

Lab Report

Title: Lab 3: Deliveries
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Project Repository: <https://github.com/and04671/GIS5572/tree/main/Lab3>

Abstract

The goal of this lab was to create network datasets and use a vehicle routing problem to compare them to pre-made network datasets. Specifically, the routing problem was to find the fastest route for two UPS trucks to deliver 10 packages on time, not drive on 35W and 94, and then return home. In order to create the necessary network dataset, a base street centerlines layer was required, in addition to a set of parameters regarding costs and units of time/distance. The other network was a pre-made ESRI file. The given addresses were then geocoded in ArcPro. Barrier polygons were required to prevent travel on restricted interstates, with intersections removed to still allow crossing. Once these items were completed, they were fed to a VRP (Vehicle Routing Problem) as orders, depots, and barriers. Route criteria were created next in order to specify the costs and number of routes. The VRP layer was then solved to create the most effective routes, displaying them to a map and printing directions. This entire process was repeated on each network dataset, and the total times compared. Both seemed to have about a minimum time of 2:20-2:45, and satisfied the evaluation criteria.

Problem Statement

2 delivery drivers starting from 1436 Lone Oak Rd, St Paul, MN 55121 at 8:00 AM must deliver 10 packages to 10 listed addresses and return to the start point in the shortest time possible. Find the best (fastest) routes between the 2 drivers, avoiding both 94 and 35W. Solve the problem in ArcGIS Pro and ArcGIS Online using your own constructed network dataset. (Can compare with ESRI's proprietary network services). **Modified: compare new and ESRI network datasets in ArcPro.**

Deliveries:

5525 Cedar Lake Rd S, St Louis Park, MN 55416
225 Thomas Ave N #700, Minneapolis, MN 55405 MUST arrive between 10 and 11am
701 N 5th St, Minneapolis, MN 55401
920 E Lake St #123, Minneapolis, MN 55407
783 Harding St NE, Minneapolis, MN 55413
4165 W Broadway Ave, Robbinsdale, MN 55422
1321 E 78th St, Bloomington, MN 55425
12547 Riverdale Blvd, Coon Rapids, MN 55448
9875 Hospital Dr, Maple Grove, MN 55369
3300 Oakdale Ave N, Robbinsdale, MN 55422 MUST arrive between 10 and 11am

Table 1. Problem Statement Requirements

#	Requirement	Defined As	Spatial Data	Attribute Data	Dataset	Preparation
1	Street Network	Road centerlines for Twin Cities	Road segment length	Speed Limits	https://gisdata.mn.gov/dataset/us-mn-state-metrogis-trans-road-centerlines-gac	Create Network Layer
2	Delivery Locations	The 10 specified addresses	Point Location	Start/Stop Bounds	Created CSV	Geocode Addresses CSV

3	Start Locations	Point where routes start	Point Location	Start/Stop Bounds	Created CSV	Geocode Depots CSV
4	Restrictions	Cannot cross 35W or I94	Buffer Polygons	n/a	Road centerlines	Select Out
5	VRP Layer	Layer to solve routing	Delivery, Depots, Routes	Directions	n/a	Above Preps

Input Data

The problem needs data for two different networks, a created one and an ESRI one. A raw road-lines file is required to create the new dataset. We also need the location data given in the brief.

Table 2. Input Data

#	Title	Purpose in Analysis	Link to Source
1	Road Centerlines	Network Creation	https://gisdata.mn.gov/data/set/us-mn-state-metrogis-trans-road-centerlines-gac
2	ESRI Network DS	Network Comparison	In ArcPro, set source to arcgis.com
3	Point Locations	Places to visit on routes	Given

Methods

Create a new Network Dataset:

Add the RoadCenterlines shapefile to the map and gdb.

Create an ND dataset from the shapefile using Create Network Dataset tool.

In tool, select the shapefile as the Target Feature.

Click Run

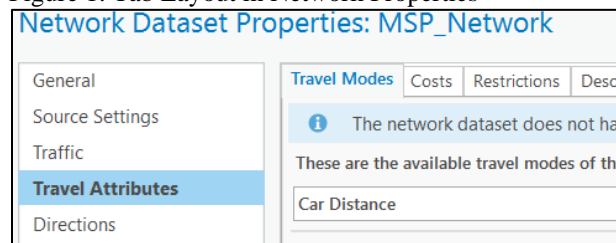
A new dataset called MSP_ND will be created.

Network Dataset Properties:

To set the correct properties for the network dataset, find it in the .gdb and right click. Click Properties to open a dialog box.

Click the Travel Attributes tab on the side. A set of tabs will appear.

Figure 1: Tab Layout in Network Properties



Under Travel Modes: create 2 travel modes called Car Distance and Car Time. Set the impedance as length/meters and time/minutes respectively.

Under Costs: create a new cost called Minutes. Keep units in minutes.

Under evaluators (inside box for selected cost): set type to Field Script. For a script, type $[\text{SHAPE_Leng}]/([\text{SPEED_IMP}]*26.8224)$ to get an accurate meters per minutes. Do this for Roadlines(Along) and Roadlines(Against).

Figure 2: Evaluators box for Time Cost

Source	Type	Value
Edges		
Roadlines (Along)	Field Script	[SHAPE_Leng]/([SPEED_IMP]*26.8224)
Roadlines (Against)	Same as Along	[SHAPE_Leng]/([SPEED_IMP]*26.8224)
<Default>	Constant	0

Under the existing distance cost: make sure units are meters and that Roadlines(Along) and Roadlines(Against) are set to [SHAPE_Leng] in evaluators.

Figure 3: Evaluators box for Distance Cost

Source	Type	Value
Edges		
Roadlines (Along)	Field Script	[SHAPE_Leng]
Roadlines (Against)	Same as Along	[SHAPE_Leng]
<Default>	Constant	0

Under the Directions tab on the side, check the box for directions
Exit the box. Right Click the network dataset in the gdb again and click Build.

Create Order/Depot points:

Put required addresses in a CSV for geocoding

Geocode orders and depots CSVs using the Geocode Addresses tool.

Clean up geocoded locations by eliminating blank address rows (a problem on the depots version), and creating a name, start-time, and stop-time column for each. Eliminate unnecessary columns.

