Lab Report

Title: I-94 Removal: An Exploratory Analysis
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Date: December 12, 2023

Project Repository: https://github.com/greg-kohler/GIS5571/tree/main/Final
Google Drive Link: N/A
Time Spent: 40

Abstract

Freeway removal is a topic in transportation that is often opposed due to fears of increasing commute times. This project dives into the changes in service area and length before and after the removal of I-94 between downtown Minneapolis and Saint Paul. This is how far someone can get from one point or how far someone can be away to reach a point. This report will summarize the methods used to build the network dataset and service area analysis layers. It will then show the results and compare the differences in service areas before and after the removal of the freeway. Next, this report will validate the results by comparing the network to ESRI's network dataset and will discuss the results and any lessons learned.

Problem Statement

Urban freeway removal is becoming a relevant topic for transportation departments, governments, and community stakeholders. According to (*Alternatives | Rethinking I-94 — Minneapolis to St. Paul | Let's Talk Transportation - MnDOT*, 2023), in the Twin Cities, one of MnDOT's alternative for I-94 is the removal of the freeway between the two downtowns and replacing it with urban development. The main argument against this is an increase in travel time and loss of convenience. In this project, I will explore how great this impact is. This project will analyze the service area and length for multiple randomly sampled points near I-94 and find the difference in distance reachable.

Table 1 - Required Resources

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	MnGeospatial Commons	Open data used to download data	Road geometry	Speed limit, segment length, elevation	Mn GeoSpatial Commons	Calculated new fields
2	ArcGIS Pro Network Analysis	ArcGIS Pro tools used to define travel attributes of network	N/A	Time and length	Metro Road Network	Needed to adjust travel attributes
3	ArcGIS Pro Notebooks	Juypter Notebooks used to store code for analysis	N/A	N/A	N/A	N/A

Input Data

The main source of data used in this project was the Road Centerlines from the Minnesota Geospatial Commons. This is line data of all roads in the Twin Cities metro and follows the Geospatial Advisory Council's Schema. It contains several attributes needed to generate a network dataset, including elevation, speed limit, road type, and one-way. This data had to be altered slightly to calculate length in miles, and if the road is prohibited from private vehicles.

Table 2 - Input Data

#	Title	Purpose in Analysis	Link to Source
1	Road Centerlines (Geospatial Advisory Council Schema)	Raw input dataset for creating network dataset from MetroGIS	Mn GeoSpatial Commons
2	I-94 Removal	Line feature used to represent how I-94 will be removed.	Created locally

Methods

The biggest piece of this project is the actual removal of I-94 from the network. For the removal of I-94, I chose to follow MnDOT's Rethinking I-94 guidelines, which extend from Highway 55 in downtown Minneapolis to Marion Street near downtown Saint Paul. I extended further past Highway 55 to account for different connecting ramps. I also chose to remove all ramps that connect to it. See Figure 1 for an overview of the pieces of I-94 that were removed.

Figure 1 - Portion of I-94 Removed

The first step of this process was downloading the Metro Centerlines from the Minnesota Geospatial Commons. This required using requests.get() and the zipfile module to download the Shapefiles and extract them to the local disk (See Figure 2).

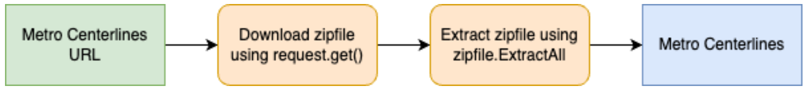

Figure 2 - Downloading Metro Centerlines

After obtaining the data, the centerlines were used for several operations. I manually created a line feature that represented the parts of I-94 that would be removed, refer to Figure 1. With this feature, I exported features that were called I-94, which allowed me to remove ramps for buffer creation later. The next step was to calculate a few fields for the centerlines dataset. I had to select roadways that banned cars manually. This included the University of Minnesota Transitway, Nicollet Mall, and the East Bank Transit Mall. After this, I had to calculate the length of all of the segments in Miles. I did this by dividing the length in meters by 1,609.34. I also had to calculate how far a vehicle could go on these segments in a minute. I did this by dividing the length in Miles by the Speed Limit and multiplying by 60 (*Create a Network Dataset—ArcGIS Pro | Documentation*, n.d.). Once these fields were calculated, I created two feature datasets for the centerlines and added them to it. One feature dataset was for the original centerlines and one was for the centerlines without I-94. I then used these feature datasets to create a network dataset. For the feature dataset that would have the removal of I-94, I had to join the I-94 removal layer I previously created with the centerlines. This added a “REMOVE” field to the centerlines. I then exported all features that did not have this “REMOVE” attribute and added the edited centerlines to a new feature dataset (See Figure 3).

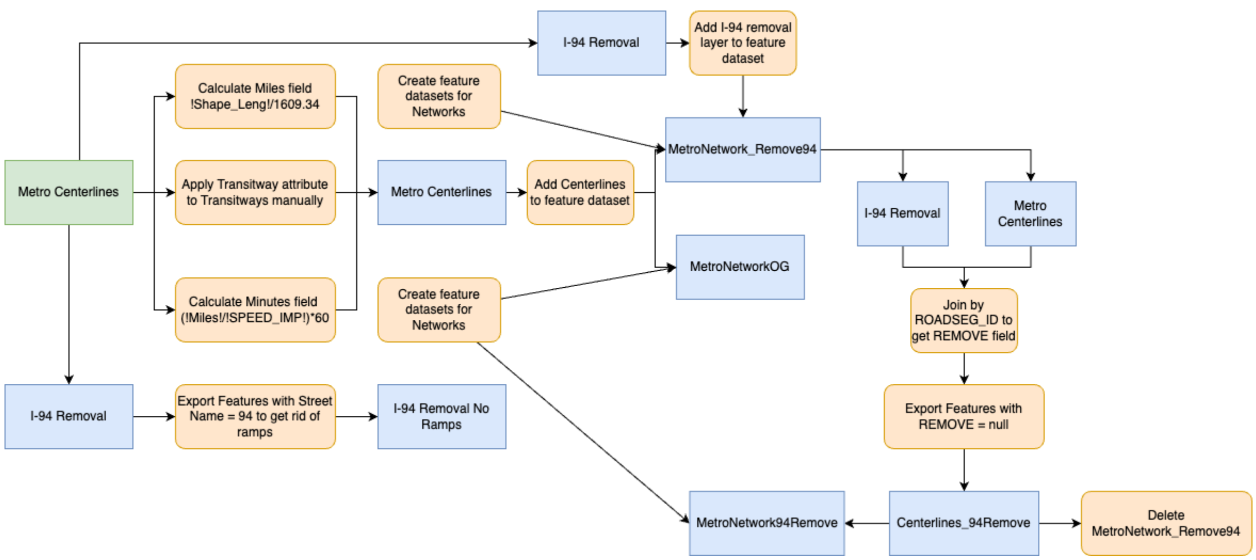

Figure 3 -Preparing Road Centerlines for Network Creation

Once the feature datasets were ready with the correct centerlines, I had to create the network dataset. Using guidance from *Create a Network Dataset—ArcGIS Pro | Documentation* (n.d.), I created a template for travel attributes that the network would follow. I set the distance parameter to the Miles field and the time parameter to the Minutes field. I added restrictions, so cars could not go on Transitways or down the wrong side of one-ways. Additionally, I set the elevation attribute to the elevation field in the Metro Centerlines dataset, this lets the network know what was bridged over and what was connected. I followed ESRI’s guidance for turn category cost (See Figure 4). This controls the time cost of going through or turning at intersections.

```
Default Turns: Turn Category
  Value:
    Azimuth Range: 30° - 150°
    0 sec: Default
    Right Turn:
      2 sec: Local To Local Road
      3 sec: Local To Secondary Road
      2 sec: Secondary To Local Road
      3 sec: Secondary To Secondary Road
    Left Turn:
      7 sec: Local To Local Road
      10 sec: Local To Secondary Road
      5 sec: Secondary To Local Road
      8 sec: Secondary To Secondary Road
    Straight Ahead:
      2 sec: Local To Local Road Across Local Road
      15 sec: Local To Local Road Across Major Road
      3 sec: Local To Secondary Road
      3 sec: Secondary To Local Road
      0.5 sec: Secondary To Secondary Road Across Local Road
      5 sec: Secondary To Secondary Road Across Major Road
    Reverse:
      5 sec: Local To Local Road
      15 sec: Local To Secondary Road
      5 sec: Secondary To Local Road
      5 sec: Secondary To Secondary Road
```

