Factorial Computer Experiment

Major Road Directional Hourly Flow (vphpl) (AADT vehicles/day)	Signalized Minor Road Directional Hourly Flow (% of Major Road Flow)	Unsignalized Minor Road Directional Hourly Flow (% of MUTCD Limit)
500 (10000)	20	50
		75
		100
	40	50
		75
		100
	60	50
		75
		100
750 (15000)	20	50
		75
		100
	40	50
		75
		100
	60	50
		75
		100
1000 (20000)	20	50
		75
		100
	40	50
		75
		100
	60	50
		75
		100
1250 (25000)	20	50
		75
		100
	40	50
		75
		100
	60	50
		75
		100



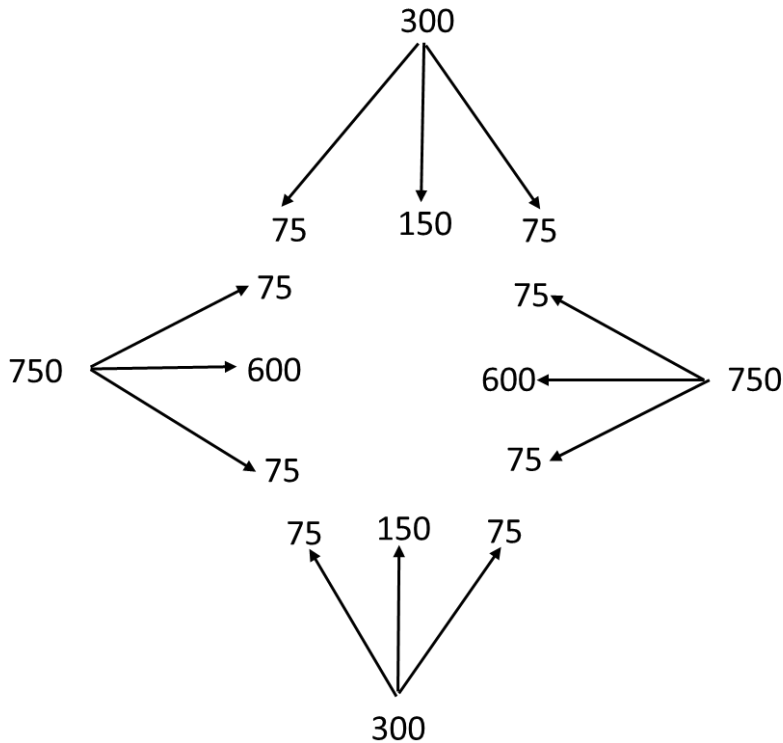
# Simulation Procedure

**For given level of demand:**

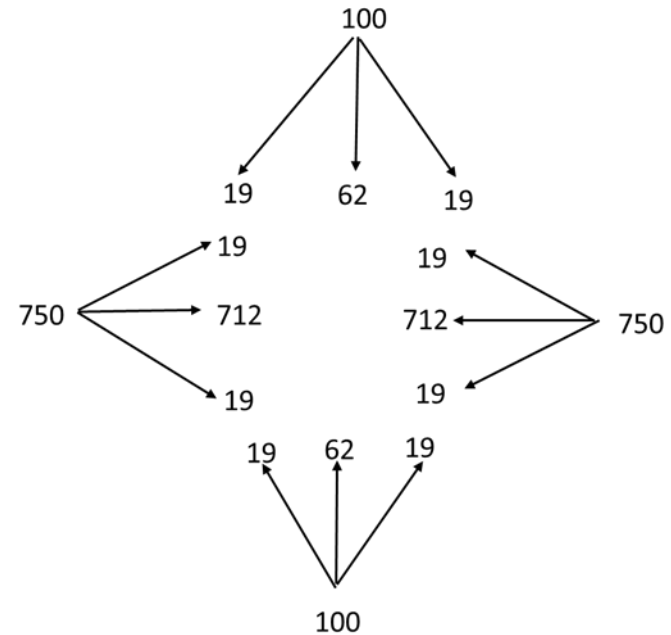
- (1) Time signalized intersections  
Cycle length, split, offset
- (2) ~5 runs simulating peak-hour conditions
- (3) Compute average performance measures  
Delay/LOS at signalized intersections  
Delay/LOS at TWSC intersections  
Speed/delay on main road links
- (4) Summarize results