For each delivery set the start time to 8:00 AM and the end to 6:00 PM, except the two locations that should have 10:00 and 11:00 instead.

Figure 4: Example of start, end, and max violation times

MaxViol	Start	End
0	3/26/2021 10:00:00 AM	3/26/2021 11:00:00 AM
0	3/26/2021 8:00:00 AM	3/26/2021 6:00:00 PM
0	3/26/2021 8:00:00 AM	3/26/2021 6:00:00 PM

Feature sets are ready to pass into VRP layer

Create Barrier Polygons:

From a road centerlines layer, select all segments of both 35W and I94. Export these to a new layer.

Create 20-foot buffer around the new layer using the Buffer tool

Erase portions of the buffer using Split, that contain intersections to allow vehicles to cross the restricted roads.

Save this as a new layer

Figure 5: Overview of barrier polygons

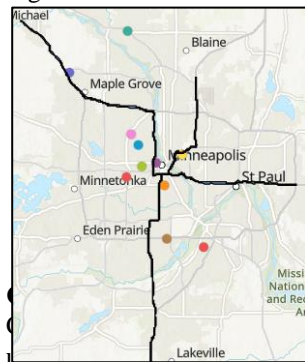
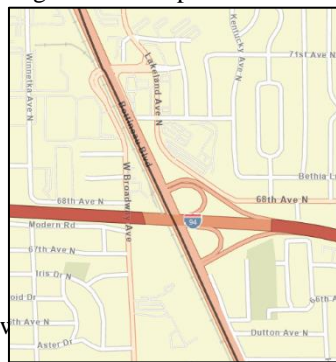
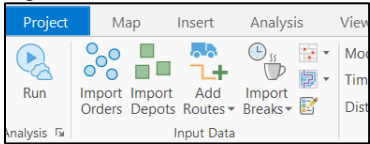


Figure 6: Example of cut-out intersection crossing



Add geocoded orders via Add Locations tool, and map name, start-stop fields. Set max violation time to 0. Make sure the Sublayer is set to Orders

Figure 7: Add locations and routes tools



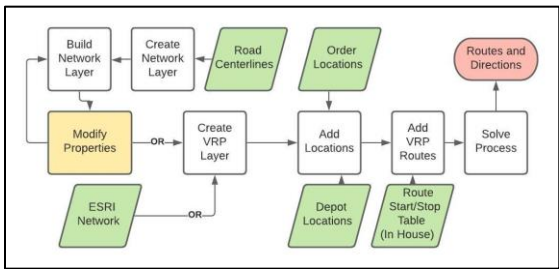
Add geocoded depots via Add Locations tool and map name, start-stop fields. Make sure the Sublayer is set to Depots

Add routes with the Add Vehicle Routing Problem Tool. Specify 2 routes, a start time of 8:00 AM, costs per unit time (it's 1), and the max packages per truck

Add the polygon barrier layer via Add Locations. Map the required name field to the polygon's ID. Make sure the Sublayer is set to Polygon Barrier

Click Run under the purple VRP tab.

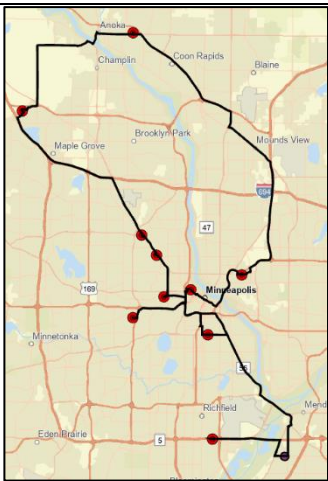
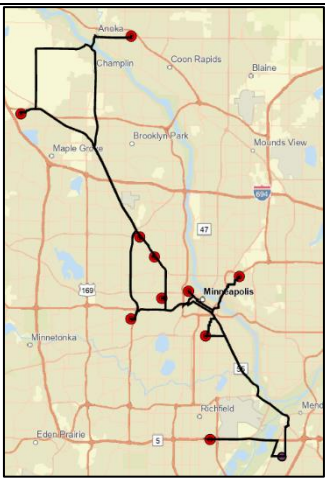
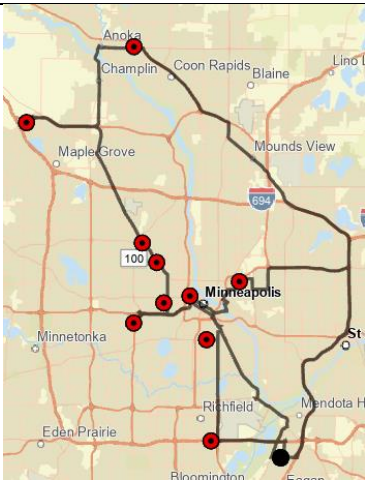
Figure 8: Process Overview



Results

The three network/barrier combination routes were created successfully, and show noticeable differences in route, mostly in regard to the ‘outer’ deliveries.

Please see directions PDF after self-evaluation for directions!

Created Network without Barriers	Created Network with Barriers	ESRI Network with Barriers
		

Results Verification

There isn't really a way to know if the route is truly the shortest, but it should be given the conditions (unless the conditions are not set correctly for the problem). Still, we can compare route times between datasets. We can also make sure the results get to deliveries on time, and avoid restricted interstates.

First Criteria: Hit all targets in required time frames

Second Criteria: Avoids restricted areas

Third Criteria: Finishes in under 3 hours

Created wo Barriers:

- First Criteria: All deliveries are made in appropriate time; time restricted deliveries are made at 9:24 (waits :34 until 10) and 10:05.
- Second Criteria: Does not avoid 35W and 94, but was not programmed to do so; valid
- Third Criteria: all routes finish by 10:24 AM, 2:24 from start time

Created w Barriers:

- First Criteria: All deliveries are made in appropriate time; time restricted deliveries are made at 9:34 (waits :26 until 10) and 10:05.
- Second Criteria: Successfully avoids 35W and 94.
- Third Criteria: all routes finish by 10:26 AM, 2:26 from start time

ESRI w Barriers:

- First Criteria: All deliveries are made in appropriate time; time restricted deliveries are made at 9:25 (waits :35 until 10) and 10:08. (The directions show the UTC times for limits for some reason)
- Second Criteria: Successfully avoids 35W and 94.
- Third Criteria: all routes finish by 10:39 AM, 2:39 from start time

Discussion and Conclusion

The primary goal in this lab was to compare created and pre-existing network datasets. The delivery times on the newly created dataset ended up being faster, but it is likely this is due to some improper network properties or non-current road data. The created network turned out better than expected. It is interesting to note that the second truck actually doesn't help the time a lot. The last packages can't be delivered until 10, which leaves enough time for one truck to get it all done. The second truck just means one of them has a wait time until 10. In theory, the shortest delivery time is 2 hours, from 8-10 AM, but cannot be faster due to time restrictions. All routes finish within 2-3 hours, but have large segments of just waiting on location. However, the number of packages per truck does affect the time: 5 vs 30 in the ESRI dataset causes a difference of about 11 minutes. The other two datasets were set to 30, and one of the versions only creates one route, which isn't really fair to either of the drivers. This would certainly be worth playing with for each network dataset to find the optimal package limit.