Figure 4 - Turn Category Cost

The final piece I had to edit was the hierarchy, which determines if a road is primary, secondary, or local. I used the “CLASS” field from the centerlines for this. With this template, I created the network dataset for both centerline datasets. After creating the datasets, I built the network with all the correct travel attributes (See Figure 5).

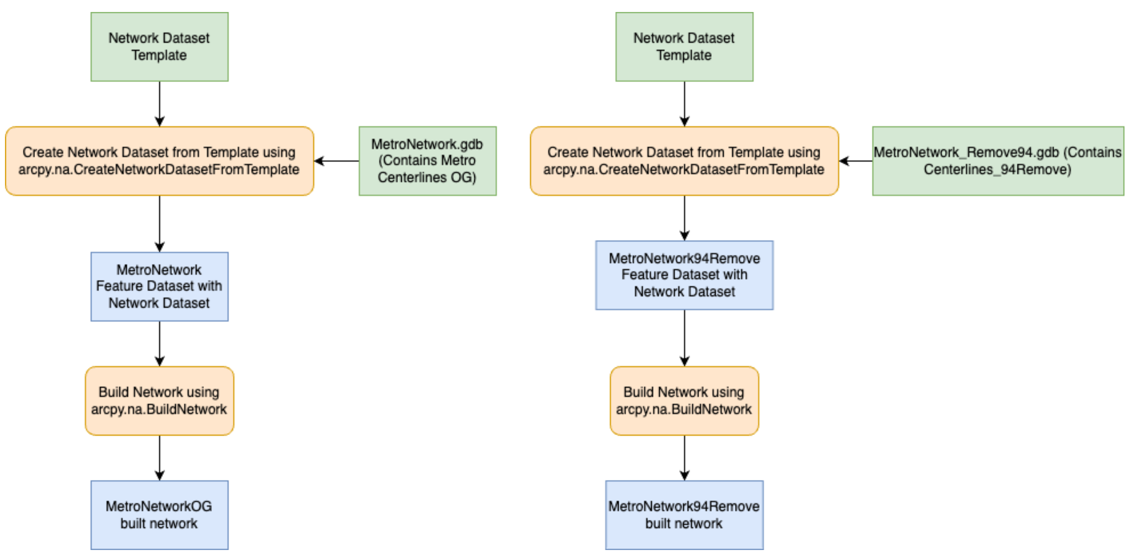

Figure 5 - Create and Build Network Datasets

With the networks built for centerlines with and without I-94, the next process was to prepare the dataset for the service area analysis. Using the I-94 removal layer without ramps created earlier in the pipelines, I created a buffer of 5 miles around I-94. I chose 5 miles for this analysis, as it encapsulated both downtowns and represented a good portion of the surrounding population that might use I-94. After creating the buffer, I generated 100 random points within this buffer. These points were used as facilities in the Service Area Analysis. I chose to create 100 points to generate significant results (See Figures 6 and 7).

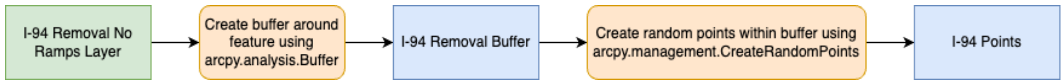

Figure 6 - Create Buffer and Random Points

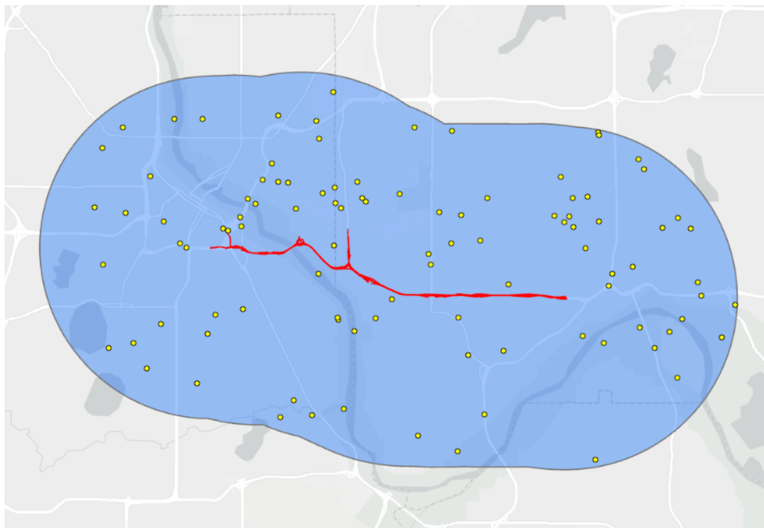

Figure 7 - Buffer and Random Points

With the points created, the next process was creating the service area analysis layer. This process, like all of the processes that follow it, was nearly identical for both networks. This process was within a for loop that allowed it to calculate both “FROM” and “TO” service areas. Using the built networks, I made a service area analysis layer that would generate polygons and lines. It generated independent disks and allowed overlap. This created a single service area polygon/line for each point. I chose to make the cutoff 15 minutes for this project analysis as the trip cutoff. This decision was made as 15 minutes seemed to be a good middle ground for trip length. With the service area analysis layer created, I added the randomly generated points. The points were chosen to snap to the network to prevent any routing starting in the middle of a park or water body (See Figure 8).

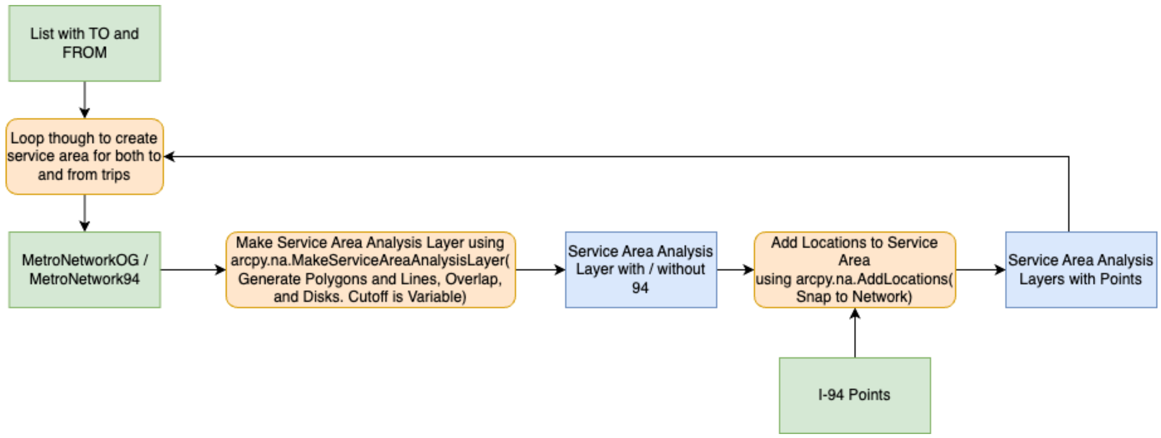

Figure 8 - Create Service Area Analysis Layer

The next step was to solve the service area analysis layer. This process was also looped through to create both to and from service areas. This was a long process, as it took several hours for all of the calculations to be completed. In this process, the service areas with the locations were solved. The polygons that were generated were exported and the lines that were created were dissolved into one feature based on their facility ID and exported. This allowed me to have all the created features in the same geodatabase (See Figure 9).