# Example Turning Movements



Signalized Intersection:  
 Major flow = 750 vph  
 Minor flow = 300 vph (40%)



TWSC Intersection:  
 Major flow = 750 vph  
 Minor flow = 100 vph (100%)



# 50<sup>th</sup> Street Site

Street		50 <sup>th</sup> St
From		Chowen Ave
To		Zenith Ave
Length (miles)		0.2
AADT (year)		11, 400 (2019)
Internal Intersection	Signalized	2 (Chowen Ave, Zenith Ave)
	Unsignalized (TWSC)	2 (Beard Ave, Abbott Ave)
	Driveways /Alleys	5









# Example Major Road LOS

## WB 50<sup>th</sup> at Chowen

WB @ Chowen Ave				
Main Flow (vhe/h/dir)	Minor Signal (%)	Minor Unsignal (%)	Avg. Delay in sec/veh (LOS)	Corridor Avg. Speed in mph (LOS)
500	20	50	5.2 (A)	25.2 (B)
		75	5.1 (A)	25.1 (B)
		100	5.4 (A)	24.9 (B)
	40	50	6.8 (A)	24.4 (B)
		75	6.7 (A)	24.3 (B)
		100	6.7 (A)	24.3 (B)
	60	50	12.2 (B)	18.7 (C)
		75	12.7 (B)	18.7 (C)
		100	12.4 (B)	18.7 (C)
750	20	50	7.3 (A)	23.8 (B)
		75	7.2 (A)	23.9 (B)
		100	7.2 (A)	23.7 (B)
	40	50	11.6 (B)	19.7 (C)
		75	10.9 (B)	19.9 (C)
		100	11.1 (B)	19.7 (C)
	60	50	21.0 (C)	14.9 (D)
		75	22.0 (C)	14.8 (D)
		100	15.9 (B)	17.1 (D)
1000	20	50	11.3 (B)	17.1 (D)
		75	15.0 (B)	16.9 (D)
		100	15.1 (B)	16.9 (D)
	40	50	21.0 (C)	12.1 (E)
		75	21.4 (C)	12.3 (E)
		100	20.3 (C)	11.8 (E)
	60	50	26.0 (C)	10.1 (F)
		75	26.0 (C)	10.7 (F)
		100	25.7 (C)	10.4 (F)
1250	20	50	13.1 (B)	13.6 (E)
		75	14.2 (B)	13.8 (E)
		100	13.7 (B)	13.3 (E)



# Example Minor Road LOS (Signal)

## NB Chowen at 50<sup>th</sup>

Northbound at Chowen Ave				
		Minor Flow (percent of major flow)		
		20%	40%	60%
Major Flow (AADT)	500 (10000)	B	C	E
	750 (15000)	C	F	F
	800 (16000)	C	F	F
	850 (17000)	C	F	F
	900 (18000)	D	F	F
	950 (19000)	F	F	F
	1000 (20000)	F	F	F
	1250 (25000)	F	X	X



# Example Minor Road LOS (TWSC)

## NB Abbott at 50<sup>th</sup>

Northbound at Abbott Ave				
		Minor Flow (% of MUTCD Signal Warrant)		
		50%	75%	100%
Major Flow (AADT)	500 (10000)	B	C	D
	750 (15000)	C	D	E
	800 (16000)	C	D	E
	850 (17000)	C	E	E
	900 (18000)	D	E	F
	950 (19000)	E	F	F
	1000 (20000)	F	F	F
	1250 (25000)	F	X	X



# Results: 50<sup>th</sup> Street

- (1) Target road traffic: acceptable LOS, both signalized and TWSC, at hourly volumes greater than 750 v/h/l (AADTs > 15,000)
- (2) Cross road approaches, signalized: Substantial deterioration in LOS when target road flows > 750 v/h/l. Acceptable LOS possible for main road flows up to 900 v/h/l when cross flows did not exceed 20% of the target road flow.
- (3) Cross road approaches, TWSC: LOS=F conditions appearing as target road flow increased from 750 v/h/l to 1000 v/h/l, depending on the level of cross road flow.