The VRP solver is remarkably picky about the format of the data you send it. There were multiple problems where the dates weren't manually set in the Default Date box in the VRP tab (instead of leaving as "today", when "today" was the same date set elsewhere in the data). The barrier layer was a class-wide dilemma. By simply creating a barrier along all of 35 and 94, the computer interprets that it cannot cross the roads perpendicularly, which is possible when roads are closed. Therefore, all the little intersections with any street that cross the interstate had to be erased. This does affect the result; on another test layer I erased ALL intersections, and the time actually increased.

References

ESRI. (2020). Create a network dataset. Retrieved March 28, 2021, from <https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/how-to-create-a-usable-network-dataset.htm>

ESRI. (2020). Service a set of orders with a fleet of vehicles. Retrieved March 28, 2021, from <https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/service-a-set-of-orders-with-a-fleet-of-vehicles.htm>

Self-score

























Fill out this rubric for yourself and include it in your lab report. The same rubric will be used to generate a grade in proportion to the points assigned in the syllabus to the assignment.




























Category	Description	Points Possible	Score
Structural Elements	All elements of a lab report are included (2 points each): Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score	28	27
Clarity of Content	Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level (12 points). There is a clear connection from data to results to discussion and conclusion (12 points).	24	23
Reproducibility	Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified.	28	26
Verification	Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated (10 points), the method of comparison is clearly stated (5 points), and the result of verification is clearly stated (5 points).	20	19
		100	95



























Own Network Dataset w/o Barriers


























Route: Route1

	8:00 AM	Start at Depot Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	
	8:00 AM	Go east on Lone Oak toward Vince / Timberwood	0.2 mi ~ < 1 min
	8:00 AM	Turn left on Pilot Knob	1.7 mi ~ 2 min
	8:02 AM	Turn right on 13	0.2 mi ~ < 1 min
	8:02 AM	Turn left on 55	1.8 mi ~ 2 min
	8:04 AM	Turn right on 5, then turn left on 55	456 ft ~ < 1 min
	8:05 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	8:05 AM	Continue forward on 55	0.3 mi ~ < 1 min
	8:05 AM	Continue forward on 62	0.1 mi ~ < 1 min
	8:05 AM	Turn right on Minnehaha	273 ft ~ < 1 min
	8:05 AM	Continue forward on 55	0.4 mi ~ < 1 min
	8:06 AM	Continue forward on Hiawatha	3.6 mi ~ 5 min
	8:11 AM	Turn left on Lake	1.1 mi ~ 2 min
	8:14 AM	Arrive at Brewery4, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:14 AM	Depart Brewery4	
	8:14 AM	Continue west on Lake	0.3 mi ~ < 1 min
	8:14 AM	Turn right on Portland	0.5 mi ~ < 1 min
	8:15 AM	Turn left on 26th	0.1 mi ~ < 1 min
	8:15 AM	Make a sharp right on 35W	0.1 mi ~ < 1 min
	8:15 AM	Bear left on 65	0.6 mi ~ < 1 min
	8:16 AM	Turn left on 94	1.4 mi ~ 2 min
	8:18 AM	Turn left on Dunwoody, then turn right on Ramp	0.5 mi ~ < 1 min
	8:18 AM	Continue forward on HOV/HOT reversible lane	2.0 mi ~ 2 min
	8:20 AM	Continue forward on Ramp	0.5 mi ~ < 1 min
	8:21 AM	Turn right on Wayzata, then turn left on 100	0.5 mi ~ < 1 min
	8:21 AM	Turn right on Cedar Lake	0.2 mi ~ < 1 min

	8:21 AM	Arrive at Brewery1, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:21 AM	Depart Brewery1	
	8:21 AM	Go back southeast on Cedar Lake	0.2 mi ~ < 1 min
	8:22 AM	Turn left on 100	0.5 mi ~ < 1 min
	8:22 AM	Turn right on Wayzata, then turn left on Ramp	0.5 mi ~ < 1 min
	8:23 AM	Continue forward on HOV/HOT reversible lane	2.0 mi ~ 2 min
	8:25 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	8:25 AM	Turn left on 94	0.6 mi ~ < 1 min
	8:26 AM	Turn right on Olson Memorial	0.1 mi ~ < 1 min
	8:26 AM	Turn left on Oak Lake	0.1 mi ~ < 1 min
	8:26 AM	Turn right on 8th	0.2 mi ~ < 1 min
	8:27 AM	Bear right on 5th	249 ft ~ < 1 min
	8:27 AM	Arrive at Brewery3, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:27 AM	Depart Brewery3	
	8:27 AM	Continue southeast on 5th	0.4 mi ~ < 1 min
	8:28 AM	Turn left on 394	315 ft ~ < 1 min
	8:28 AM	Bear right on Ramp	171 ft ~ < 1 min
	8:28 AM	Bear right on 4th	1.3 mi ~ 2 min
	8:30 AM	Turn left on 35W	1.6 mi ~ 2 min
	8:32 AM	Bear right on Johnson	94 ft ~ < 1 min
	8:32 AM	Bear left on 35W	1.1 mi ~ 1 min
	8:33 AM	Turn right on Stinson	0.2 mi ~ < 1 min
	8:33 AM	Turn left on Broadway	0.2 mi ~ < 1 min
	8:34 AM	Turn right on Harding	209 ft ~ < 1 min
	8:34 AM	Arrive at Brewery5, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:34 AM	Depart Brewery5	