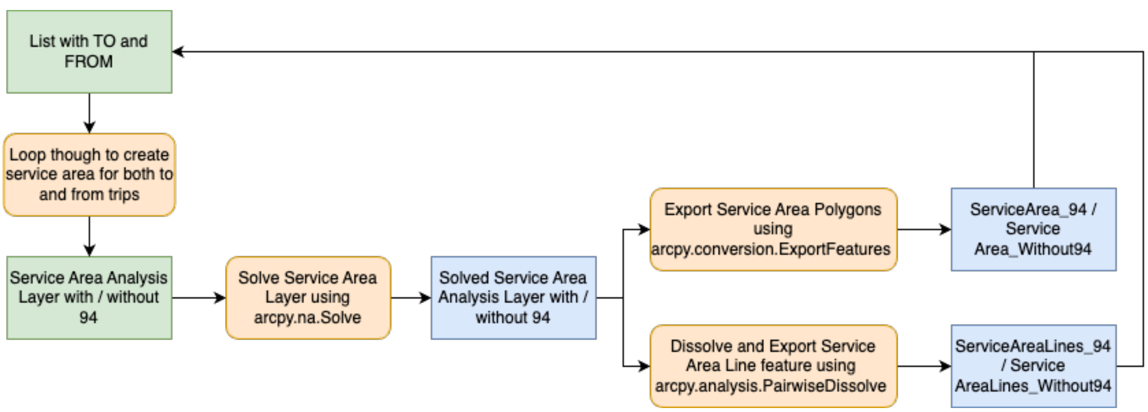

Figure 9 - Solve and Export Service Area Analysis Layer

The final step was to perform calculations on the exported service area polygons and lines. Similar to the processes in Figures 8 and 9, this process was in a for loop to generate both to and from data. For the polygons, I created a new field that calculated the square miles from the provided square meters. Similarly, for the lines I calculated the length in miles based on the length in meters (OpenAI, 2023). With this generated, I joined the polygon/line layer for the service areas with and without I-94. These were joined based on the facility ID attribute. After the join, the service area with I-94 had the area/length of the service area without I-94 in the same attribute table. Next, I calculated the service difference by subtracting the service area/length without I-94 from the service area/length with I-94. I then calculated the percent change in service area/length by dividing the service difference by the area/length of the service area with I-94 and multiplying that by 100. After all the above processes, I was able to generate an average change in service area/length with the removal of 94 for a 15-minute cutoff. The final step was to export 2 copies of the 100 random points and join them with the service area and length to have the service difference appended to the points. This step was for visualization purposes (See Figure 10).

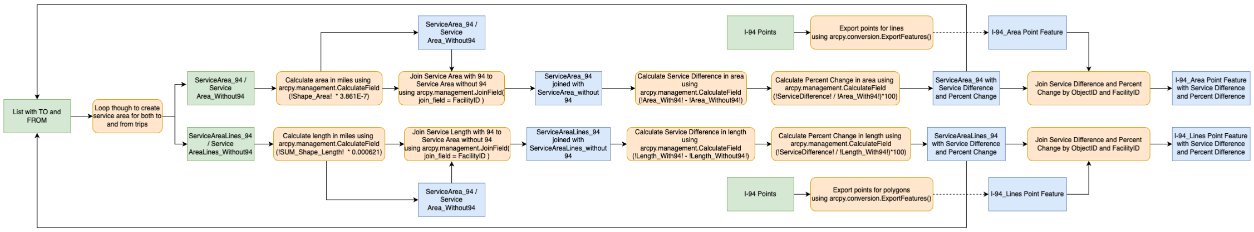

Figure 10 - Calculate Change in Service Area

Results

The process outlined above produced to and from service areas and service lines for 100 different points. This results section will showcase the results from five of these points, as well as a discussion of the overall results. For Figures 11-14, the results are for a point near Hennepin Avenue & I-35W in Minneapolis. The to and from results are very similar. There is an expected decrease in service area and length when going east. With I-94, a person in a car could reach downtown Saint Paul within the 15-minute cutoff, but without I-94 they could not. Otherwise, the service area and length for going north, west, and south remain the same.

