Equitability and Viability of the Minneapolis Green Line Light Rail Extension

Yoni Potter - GIS Final Paper

Introduction

The METRO Green Line Extension (GLE) in Minneapolis is an ongoing light rail transit development project aimed at connecting the southwestern region of the Minneapolis metropolitan area to the city center and to the rest of the city's transit network (*About the Green Line*, n.d.). The plan involves the construction of 16 new stations along 14.5 new miles of track through Minneapolis and its suburbs St. Louis Park, Hopkins, Minnetonka, and Eden Prairie. While aiming to connect new areas and their populations to the existing transit network, the project also is intended to spur new development and investment in the communities through which it runs (*About the Green Line*, n.d.). Figure 1 shows the location of the light rail corridor and its stations. Of the stations themselves, 5 will be in Minneapolis, and 11 in the suburbs (*Route and Stations,* n.d.).

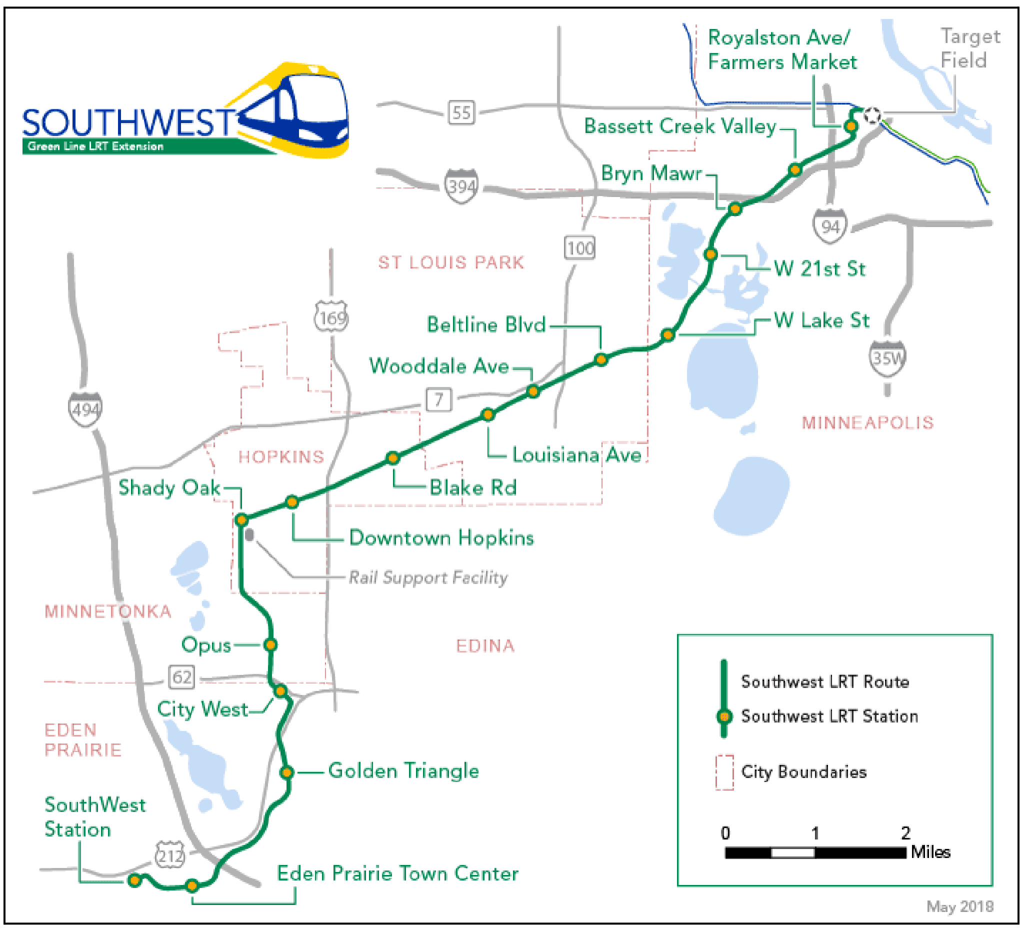


Figure 1: The route map of the GLE (Source: *Route and Stations*, n.d.).

The aim of this model will thus be to characterize both the existing areas—especially the demographics of nearby residents—and the potential for surrounding development—especially with respect to zoning codes—in order to determine if transit placement and the resulting development will be viable and equitable. The concept map below, shown in Figure 2, illustrates the various features that will be used to assess the viability and equitability of the GLE and its related development. Each choice of feature and variable will be justified in the literature review below.