	8:34 AM	Go back north on Harding	209 ft	~ < 1 min
	8:34 AM	Turn right on Broadway	0.5 mi	~ < 1 min
	8:35 AM	Turn left on Industrial	0.2 mi	~ < 1 min
	8:35 AM	Turn right on 35W	0.5 mi	~ < 1 min
	8:36 AM	Turn left on 280, then turn right on 35W	0.5 mi	~ < 1 min
	8:36 AM	Continue forward on 36	0.3 mi	~ < 1 min
	8:37 AM	Bear left on 35W	5.7 mi	~ 6 min
	8:43 AM	Turn left on NB I35W to Mounds View Blvd	0.3 mi	~ < 1 min
	8:43 AM	Continue forward on Mounds View	2.3 mi	~ 3 min
	8:46 AM	Continue forward on County Road 10	0.6 mi	~ < 1 min
	8:46 AM	Make a sharp right on Highway 65	0.3 mi	~ < 1 min
	8:47 AM	Continue forward on Central	0.6 mi	~ < 1 min
	8:47 AM	Turn left on Highway 10	7.0 mi	~ 6 min
	8:54 AM	Bear left on Main	0.5 mi	~ < 1 min
	8:54 AM	Turn right on Riverdale	357 ft	~ < 1 min
	8:55 AM	Arrive at Brewery8, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM		
	8:55 AM	Depart Brewery8		
	8:55 AM	Go back south on Riverdale	357 ft	~ < 1 min
	8:55 AM	Turn right on Main	2.1 mi	~ 3 min
	8:58 AM	Turn left on Ferry	0.5 mi	~ 1 min
	8:59 AM	Continue forward on 169	0.2 mi	~ < 1 min
	8:59 AM	Turn right on Dayton	0.4 mi	~ < 1 min
	9:00 AM	Turn left on French Lake	0.6 mi	~ < 1 min
	9:01 AM	Turn right at Elm Creek / Brookside to stay on French Lake	0.4 mi	~ < 1 min
	9:02 AM	Continue forward on 129th	1.9 mi	~ 2 min
	9:04 AM	Continue forward on Fernbrook	3.5 mi	~ 4 min
	9:08 AM	Turn right on 610	0.2 mi	~ < 1 min

	9:08 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	9:08 AM	Turn left on Maple Grove	0.1 mi ~ < 1 min
	9:09 AM	Turn right on 99th, then turn left on Maple Grove	116 ft ~ < 1 min
	9:09 AM	Turn right on Grove	0.3 mi ~ < 1 min
	9:09 AM	Turn left on Hospital	0.1 mi ~ < 1 min
	9:09 AM	Arrive at Brewery9, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	9:09 AM	Depart Brewery9	
	9:09 AM	Continue southeast on Hospital	0.1 mi ~ < 1 min
	9:10 AM	Turn right on Maple Grove	0.3 mi ~ < 1 min
	9:10 AM	Turn left on Grove, then turn right on Maple Grove	0.1 mi ~ < 1 min
	9:10 AM	Make a sharp left on 94	3.2 mi ~ 3 min
	9:13 AM	Continue forward on 694	3.7 mi ~ 4 min
	9:17 AM	Turn right on 81	3.6 mi ~ 5 min
	9:22 AM	Make a sharp right on Lake	190 ft ~ < 1 min
	9:22 AM	Continue forward on 42nd	201 ft ~ < 1 min
	9:22 AM	Make a sharp left on West Broadway	250 ft ~ < 1 min
	9:22 AM	Arrive at Brewery6, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	9:22 AM	Depart Brewery6	
	9:22 AM	Continue southeast on West Broadway	0.1 mi ~ < 1 min
	9:22 AM	Turn left on 41st	380 ft ~ < 1 min
	9:22 AM	Turn right on 81	1.2 mi ~ 2 min
	9:24 AM	Turn right on Abbott	0.1 mi ~ < 1 min
	9:24 AM	Make a sharp left on Oakdale	0.1 mi ~ < 1 min
	9:24 AM	Arrive early at Brewery10, on the right Time Window: 3/26/2021 10:00 AM - 3/26/2021 11:00 AM Wait Time: 36 min	
	10:00 AM	Depart Brewery10	
	10:00 AM	Continue east on Oakdale	0.1 mi ~ < 1 min

	10:00 AM	Bear right on 81	100 ft ~ < 1 min
	10:00 AM	Continue forward on West Broadway	0.8 mi ~ 1 min
	10:02 AM	Turn right on Penn	1.6 mi ~ 3 min
	10:05 AM	Turn right on Glenwood	331 ft ~ < 1 min
	10:05 AM	Turn left on Queen, then turn right on Inglewood	0.2 mi ~ < 1 min
	10:05 AM	Turn right on Thomas	22 ft ~ < 1 min
	10:05 AM	Arrive at Brewery2, on the left Time Window: 3/26/2021 10:00 AM - 3/26/2021 11:00 AM	
	10:05 AM	Depart Brewery2	
	10:05 AM	Go back southeast on Thomas	22 ft ~ < 1 min
	10:05 AM	Turn left on Inglewood	0.2 mi ~ < 1 min
	10:06 AM	Turn left on Queen, then turn right on Glenwood	1.1 mi ~ 2 min
	10:08 AM	Turn right on 94	2.8 mi ~ 3 min
	10:11 AM	Bear right on Ramp	358 ft ~ < 1 min
	10:11 AM	Continue forward on Hiawatha	4.9 mi ~ 7 min
	10:18 AM	Continue forward on 55	0.4 mi ~ < 1 min
	10:19 AM	Continue forward on Minnehaha	273 ft ~ < 1 min
	10:19 AM	Turn left on 62	0.1 mi ~ < 1 min
	10:19 AM	Continue forward on 55	0.3 mi ~ < 1 min
	10:19 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	10:20 AM	Continue forward on 55	422 ft ~ < 1 min
	10:20 AM	Turn right on 5, then turn left on 55	1.8 mi ~ 2 min
	10:22 AM	Turn right on 13	0.2 mi ~ < 1 min
	10:22 AM	Turn left on Pilot Knob	1.7 mi ~ 2 min
	10:24 AM	Turn right on Lone Oak	0.2 mi ~ < 1 min
	10:24 AM	Finish at Depot, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	