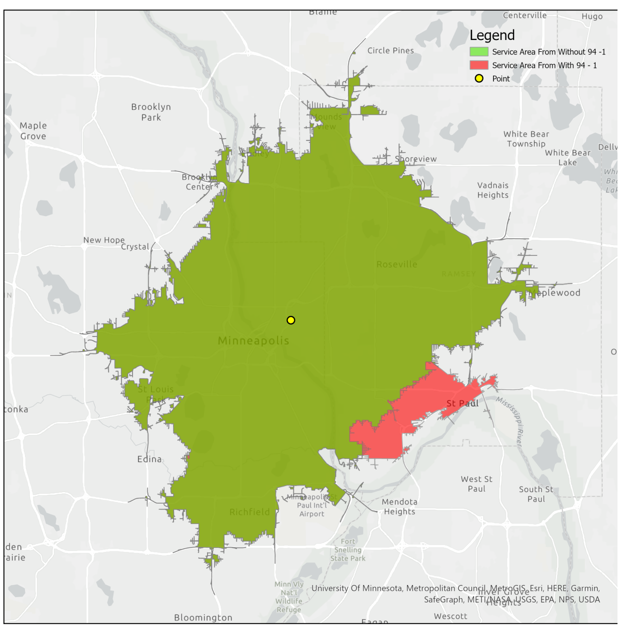

Figure 11 - Service Area From Point 1

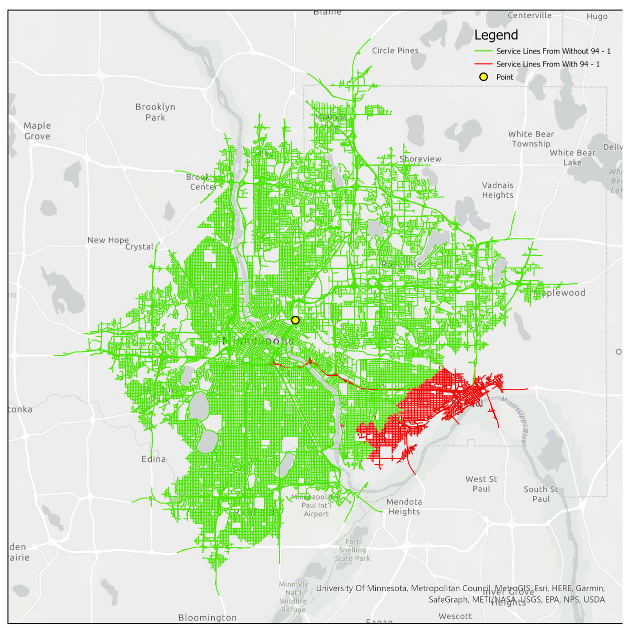

Figure 12 - Service Lines From Point 1

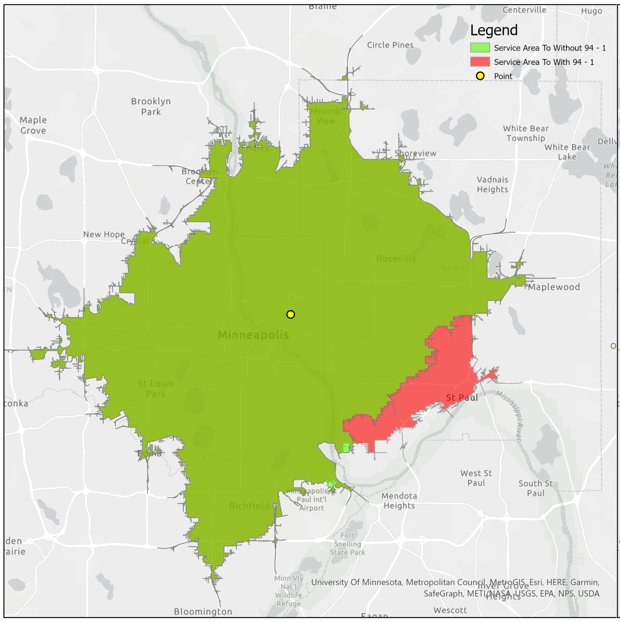

Figure 13 - Service Area To Point 1

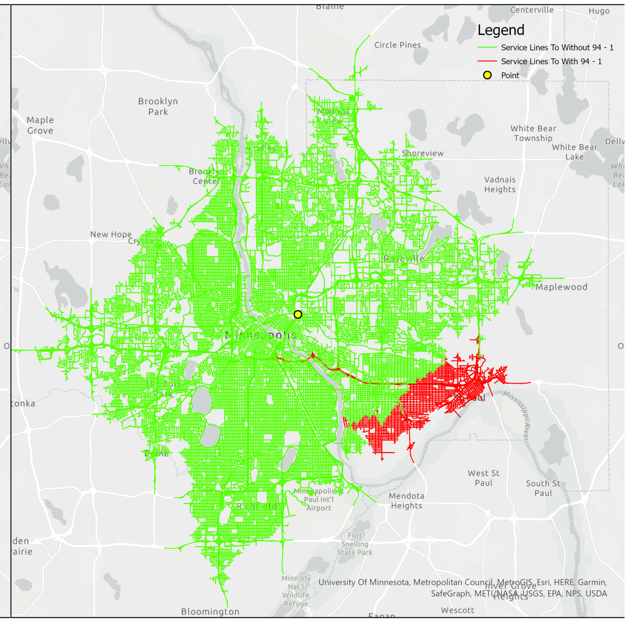

Figure 14 - Service Lines To Point 1

The next set of results tells a similar story, see Figures 15-18. These results are for a point near Indian Mounds Regional Park in Saint Paul. The service area and lines to the point are more extensive than the from results. Due to this point being east of the I-94 removal, the service area and lines remain the same for trips going north, south, and east. Within the 15-minute cutoff, without I-94 a person in a car would not be able to reach the University of Minnesota campus, but would still be able to reach the majority of Saint Paul and the Minneapolis-Saint Paul International Airport.