# Minnetonka Blvd Site

Street		Minnetonka Blvd
From		MNTH 100
To		Inglewood Ave
Length (miles)		0.7
AADT (year)		25,500 (2018)
Internal Intersections	Signalized	1 (Ottawa Ave)
	TWSC, 4-legged intersections	5 (Joppa, Monterey, Natchez, Raleigh, Salem)
	TWSC, T-intersections	3 (Lynn, Princeton, Quentin)





Minnetonka Blvd

Legend

Google Earth

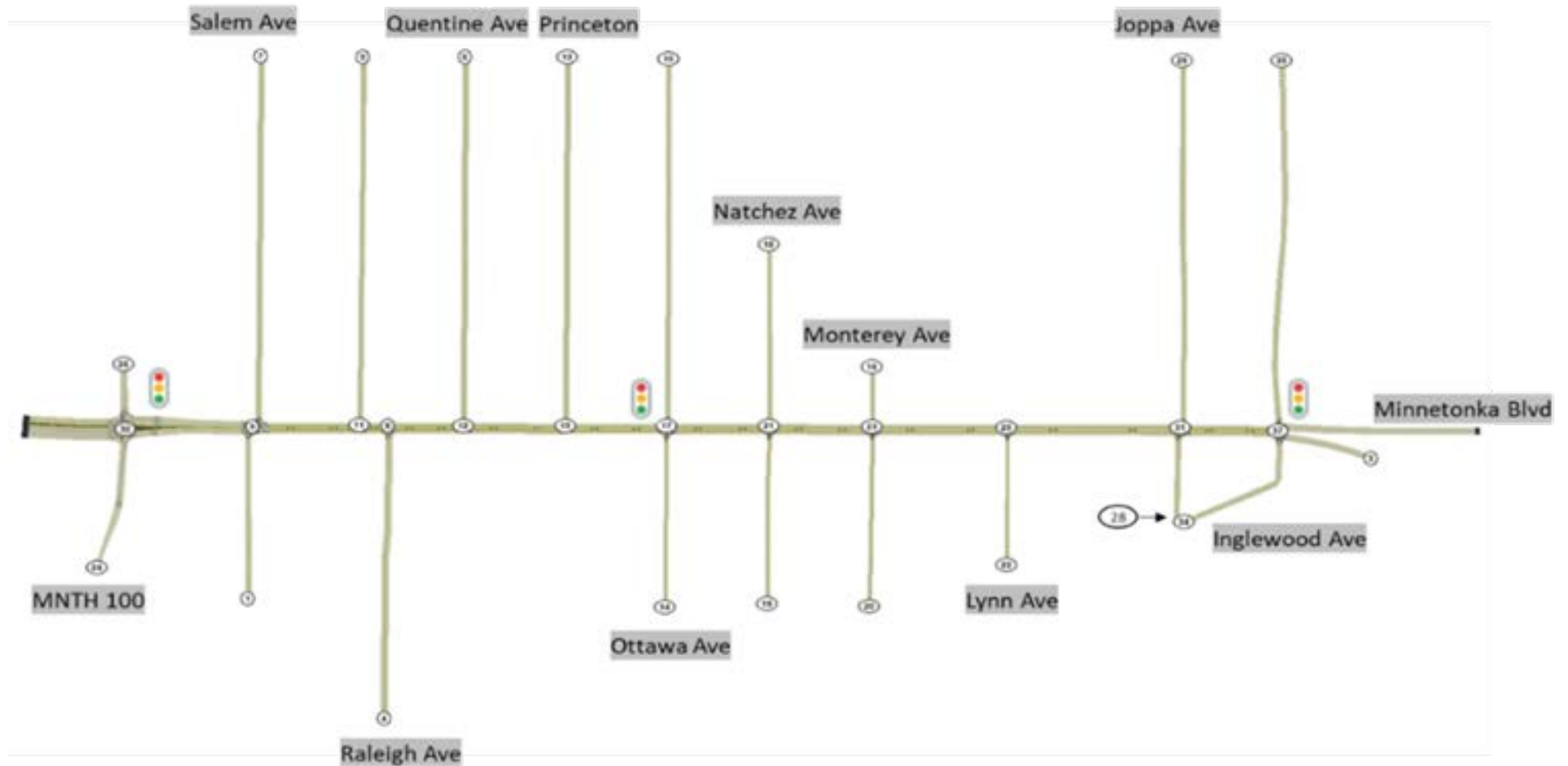
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1000 ft