Total Time: 2 hr 24 min
Total Distance: 86 mi
Total Wait Time: 36 min
Start Time: 3/26/2021 8:00 AM
Finish Time: 3/26/2021 10:24 AM


Route: Route2



8:00 AM

Start at Depot


Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM



8:00 AM

Go west on Lone Oak toward Woodlark


0.6 mi ~ < 1 min



8:01 AM

Make a sharp right on Sibley Memorial


1.0 mi ~ 1 min



8:02 AM

Make a sharp left on 494


4.0 mi ~ 4 min



8:06 AM

Turn left on 12th, then turn left on 78th


0.1 mi ~ < 1 min



8:06 AM


Arrive at Brewery7, on the right

Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM



8:06 AM


Depart Brewery7



8:06 AM

Go back west on 78th


0.1 mi ~ < 1 min



8:06 AM

Turn right on 12th, then turn right on 494


4.0 mi ~ 4 min



8:10 AM

Make a sharp right on Sibley Memorial


1.0 mi ~ 1 min



8:11 AM

Make a sharp left on Lone Oak

0.6 mi ~ < 1 min



8:12 AM



























Finish at Depot, on the right




























Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM



























Total Time: 12 min
Total Distance: 11 mi
Start Time: 3/26/2021 8:00 AM
Finish Time: 3/26/2021 8:12 AM



























Own Network Dataset w/ Barriers



























Route: Route1

	8:00 AM	Start at Depot Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	
	8:00 AM	Go east on Lone Oak toward Vince / Timberwood	0.2 mi ~ < 1 min
	8:00 AM	Turn left on Pilot Knob	1.7 mi ~ 2 min
	8:02 AM	Turn right on 13	0.2 mi ~ < 1 min
	8:02 AM	Turn left on 55	1.8 mi ~ 2 min
	8:04 AM	Turn right on 5, then turn left on 55	456 ft ~ < 1 min
	8:05 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	8:05 AM	Continue forward on 55	0.3 mi ~ < 1 min
	8:05 AM	Continue forward on 62	0.1 mi ~ < 1 min
	8:05 AM	Turn right on Minnehaha	273 ft ~ < 1 min
	8:05 AM	Continue forward on 55	0.4 mi ~ < 1 min
	8:06 AM	Continue forward on Hiawatha	3.6 mi ~ 5 min
	8:11 AM	Turn left on Lake	1.1 mi ~ 2 min
	8:14 AM	Arrive at Brewery4, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:14 AM	Depart Brewery4	
	8:14 AM	Go back east on Lake	0.1 mi ~ < 1 min
	8:14 AM	Turn left on 11th	0.2 mi ~ < 1 min
	8:14 AM	Turn right on 28th	327 ft ~ < 1 min
	8:14 AM	Turn left on 12th	0.4 mi ~ < 1 min
	8:15 AM	Turn right on 25th	329 ft ~ < 1 min
	8:15 AM	Turn left on 13th	0.2 mi ~ < 1 min
	8:16 AM	Turn right on 23rd	338 ft ~ < 1 min
	8:16 AM	Turn left on 14th	0.2 mi ~ < 1 min
	8:16 AM	Turn right on Franklin	0.3 mi ~ < 1 min
	8:17 AM	Make a sharp left on Hiawatha	0.4 mi ~ < 1 min
	8:17 AM	Turn right on 35W	0.2 mi ~ < 1 min





	8:17 AM	Turn right on Ramp, then make a sharp left on Ramp	0.2 mi	~ < 1 min
	8:18 AM	Turn right on 122	280 ft	~ < 1 min
	8:18 AM	Turn left on Ramp, then turn right on 122	0.2 mi	~ < 1 min
	8:18 AM	Turn left on 19th	0.4 mi	~ < 1 min
	8:19 AM	Continue forward on 10th	0.8 mi	~ 2 min
	8:21 AM	Continue forward on 11th	0.1 mi	~ < 1 min
	8:21 AM	Turn right on Talmage	319 ft	~ < 1 min
	8:21 AM	Turn left on 12th	0.1 mi	~ < 1 min
	8:21 AM	Turn right on Hennepin	0.4 mi	~ < 1 min
	8:22 AM	Turn left on Stinson	0.3 mi	~ < 1 min
	8:22 AM	Turn right on Kennedy	0.1 mi	~ < 1 min
	8:23 AM	Turn left on Taft	0.1 mi	~ < 1 min
	8:23 AM	Turn right on Summer	0.1 mi	~ < 1 min
	8:23 AM	Turn left on Harding	453 ft	~ < 1 min
	8:23 AM	Arrive at Brewery5, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM		
	8:23 AM	Depart Brewery5		
	8:23 AM	Go back south on Harding	453 ft	~ < 1 min
	8:23 AM	Turn right on Summer	0.1 mi	~ < 1 min
	8:24 AM	Turn left on Taft	0.1 mi	~ < 1 min
	8:24 AM	Turn right on Kennedy	0.1 mi	~ < 1 min
	8:24 AM	Turn left on Stinson	0.3 mi	~ < 1 min
	8:25 AM	Turn right on Hennepin	0.4 mi	~ < 1 min
	8:25 AM	Turn left on 12th	0.1 mi	~ < 1 min
	8:26 AM	Turn right on Talmage	319 ft	~ < 1 min
	8:26 AM	Turn left on 11th	0.1 mi	~ < 1 min
	8:26 AM	Continue forward on 10th	0.8 mi	~ 2 min
	8:28 AM	Continue forward on 19th	0.4 mi	~ < 1 min