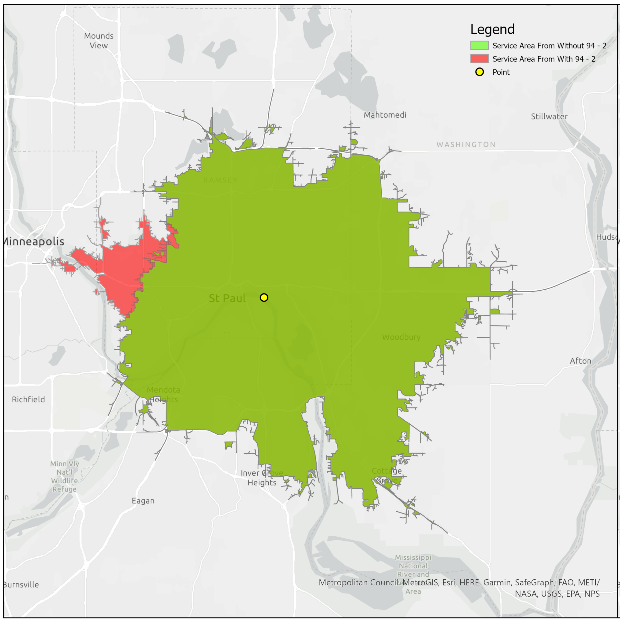

Figure 15 - Service Area From Point 2

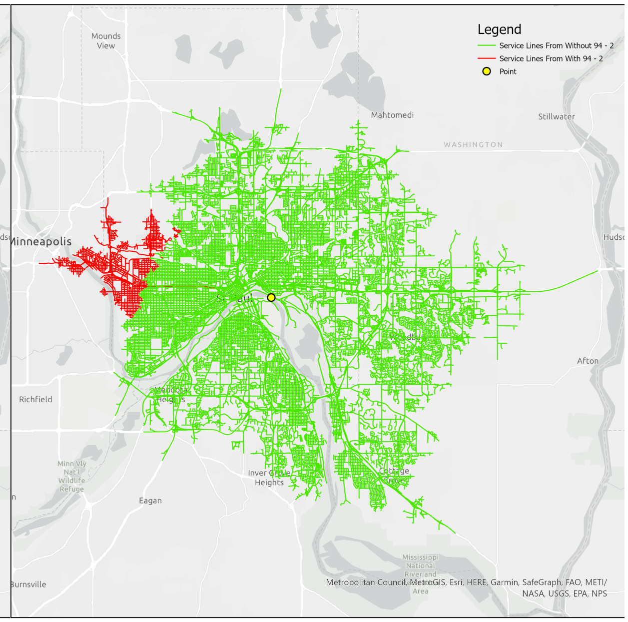

Figure 16 - Service Lines From Point 2

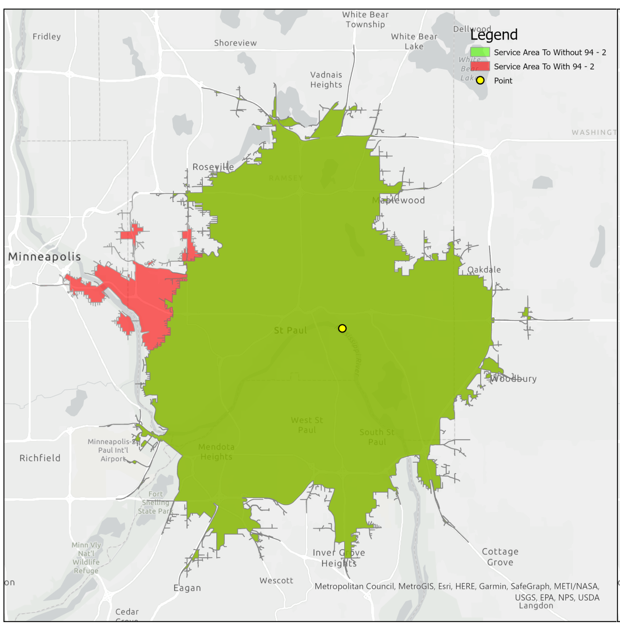

Figure 17 - Service Area To Point 2

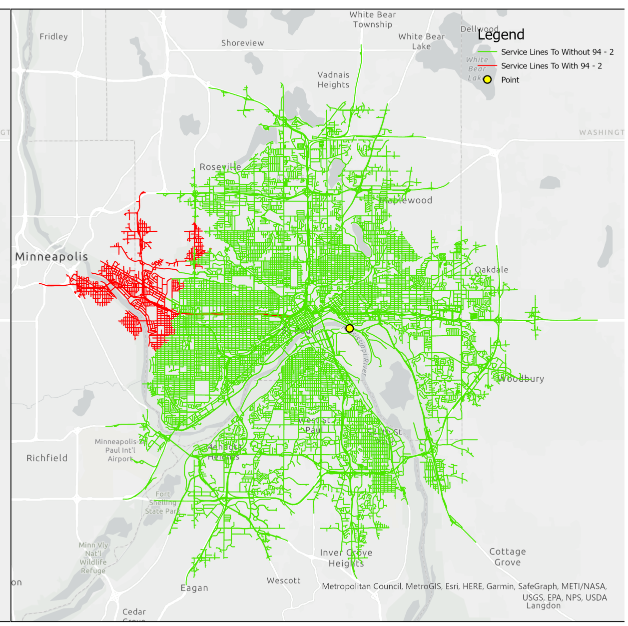

Figure 18 - Service Lines To Point 2

The third set of results is for a point in the east of Downtown Minneapolis, near US Bank Stadium, see Figures 19-22. These results share similar results to the first point in Figures 11-14. The to and from service areas and lines are similar. The distance a car could go within 15 minutes is not altered when going north, south, or west of the point. However, a larger portion of Saint Paul is unreachable within 15 minutes after the removal of I-94. This includes all of downtown Saint Paul, most of West Seventh, Summit Hill, and Frogtown.

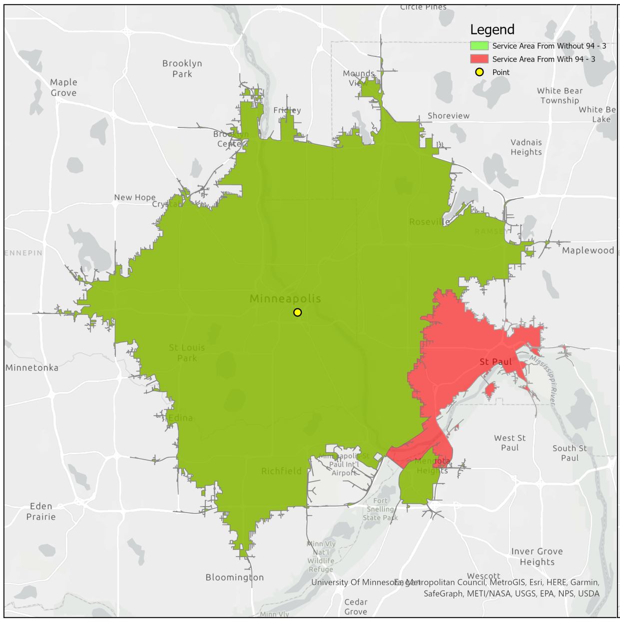

Figure 19 - Service Area From Point 3

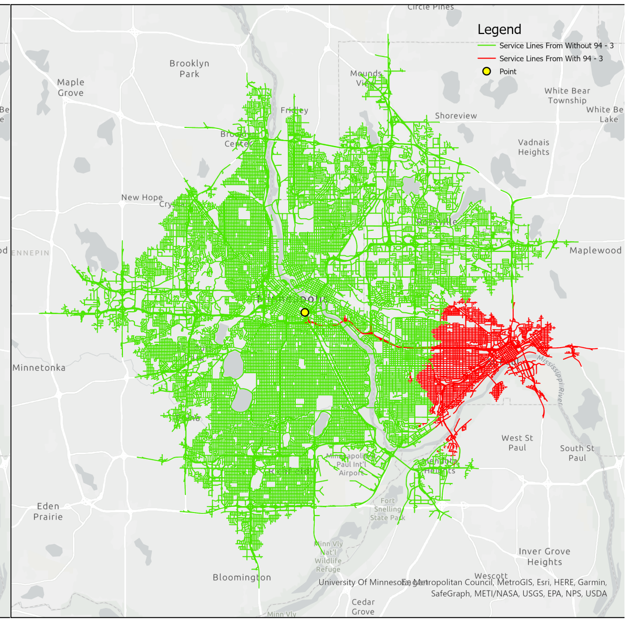

Figure 20 - Service Lines From Point 3

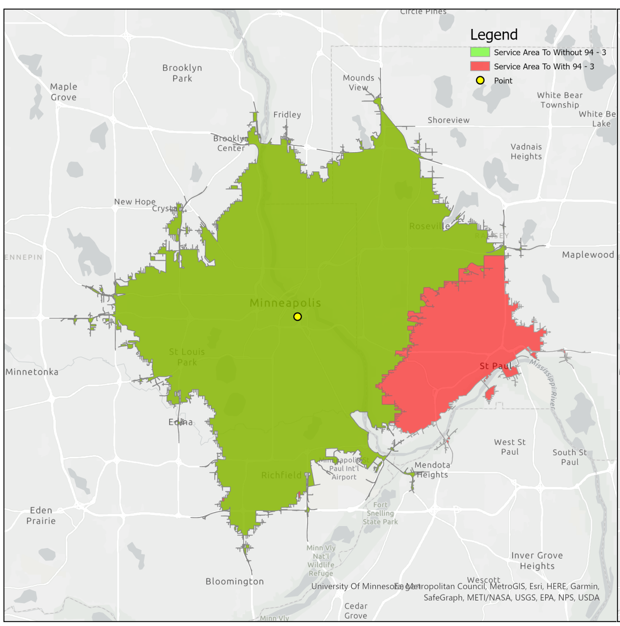

Figure 21 - Service Area To Point 3

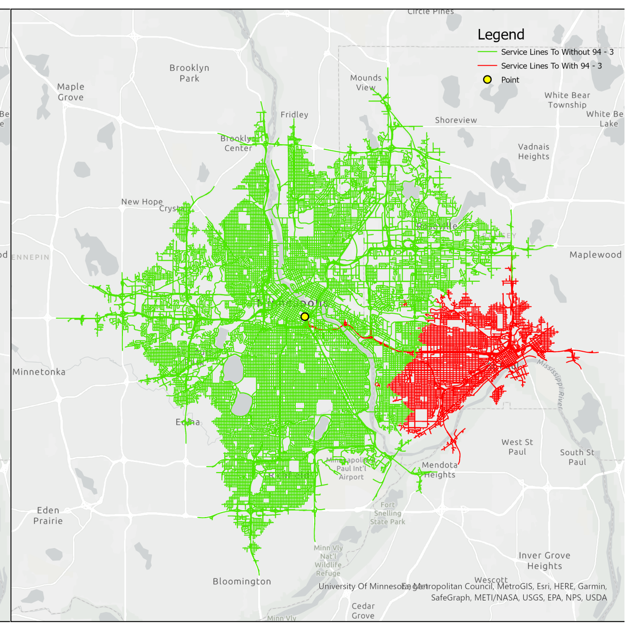

Figure 22 - Service Lines To Point 3

The fourth set of figures is similar to that of the second point in Figures 15-18. These figures show the service area and lines from a point near Harriet Island south of downtown Saint Paul. The to and from service areas and lines are very similar. The 15-minute cutoff area and lines are not affected to the north, east, and south, see Figures 23-26. Without I-94 a person in a car could not reach the University of Minnesota campus, anywhere near downtown Minneapolis, or anywhere along MN 280. They would still be able to reach the airport and parts of south Minneapolis.