# Transmodeler SE Model Minnetonka Blvd





# Example Target Road LOS (signal)

## WB Minnetonka at TH100

WB @ MNTH 100				
Main Flow (vhe/h/dir)	Minor Signal (%)	Minor Unsignal (%)	Avg. Delay in sec/veh (LOS)	Corridor Avg. Speed in mph (LOS)
500	20	50	4.9 (A)	22.4 (C)
		75	4.6 (A)	22.3 (C)
		100	2.6 (A)	22.2 (C)
	40	50	10.4 (B)	20.8 (C)
		75	10.1 (B)	20.8 (C)
		100	10.7 (B)	20.6 (C)
	60	50	13.3 (B)	19.6 (C)
		75	12.6 (B)	19.9 (C)
		100	11.5 (B)	19.8 (C)
750	20	50	2.7 (A)	21.2 (C)
		75	2.6 (A)	21.0 (C)
		100	4.7 (A)	21.1 (C)
	40	50	8.3 (A)	21.2 (C)
		75	9.2 (A)	21.1 (C)
		100	10.6 (B)	21.3 (C)
	60	50	7.0 (A)	18.8 (C)
		75	6.5 (A)	18.7 (C)
		100	13.9 (B)	18.3 (C)
1000	20	50	9.3 (A)	19.2 (C)
		75	9.1 (A)	19.2 (C)
		100	8.9 (A)	19.3 (C)
	40	50	15.3 (B)	16.1 (D)
		75	14.2 (B)	16.1 (D)
		100	14.2 (B)	16.1 (D)
	60	50	22.4 (C)	13.5 (E)
		75	21.2 (C)	13.9 (E)
		100	21.4 (C)	13.8 (E)
1250	20	50	6.8 (A)	18.1 (C)
		75	6.4 (A)	18.3 (C)
		100	6.6 (A)	18.0 (C)



# Example Cross Road LOS (signal) NB Inglewood at Minnetonka

Northbound at Ave Inglewood				
		Minor Flow (percent of major flow)		
		20%	40%	60%
Major Flow (AADT)	500 (10000)	B	C	E
	750 (15000)	C	F	F
	800 (16000)	F	F	F
	850 (17000)	F	F	F
	900 (18000)	F	F	F
	950 (19000)	F	F	F
	1000 (20000)	F	F	F
	1250 (25000)	F	X	X



# Example Cross Road LOS (TWSC) NB Raleigh at Minnetonka

Northbound at Raleigh Ave				
		Minor Flow (% of MUTCD Signal Warrant)		
		50%	75%	100%
Major Flow (AADT)	500 (10000)	B	C	D
	750 (15000)	C	D	E
	800 (16000)	D	E	E
	850 (17000)	D	E	F
	900 (18000)	F	F	F
	950 (19000)	F	F	F
	1000 (20000)	F	F	F
	1250 (25000)	F	X	X



# Results: Minnetonka Blvd

- (1) Target road traffic, both the signalized and TWSC intersections: Three-lane configuration showed acceptable LOS at hourly volumes greater than 750 v/h/l (AADT= 15,000 vehicles/day.)
- (2) Cross road approaches signalized intersections: Substantial deterioration in LOS tended to occur when target road flows exceeded 750 v/h/l. Probably in part because of single-lane approaches.
- (3) Cross-road approaches TWSC: Roughly similar pattern, LOS=F conditions appearing as target road flow increased from 750 v/h/l to 1000 v/h/l, depending on the level of minor road flow.