	8:28 AM	Turn right on 122	0.2 mi ~ < 1 min
	8:29 AM	Turn left on Ramp, then turn right on 122	321 ft ~ < 1 min
	8:29 AM	Turn left on Ramp	0.2 mi ~ < 1 min
	8:29 AM	Make a sharp right to stay on Ramp	393 ft ~ < 1 min
	8:29 AM	Continue forward on 6th	1.0 mi ~ 2 min
	8:31 AM	Turn right on Nicollet	394 ft ~ < 1 min
	8:32 AM	Turn left on 5th	0.7 mi ~ 1 min
	8:33 AM	Arrive at Brewery3, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:33 AM	Depart Brewery3	
	8:33 AM	Go back southeast on 5th	0.4 mi ~ < 1 min
	8:34 AM	Make a sharp right on 394	0.5 mi ~ < 1 min
	8:35 AM	Bear right on Linden	183 ft ~ < 1 min
	8:35 AM	Continue forward on Ramp	0.2 mi ~ < 1 min
	8:35 AM	Turn left on 16th	222 ft ~ < 1 min
	8:35 AM	Turn right on Ramp	482 ft ~ < 1 min
	8:35 AM	Make a sharp right on Ramp, then make a sharp left on Ramp	268 ft ~ < 1 min
	8:35 AM	Turn right on 94	322 ft ~ < 1 min
	8:36 AM	Turn left on Ramp	0.4 mi ~ < 1 min
	8:36 AM	Continue forward on HOV/HOT reversible lane	2.0 mi ~ 2 min
	8:38 AM	Continue forward on Ramp	0.5 mi ~ < 1 min
	8:38 AM	Turn right on Wayzata, then turn left on 100	0.5 mi ~ < 1 min
	8:39 AM	Turn right on Cedar Lake	0.2 mi ~ < 1 min
	8:39 AM	Arrive at Brewery1, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:39 AM	Depart Brewery1	
	8:39 AM	Go back southeast on Cedar Lake	0.2 mi ~ < 1 min
	8:39 AM	Turn left on 100	5.3 mi ~ 5 min

	8:45 AM	Turn left on 81	9.3 mi ~ 11 min
	8:56 AM	Bear left on 610	0.5 mi ~ < 1 min
	8:57 AM	Continue forward on Ramp	0.4 mi ~ < 1 min
	8:57 AM	Turn left on Maple Grove	0.1 mi ~ < 1 min
	8:57 AM	Turn right on 99th, then turn left on Maple Grove	116 ft ~ < 1 min
	8:57 AM	Turn right on Grove	0.3 mi ~ < 1 min
	8:58 AM	Turn left on Hospital	0.1 mi ~ < 1 min
	8:58 AM	Arrive at Brewery9, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:58 AM	Depart Brewery9	
	8:58 AM	Go back northwest on Hospital	0.1 mi ~ < 1 min
	8:58 AM	Turn right on Grove	0.3 mi ~ < 1 min
	8:59 AM	Turn left on Maple Grove, then turn right on 99th	116 ft ~ < 1 min
	8:59 AM	Turn left on Maple Grove	0.1 mi ~ < 1 min
	8:59 AM	Turn right on Ramp	0.4 mi ~ < 1 min
	8:59 AM	Continue forward on 610	0.2 mi ~ < 1 min
	9:00 AM	Turn left on Fernbrook	3.5 mi ~ 4 min
	9:04 AM	Continue forward on 129th	1.9 mi ~ 2 min
	9:06 AM	Continue forward on French Lake	0.4 mi ~ < 1 min
	9:06 AM	Turn left at Elm Creek / Brookside to stay on French Lake	0.6 mi ~ < 1 min
	9:07 AM	Turn right on Dayton	0.4 mi ~ < 1 min
	9:08 AM	Turn left on 169	0.2 mi ~ < 1 min
	9:08 AM	Continue forward on Ferry	0.5 mi ~ 1 min
	9:09 AM	Turn right on Main	2.1 mi ~ 3 min
	9:13 AM	Turn left on Riverdale	357 ft ~ < 1 min
	9:13 AM	Arrive at Brewery8, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	9:13 AM	Depart Brewery8	

	9:13 AM	Go back south on Riverdale	357 ft ~ < 1 min
	9:13 AM	Turn right on Main	2.1 mi ~ 3 min
	9:16 AM	Turn left on Ferry	0.5 mi ~ 1 min
	9:17 AM	Continue forward on 169	6.1 mi ~ 7 min
	9:24 AM	Turn left on 81	5.4 mi ~ 6 min
	9:31 AM	Turn right on 100, then turn left on 81	0.4 mi ~ < 1 min
	9:31 AM	Make a sharp right on Lake	190 ft ~ < 1 min
	9:31 AM	Continue forward on 42nd	201 ft ~ < 1 min
	9:31 AM	Make a sharp left on West Broadway	250 ft ~ < 1 min
	9:31 AM	Arrive at Brewery6, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	9:31 AM	Depart Brewery6	
	9:31 AM	Continue southeast on West Broadway	0.1 mi ~ < 1 min
	9:32 AM	Turn left on 41st	380 ft ~ < 1 min
	9:32 AM	Turn right on 81	1.2 mi ~ 2 min
	9:34 AM	Turn right on Abbott	0.1 mi ~ < 1 min
	9:34 AM	Make a sharp left on Oakdale	0.1 mi ~ < 1 min
	9:34 AM	Arrive early at Brewery10, on the right Time Window: 3/26/2021 10:00 AM - 3/26/2021 11:00 AM Wait Time: 26 min	
	10:00 AM	Depart Brewery10	
	10:00 AM	Continue east on Oakdale	0.1 mi ~ < 1 min
	10:00 AM	Bear right on 81	100 ft ~ < 1 min
	10:00 AM	Continue forward on West Broadway	0.8 mi ~ 1 min
	10:02 AM	Turn right on Penn	1.6 mi ~ 3 min
	10:05 AM	Turn right on Glenwood	331 ft ~ < 1 min
	10:05 AM	Turn left on Queen, then turn right on Inglewood	0.2 mi ~ < 1 min
	10:05 AM	Turn right on Thomas	22 ft ~ < 1 min
	10:05 AM	Arrive at Brewery2, on the left Time Window: 3/26/2021 10:00 AM - 3/26/2021 11:00 AM	