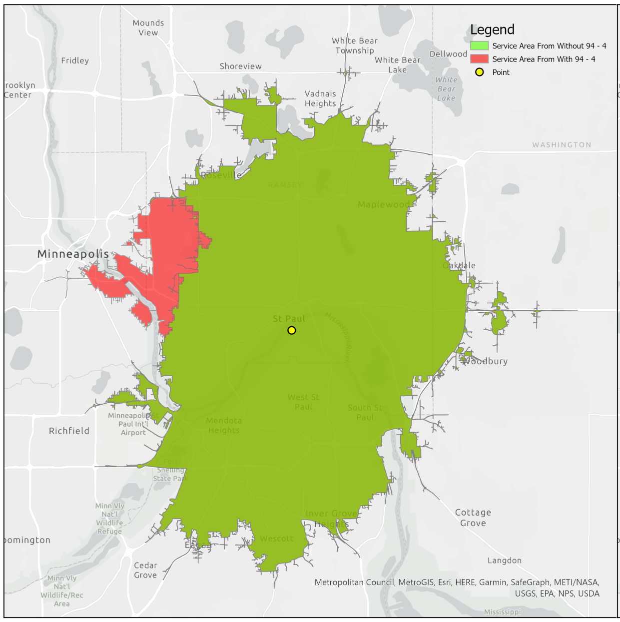

Figure 23 - Service Area From Point 4

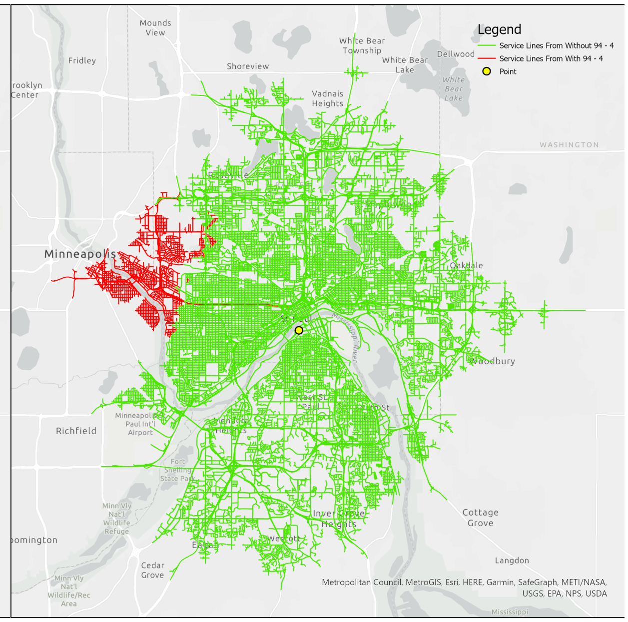

Figure 24 - Service Lines From Point 4

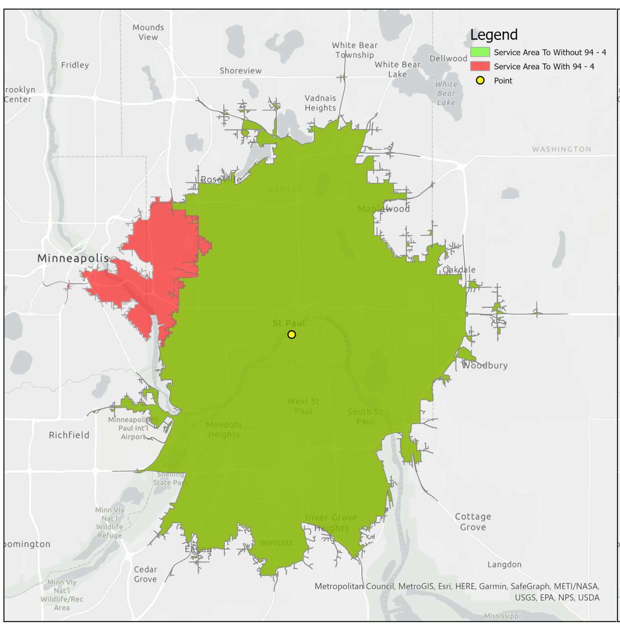

Figure 25 - Service Area To Point 4

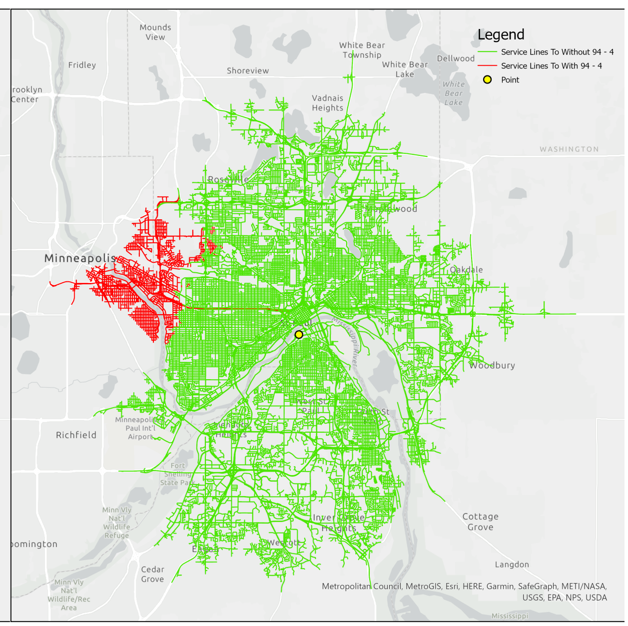

Figure 26 - Service Lines To Point 4

The fifth and final set of figures I will showcase in this report is for a point near the University of Saint Thomas in Saint Paul, see Figures 27-30. The results for this point have the largest difference in service area and length showcased so far. The 15-minute cutoff for a car traveling from the point is lessened without I-94 when traveling north, west, and east. The cutoff traveling to the point is lessened without I-94 when traveling east or west.