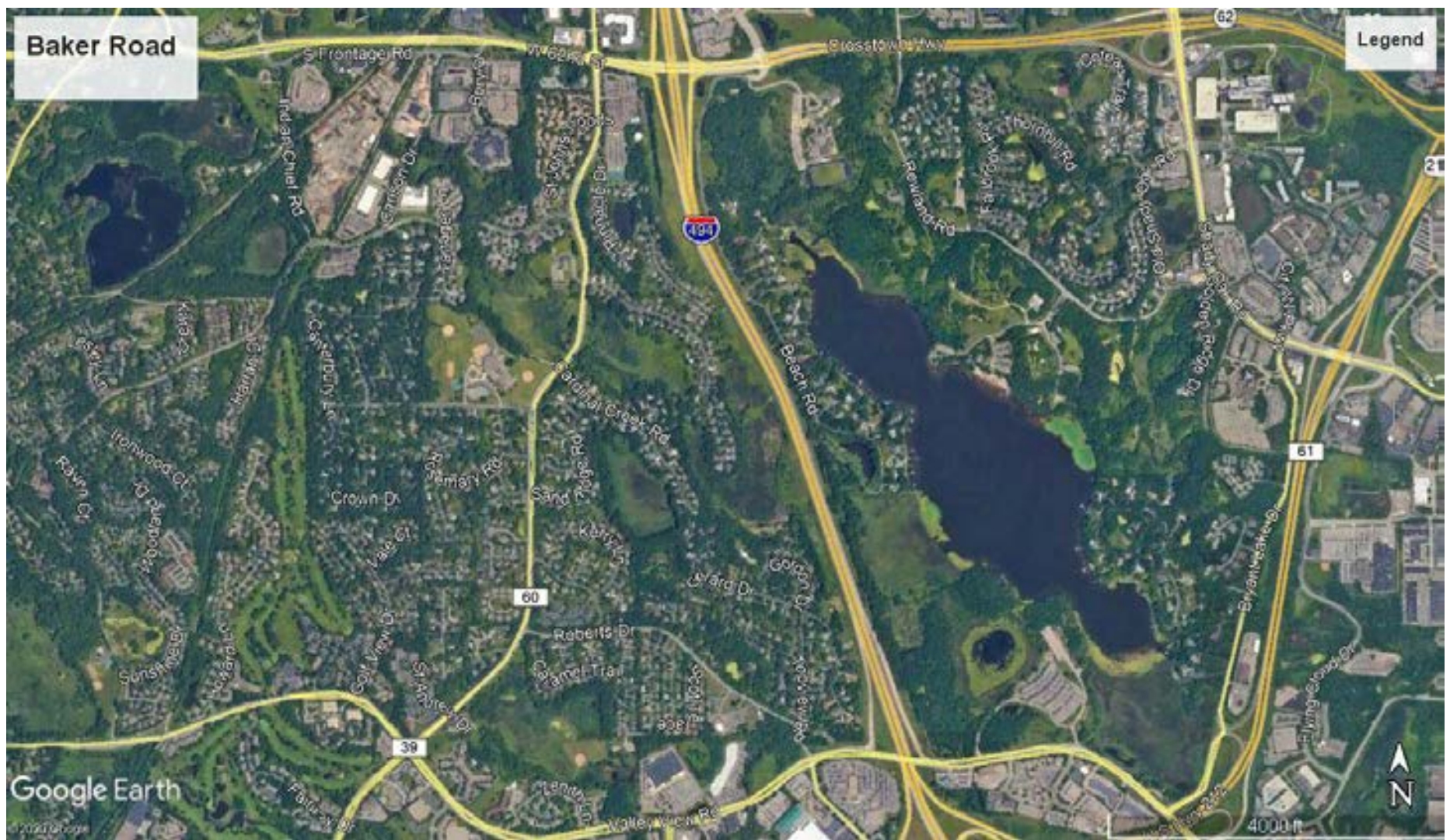
# Baker Road Site

Street		Baker Road
From		CSAH 62
To		Valley View
Length (miles)		1.7 miles
AADT (year)		10,200 (2016)
Internal Intersections	Signalized	0
	TWSC, 4-legged intersections	4
	TWSC, T-intersections	10