	10:05 AM	Depart Brewery2		
	10:05 AM	Go back southeast on Thomas	22 ft	~ < 1 min
	10:05 AM	Turn left on Inglewood	0.2 mi	~ < 1 min
	10:06 AM	Turn right on Queen	448 ft	~ < 1 min
	10:06 AM	Turn left on 2nd	331 ft	~ < 1 min
	10:06 AM	Turn right on Penn	0.5 mi	~ 1 min
	10:07 AM	Turn left to stay on Penn	497 ft	~ < 1 min
	10:07 AM	Continue forward on Wayzata	50 ft	~ < 1 min
	10:07 AM	Turn left on HOV/HOT reversible lane	0.8 mi	~ < 1 min
	10:08 AM	Continue forward on Ramp	0.4 mi	~ < 1 min
	10:08 AM	Turn right on 94	322 ft	~ < 1 min
	10:08 AM	Turn left on Ramp	100 ft	~ < 1 min
	10:09 AM	Make a sharp right on Ramp, then make a sharp left on Ramp	0.1 mi	~ < 1 min
	10:09 AM	Turn left on 16th, then turn right on Hawthorne	0.2 mi	~ < 1 min
	10:09 AM	Turn right on 13th	380 ft	~ < 1 min
	10:09 AM	Turn left on Hennepin	0.4 mi	~ < 1 min
	10:10 AM	Turn right on 8th	1.3 mi	~ 2 min
	10:12 AM	Continue forward on Hiawatha	0.1 mi	~ < 1 min
	10:13 AM	Turn left on 94, then turn right on Hiawatha	4.6 mi	~ 7 min
	10:19 AM	Turn right on Minnehaha, then make a sharp left on Hiawatha	0.4 mi	~ < 1 min
	10:20 AM	Continue forward on 55	0.4 mi	~ < 1 min
	10:20 AM	Continue forward on Minnehaha	273 ft	~ < 1 min
	10:20 AM	Turn left on 62	0.1 mi	~ < 1 min
	10:20 AM	Continue forward on 55	0.3 mi	~ < 1 min
	10:21 AM	Continue forward on Ramp	0.4 mi	~ < 1 min
	10:21 AM	Continue forward on 55	422 ft	~ < 1 min
	10:21 AM	Turn right on 5, then turn left on 55	1.8 mi	~ 2 min

	10:23 AM	Turn right on 13	0.2 mi ~ < 1 min
	10:23 AM	Turn left on Pilot Knob	1.7 mi ~ 2 min
	10:26 AM	Turn right on Lone Oak	0.2 mi ~ < 1 min
	10:26 AM	Finish at Depot, on the left Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	

Total Time: 2 hr 26 min













Total Distance: 86 mi

Total Wait Time: 26 min

Start Time: 3/26/2021 8:00 AM

Finish Time: 3/26/2021 10:26 AM

Route: Route2

	8:00 AM	Start at Depot Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	
	8:00 AM	Go west on Lone Oak toward Woodlark	0.6 mi ~ < 1 min
	8:01 AM	Make a sharp right on Sibley Memorial	1.0 mi ~ 1 min
	8:02 AM	Make a sharp left on 494	4.0 mi ~ 4 min
	8:06 AM	Turn left on 12th, then turn left on 78th	0.1 mi ~ < 1 min
	8:06 AM	Arrive at Brewery7, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 6:00 PM	
	8:06 AM	Depart Brewery7	
	8:06 AM	Go back west on 78th	0.1 mi ~ < 1 min
	8:06 AM	Turn right on 12th, then turn right on 494	4.0 mi ~ 4 min
	8:10 AM	Make a sharp right on Sibley Memorial	1.0 mi ~ 1 min
	8:11 AM	Make a sharp left on Lone Oak	0.6 mi ~ < 1 min
	8:12 AM	Finish at Depot, on the right Time Window: 3/26/2021 8:00 AM - 3/26/2021 5:00 PM	

Total Time: 12 min

Total Distance: 11 mi



























Start Time: 3/26/2021 8:00 AM



Finish Time: 3/26/2021 8:12 AM

ESRI Network Dataset w/ Barriers

Route: Route7

	8:00 AM	Start at Depot Time Window: 3/26/2021 1:00 PM - 3/26/2021 10:00 PM	
	8:00 AM	Go east on Lone Oak Rd (CR-26)	1.0 mi ~ 2 min
	8:02 AM	At the traffic light, turn left	49 ft ~ < 1 min
	8:02 AM	Take the ramp and go on I-35E N 8:03 AM Keep left at the fork to stay on I-35E toward St Paul	8.3 mi ~ 11 min
	8:14 AM	Take the ramp on the right at exit 106C to 11th St toward State Capitol	0.4 mi ~ < 1 min
	8:14 AM	At the traffic light, continue forward on 11th St E 8:15 AM Cross over the railroad track	0.4 mi ~ 1 min
	8:16 AM	Take the ramp on the left and go on I-35E N	5.1 mi ~ 6 min
	8:22 AM	Bear right onto the ramp at exit 113-114 to I-694 W / US-10 W / I-694 E	0.3 mi ~ < 1 min
	8:22 AM	Keep left at the fork onto I-694 W / US-10	3.9 mi ~ 4 min
	8:26 AM	Take the ramp on the right at exit 42A and go on US-10 W toward Anoka	2.8 mi ~ 3 min
	8:29 AM	Continue forward on CR-10 W toward County 10	3.1 mi ~ 5 min
	8:34 AM	Take the ramp on the right to MN-65 N toward Cambridge	0.3 mi ~ < 1 min
	8:34 AM	Continue forward on MN-65 N (Central Ave NE)	0.8 mi ~ 1 min
	8:35 AM	At the traffic light, turn left	100 ft ~ < 1 min
	8:35 AM	Take the ramp and go on US-10 W	1.0 mi ~ 1 min
	8:37 AM	Keep left at the fork onto US-10 toward Anoka	5.5 mi ~ 5 min
	8:42 AM	Take the ramp on the right to CR-14 / Main St	0.3 mi ~ < 1 min
	8:42 AM	At the traffic light, turn left on Main St NW (CR-14 W)	0.6 mi ~ 1 min
	8:44 AM	At the traffic light, turn right on Riverdale Blvd NW	422 ft ~ < 1 min
	8:44 AM	Arrive at Brewery8, on the right Time Window: 3/26/2021 1:00 PM - 3/26/2021 11:00 PM	
	8:44 AM	Depart Brewery8	
	8:44 AM	Go north on Riverdale Blvd NW	336 ft ~ < 1 min
	8:44 AM	Make a U-turn and go back on Riverdale Blvd NW	0.2 mi ~ < 1 min
	8:45 AM	At the traffic light, turn right on Main St NW (CR-14 W)	2.1 mi ~ 5 min
	8:51 AM	At the traffic light, turn left on US-169 S (S Ferry St)	4.6 mi ~ 7 min
	8:58 AM	Take the ramp on the right and go on MN-610 W	3.9 mi ~ 4 min