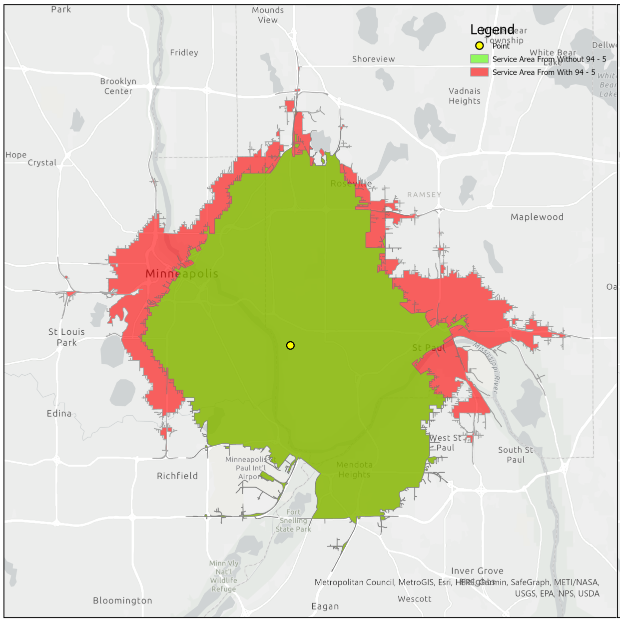

Figure 27 - Service Area From Point 5

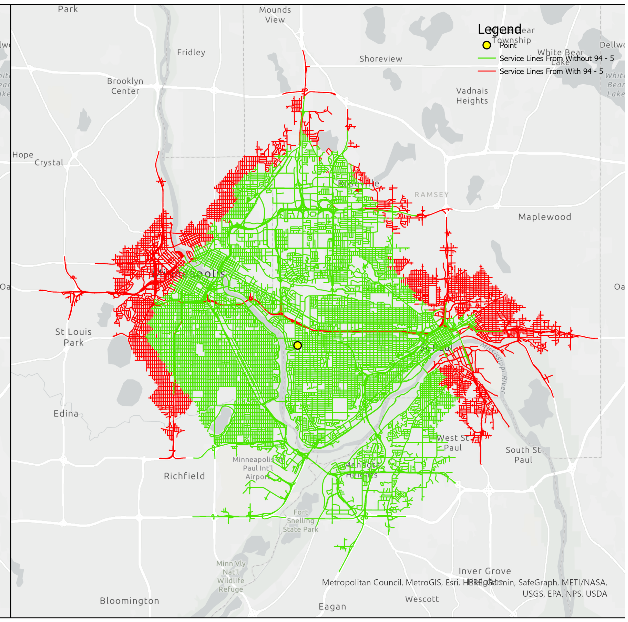

Figure 28 - Service Lines From Point 5

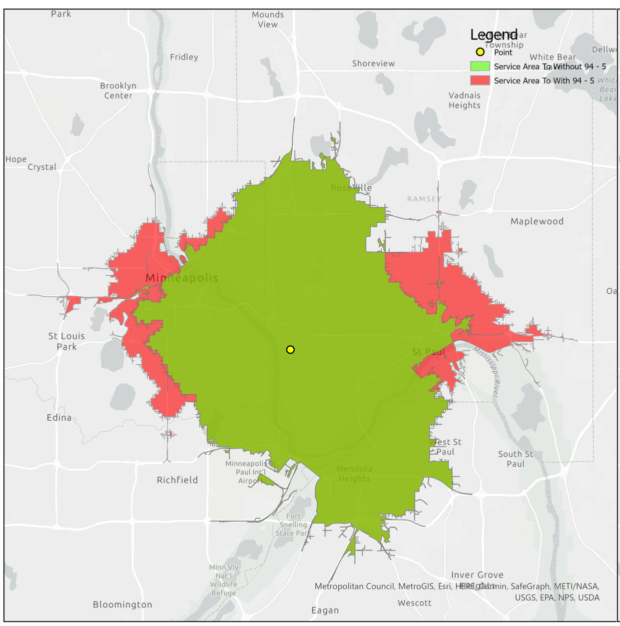

Figure 29 - Service Area To Point 5

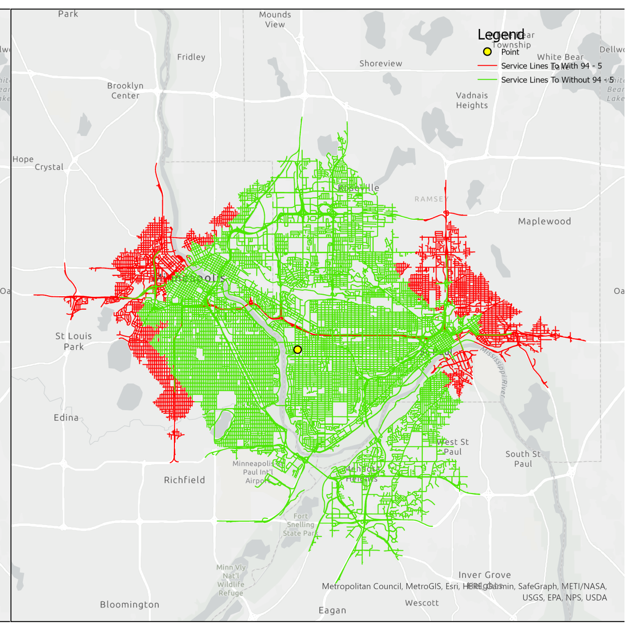

Figure 30 - Service Lines To Point 5

To visualize the change in all the points, I had to use a different technique, as the service areas and lines overlap when all 100 are displayed. Instead, I chose a method to visualize how the change in service area was dispersed spatially, see Figures 31-34. In these figures, we can see that the largest changes in service were for points close to the part of I-94 that is to be removed, especially those in Saint Paul. Overall, the points on either side of the I-94 removal are not as impacted as the points between the two downtowns. The further the points are from I-94, the less decrease in service is observed.