# Baker Road

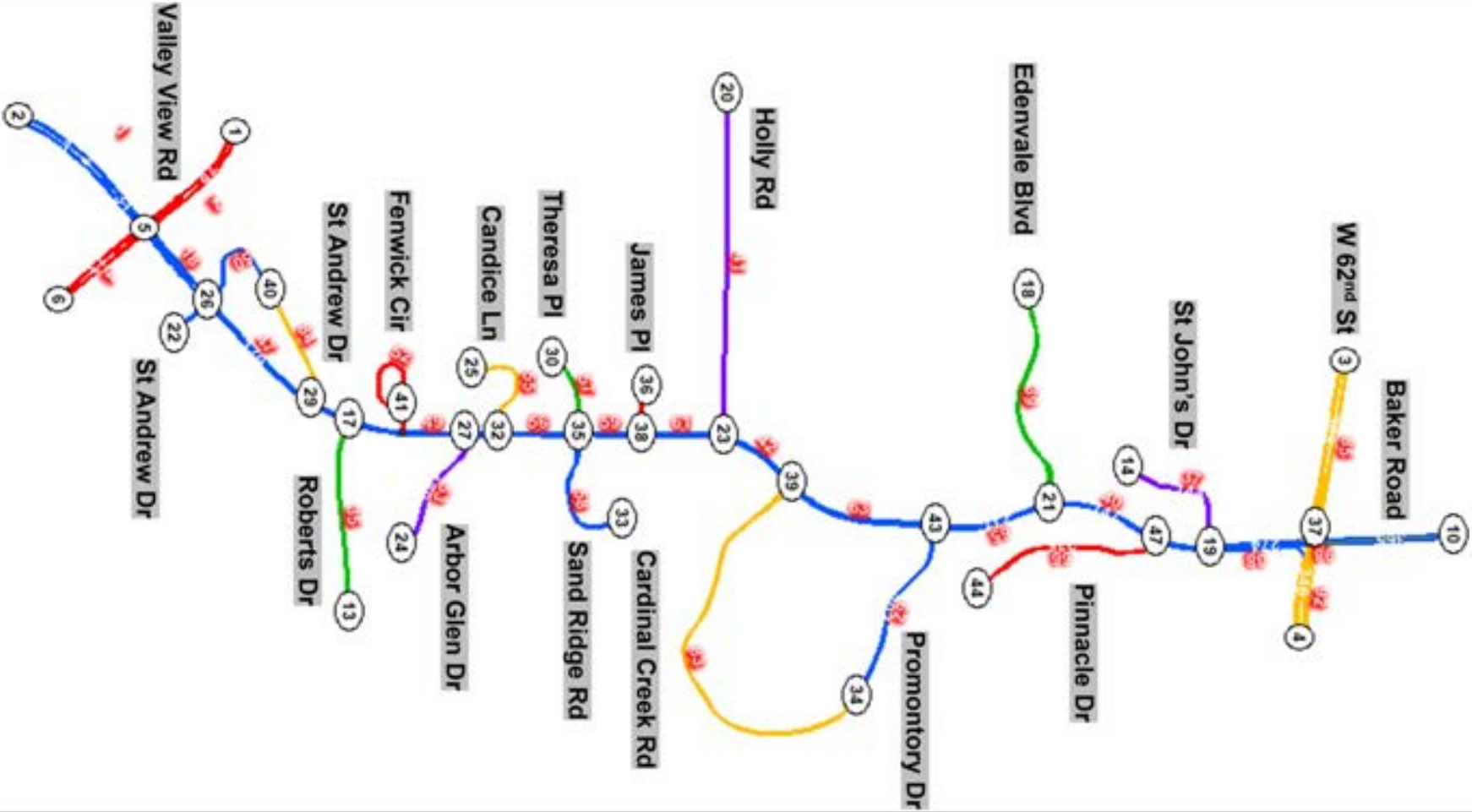
# Legend



Google Earth



# Baker Road in Transmodeler SE



# Baker and CSAH 62





# Example Target Road LOS (signal)

## NB Baker at CSAH 62

NB @ CSAH 62			
Main Flow (vhe/h/dir)	Minor Signal (%)	Minor Unsignal (%)	Avg. Delay in sec/veh (LOS)
500	20	50	14.8 (B)
		75	14.1 (B)
		100	13.4 (B)
	40	50	15.6 (B)
		75	15.7 (B)
		100	14.8 (B)
	60	50	16.1 (B)
		75	17.6 (B)
		100	16.4 (B)
750	20	50	15.9 (B)
		75	14.9 (B)
		100	15.4 (B)
	40	50	20.2 (C)
		75	20.2 (C)
		100	20 (B)
	60	50	20.1 (C)
		75	19.8 (B)
		100	21.2 (C)
1000	20	50	17.3 (B)
		75	18.4 (B)
		100	18.2 (B)
	40	50	27.4 (C)
		75	27.6 (C)
		100	25.3 (C)
	60	50	36.2 (D)
		75	34 (C)
		100	31.6 (C)
1250	20	50	26 (C)
		75	24.7 (C)
		100	22.7 (C)



# Example Cross Road LOS (signal)

## EB CSAH 62 at Baker

EB @ CSAH 62

Main Flow (vhe/h/dir)	Minor Signal (%)	Minor Unsignal (%)	Avg. Delay in sec/veh (LOS)
500	20	50	20.6 (C)
		75	19.4 (B)
		100	19.5 (B)
	40	50	26.1 (C)
		75	27.1 (C)
		100	27 (C)
	60	50	29.7 (C)
		75	29.4 (C)
		100	29.3 (C)
750	20	50	22.9 (C)
		75	22.6 (C)
		100	23.1 (C)
	40	50	34.9 (C)
		75	34.3 (C)
		100	35.1 (D)
	60	50	38.2 (D)
		75	38.1 (D)
		100	39.1 (D)
1000	20	50	27.9 (C)
		75	27.5 (C)
		100	28.7 (C)
	40	50	49.6 (D)
		75	48.6 (D)
		100	48.7 (D)
	60	50	56.6 (E)
		75	57 (E)
		100	57.1 (E)
1250	20	50	39.2 (D)
		75	38.6 (D)
		100	41.3 (D)