	9:01 AM	Take the ramp on the right at exit 1 to Maple Grove Pkwy	0.3 mi ~ < 1 min
	9:02 AM	At the traffic light, turn left on Maple Grove Pkwy	0.6 mi ~ 1 min
	9:03 AM	At the traffic light, turn right on Hospital Dr	0.1 mi ~ < 1 min
	9:04 AM	Turn left	310 ft ~ < 1 min
	9:04 AM	Restriction: Through Traffic Prohibited	
	9:04 AM	Make a sharp left	151 ft ~ < 1 min
	9:04 AM	Turn left	220 ft ~ < 1 min
	9:04 AM	Arrive at Brewery9, on the left Time Window: 3/26/2021 1:00 PM - 3/26/2021 11:00 PM	
	9:04 AM	Depart Brewery9	
	9:04 AM	Continue east	7 ft ~ < 1 min
	9:04 AM	Turn right on Hospital Dr	0.1 mi ~ < 1 min
	9:05 AM	At the traffic light, turn left on Maple Grove Pkwy	0.4 mi ~ < 1 min
	9:06 AM	Turn right onto the ramp toward MN-610 E	3.8 mi ~ 4 min
	9:09 AM	Take the ramp on the right and go on US-169 S	1.2 mi ~ 1 min
	9:11 AM	Bear right onto the ramp to Bottineau Blvd (CR-81 S)	0.2 mi ~ < 1 min
	9:11 AM	Keep right at the fork onto CR-81 S / Bottineau Blvd	0.7 mi ~ 1 min
	9:12 AM	Continue forward on Bottineau Blvd (CR-81 S)	5.7 mi ~ 9 min
	9:21 AM	Turn right after the Pilgrim Dry Cleaners on 42nd Ave N (Lake Dr N)	404 ft ~ < 1 min
	9:21 AM	At the traffic light, turn left on W Broadway Ave	241 ft ~ < 1 min
	9:21 AM	Arrive at Brewery6, on the right Time Window: 3/26/2021 1:00 PM - 3/26/2021 11:00 PM	
	9:21 AM	Depart Brewery6	
	9:21 AM	Go back northwest on W Broadway Ave	241 ft ~ < 1 min
	9:22 AM	Turn right before the Shell on 42nd Ave N (Lake Dr N)	303 ft ~ < 1 min
	9:22 AM	Turn right after the Pilgrim Dry Cleaners on Bottineau Blvd (CR-81 S)	1.4 mi ~ 3 min
	9:24 AM	At the traffic light, turn right on Abbott Ave N	0.1 mi ~ < 1 min
	9:25 AM	At the stop sign, make a sharp left on Oakdale Ave N	0.1 mi ~ < 1 min
	9:25 AM	Arrive early at Brewery10, on the right Time Window: 3/26/2021 3:00 PM - 3/26/2021 4:00 PM	

	10:00 AM	Depart Brewery10	
	10:00 AM	Continue east on Oakdale Ave N	0.1 mi ~ < 1 min
	10:00 AM	Turn right on N Theodore Wirth Pkwy (Glenwood Pkwy)	0.1 mi ~ < 1 min
	10:01 AM	Turn left	42 ft ~ < 1 min
	10:01 AM	Take the ramp to W Broadway Ave (CR-81 S)	0.1 mi ~ < 1 min
	10:01 AM	Continue forward on W Broadway Ave (CR-81 S)	0.7 mi ~ 2 min
	10:03 AM	At the traffic light, turn right on N Penn Ave (CR-2)	1.6 mi ~ 5 min
	10:07 AM	At the traffic light, turn right on Glenwood Ave (CR-40)	0.2 mi ~ < 1 min
	10:08 AM	Turn left on N Thomas Ave	376 ft ~ < 1 min
	10:08 AM	Arrive at Brewery2, on the right Time Window: 3/26/2021 3:00 PM - 3/26/2021 4:00 PM	
	10:08 AM	Depart Brewery2	
	10:08 AM	Go back northwest on N Thomas Ave	376 ft ~ < 1 min
	10:09 AM	Turn right on Glenwood Ave (CR-40)	0.2 mi ~ < 1 min
	10:09 AM	At the traffic light, turn right on N Penn Ave (CR-2)	0.8 mi ~ 2 min
	10:11 AM	At the traffic light, turn left	45 ft ~ < 1 min
	10:11 AM	Take the ramp and go on I-394 E (US-12 E)	2.0 mi ~ 3 min
	10:13 AM	Keep left at the fork to stay on I-394 toward Downtown	
	10:15 AM	Take the ramp to N 4th St	495 ft ~ < 1 min
	10:15 AM	At the traffic light, bear right on N 4th St	1.1 mi ~ 5 min
	10:19 AM	Cross over the railroad track	
	10:20 AM	Continue forward on S 3rd St (MN-122 E)	369 ft ~ < 1 min
	10:20 AM	Take the ramp on the right to I-35W S / MN-55 E / Hiawatha Ave	0.3 mi ~ < 1 min
	10:21 AM	Keep left at the fork onto I-55 E / Hiawatha Ave	0.3 mi ~ < 1 min
	10:21 AM	Continue forward on Hiawatha Ave (MN-55 E)	5.5 mi ~ 11 min
	10:32 AM	Take the ramp on the right and go on MN-55 E (MN-62 E)	2.2 mi ~ 3 min
	10:33 AM	Keep left at the fork to stay on MN-55 E (MN-62 E)	
	10:34 AM	Go after Minnesota River. It will be on the right	
	10:35 AM	Take the ramp on the right at exit 117 and go on MN-55 toward MN-13 S	0.7 mi ~ < 1 min
	10:36 AM	Turn right on MN-13 S	2.1 mi ~ 3 min
	10:38 AM	Make a sharp left on Lone Oak Rd (CR-26)	0.6 mi ~ 1 min



10:40 AM **Finish at Depot, on the right**

Time Window: 3/26/2021 1:00 PM - 3/26/2021 10:00 PM

Total Time: 2 hr 39 min

Total Distance: 79 mi

Total Wait Time: 37 min

Start Time: 3/26/2021 8:00 AM

Finish Time: 3/26/2021 10:39 AM

Route: Route8