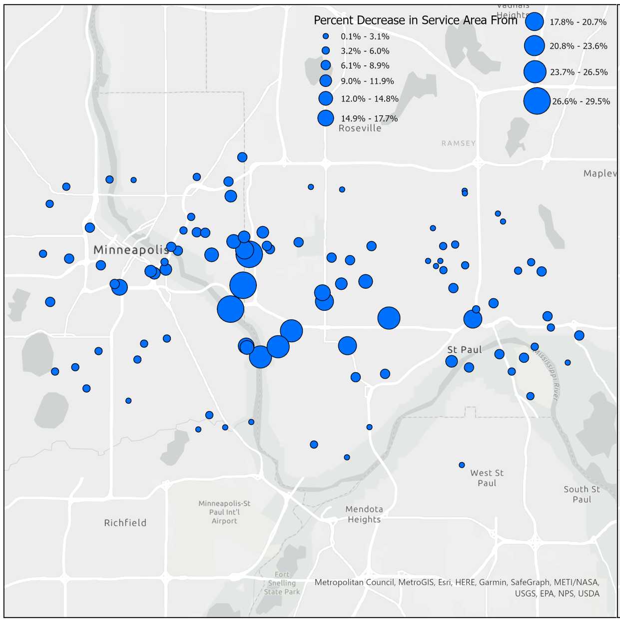

Figure 31 - Percent Change in Service Area From

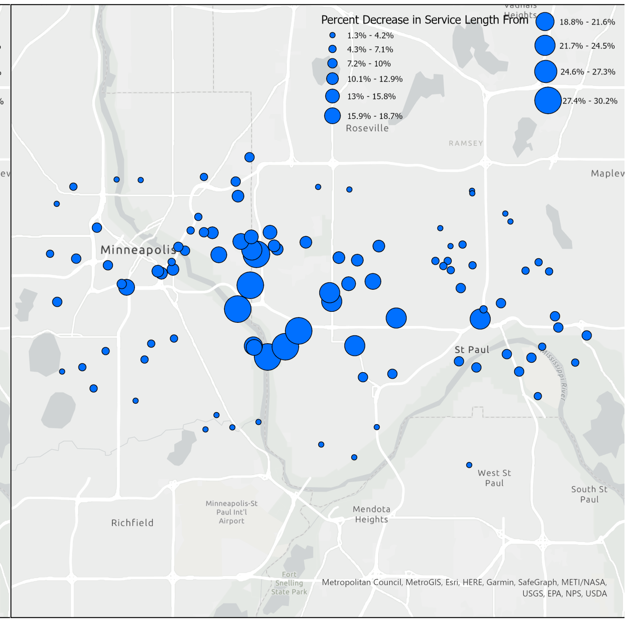

Figure 32 - Percent Change in Service Lines From

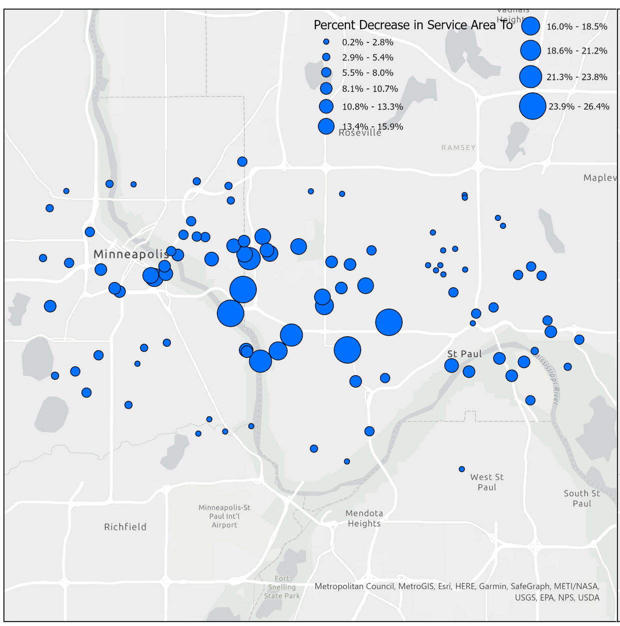

Figure 33 - Percent Change in Service Area To

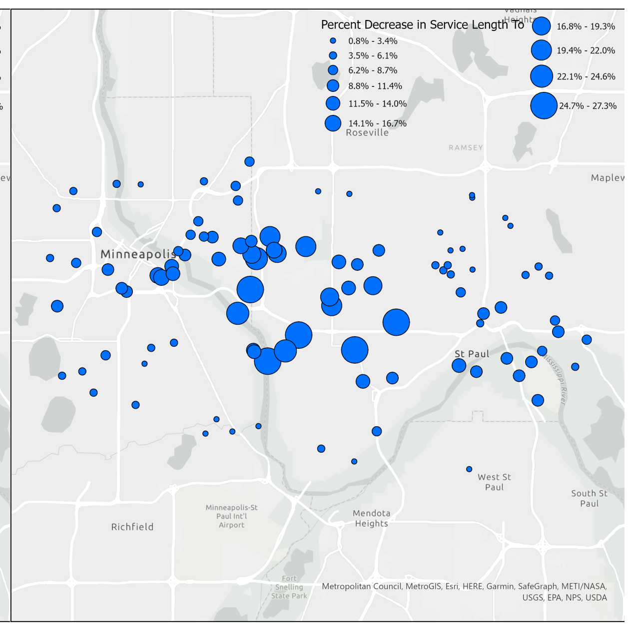

Figure 34 - Percent Change in Service Lines To

Beyond the visual comparison, the average change in service area and length was calculated. For results traveling from the 100 points, the average loss in the service area was 22.16 square miles. The average loss in service length was 376.87 miles. The average percent change was a 7.86% decrease in service area and a 9.73% loss in service length. For results traveling to the 100 points, the average loss in the service area was 22.15 square miles. The average loss in service length was 368.69 miles. The average percent change was a 7.81% decrease in service area and a 9.42% decrease in service length.

Results Verification

To verify the network I built was correct, I compared my own built network to ESRI's network in a 15-minute cutoff, see Figure 35. This comparison is for a point relatively near the middle of the I-94 removal. My network extends farther into local roads than the ESRI network, but the overall routing is sound. This difference in network length is due to the recent change in speed limits for both Minneapolis and Saint Paul, as well as a recent change in some freeway speed limits in the metro. The network dataset I used was directly from the Geospatial Advisory Committee and is kept up to date. However, on further inspection, the new 25 miles per hour speed limits for both cities had not been updated into the dataset. This is causing my built network to extend further into local streets than the ESRI network. The ESRI network also considers bridges that have been under construction recently, such as the Central Avenue Bridge to be restricted.

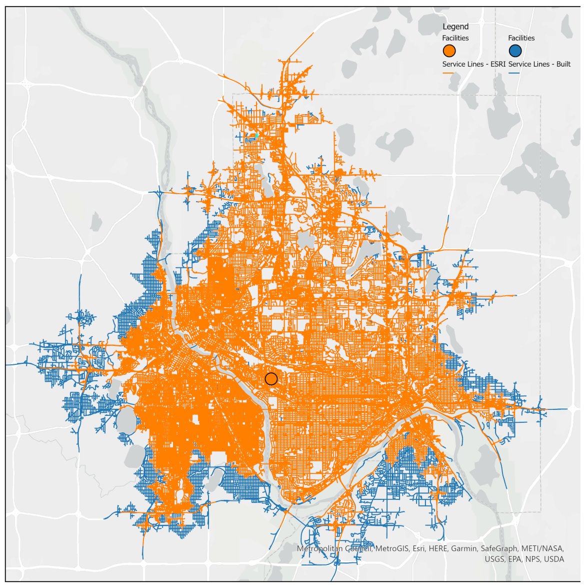

Figure 35 - Esri and Built Network Comparison

Beyond the network aspect of this analysis, the other important way to verify my results is to verify the mathematical reasoning used. I calculated the to and from distances from 100 points to maintain a significant dataset. With the solved service area layers, I computed the difference in total area and length by subtracting the area and length of the network without I-94 from the area and length of the network with I-94. This is a simple way to calculate the distance. I chose to do it this way as it would not be possible for the network without I-94 to be larger than the one with. Once the difference was calculated, I chose to find the percent difference by dividing the total difference by the area and length of the network with I-94. I chose to do it this way, as I wanted to see how the total service area or length would decrease without I-94.

Discussion and Conclusion

The impact of I-94 on the communities that surround it is impossible to ignore. I set out to do this project to show that the advantages of I-94 are strongly outweighed by the negative impacts on the community. This project produced results similar to what I expected when I set out to do this project. There will be a decrease in the service area and length for destinations or endpoints within 5 miles of the I-94 removal. I am surprised that the decrease is not higher. The highest decrease, 9.73% was for the length travelling from the points. This value not even reaching 10% is surprising to me, considering the heavy use I-94 receives today. I would predict this reduction would continue to be less considerable the longer the service area cutoff. For instance, a 30-minute service area would probably see a much smaller reduction.

This project came with a lot of learning. Having never built a network dataset before, it was a learning curve. There are many considerations to consider, such as road hierarchy, elevation, speed limits, and time spent waiting at intersections. I was lucky that the centerline data I received had fields for all of this built-in. The only parts I had to calculate were Miles, Minutes, and find the roads around I-94 that were restricted from private vehicles. Once the network and travel attributes were set, the rest of the process was relatively straightforward but time-consuming. I enjoyed creating the code for calculating the differences in service areas, it proved to produce interesting results.

In the future, I can see several ways to improve this project. I would want to test the average differences with different service area cutoffs, such as 20 or 30 minutes. I would also want to test how it changes with a larger buffer area. I know one interesting point would be to test the network with traffic and time of day. While this might be easier to model in an existing network, it would require a lot of predictions and estimations to see how traffic flow would change in a theoretical network. This would be fascinating but would require a lot of computational power. It will likely need to be done in the future if the decision to remove I-94 is made. Another aspect I would like to experiment with in the future is creating the Twin Cities Boulevard in place of I-94 and modeling how the service area would change. Instead of a complete gap in service area, there would still be a thoroughfare. It would have a reduced speed limit and more intersections but also allow for increased connections. I would also like to explore the potential health benefits of removing I-94 and perhaps doing an analysis of the cost-benefit of removing the freeway.

References

*Alternatives | Rethinking I-94 — Minneapolis to St. Paul | Let's Talk Transportation - MnDOT. (2023, July 18). ; Minnesota Department of Transportation. https://talk.dot.state.mn.us/*rethinking-i94/news_feed/alternatives

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Self-score

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	**28**
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	**24**
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	**28**
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	**20**
		100	**100**