# Example Target Road LOS (TWSC) EB Holly Rd at Baker

Eastbound at Holly Rd (Minor Signalized = 40%)				
		Minor Flow (% of MUTCD Signal Warrant)		
		50%	75%	100%
Major Flow (ADT)	500 (10000)	B	C	C
	750 (15000)	C	C	D
	800 (16000)	C	C	D
	850 (17000)	C	E	F
	900 (18000)	C	E	F
	950 (19000)	D	E	F
	1000 (20000)	E	E	F
	1250 (25000)	F	F	F



# Results: Baker Road

(1) For target road traffic, at both the signalized and TWSC intersections: Three-lane configuration showed acceptable LOS even at hourly volumes greater than 750 v/h/l, (AADT=15,000 vehicles/day)

(2) At the cross-street approaches, signalized intersections: Acceptable LOS was present even at higher demand levels. Likely due to the greater capacity at these intersections compared to those on Minnetonka Blvd.

(3) For cross road traffic at TWSC intersections: LOS=F conditions appeared as target road flow increased above 750 v/h/l, depending on the level of minor road flow.



# Summary

- Signalized intersections constrain 4-3 conversions
  - Target road capacity
  - Cross road capacity
- If signalized intersection LOS acceptable, next constraint is LOS at TWSC intersections
  - Minor road capacity (useable gaps)
- If signalized & TWSC intersection LOS acceptable, next constraint is speed/delay on main road links (traffic flow)
- Guidelines based solely on target road AADT can be misleading



# Questions and Discussion