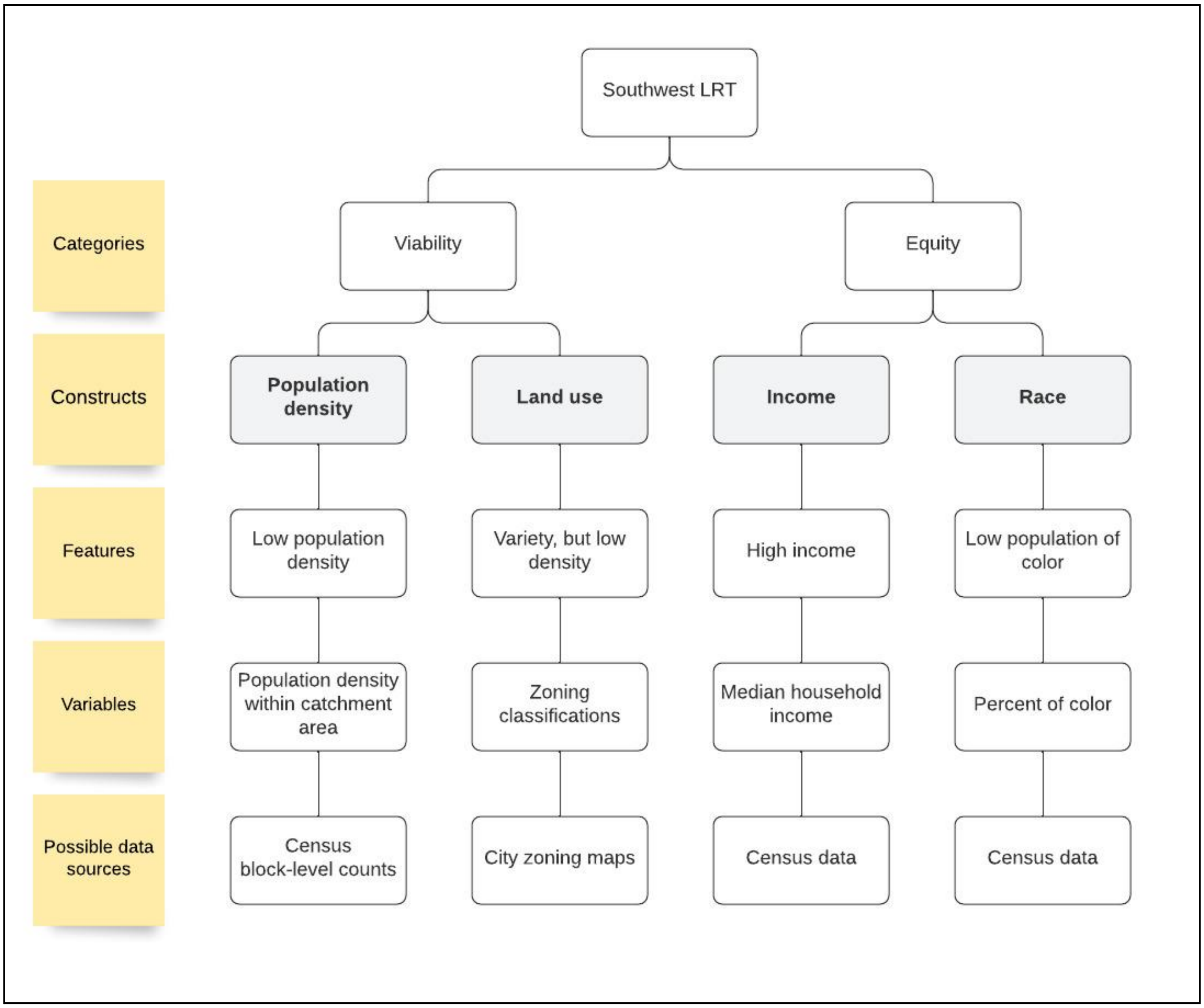


Figure 2: A concept map illustrating the four main features of focus relating to the project's viability and equitability, and how they may be measured. Created in Lucidchart.

My preliminary research has led to several problematic findings surrounding the placement of the line's new stations. First of all, within Minneapolis itself, the stations are placed in some of the areas with the lowest population density (*Population of Hennepin County* 2018), implying that each station will have a relatively small user base in its catchment area. Though population density around the suburban stations is slightly higher, none have densities over 6,000 people per square mile, and most are far below (for context, the city of Minneapolis has a population density of 7,494 people per square mile overall, and over 20,000 in its most densely populated neighborhood; *Population of Hennepin County* 2018). Meanwhile, though zoning designations vary greatly between station catchment areas, most are surrounded by areas only permitting low-density development, such as single-family homes and low-rise office and industrial parks (*Zoning Code*, n.d.; *Zoning Maps* 2021; *Hopkins, Minnesota* 2021). However, there are some notable exceptions, such as the W Lake St and Beltline Blvd stations, around which mixed-use and high-rise residential land uses are permitted (though do not necessarily exist yet). Finally, it appears that the placement of the route and stations may not be socially equitable; demographic and income data reveal that the route is planned through some of the highest income and most demographically white neighborhoods of Minneapolis, while the areas surrounding the suburban stations are also generally well-to-do and have low populations of color (*Household Income* 2018; *Race and Ethnicity* 2018). Overall, it appears that the GLE is mainly routed through areas with low population and land use densities, and will primarily benefit the area's wealthy and white residents.

Literature review

This model will focus on two main questions, whether the GLE is viable (if it has the population, jobs, and growth potential to support mass transit), and whether it is equitable (if it has a fair distribution of wealth and populations of color relative to the metropolitan area as a whole).

Viability

Guerra and Cervero (2012) emphasize the need to account for population density in areas surrounding transit stations in order to determine whether a new transportation investment will be cost effective.[1] Analyzing 54 light- and heavy-rail investments across the United States from 1970 to 2006, the authors find that a population density threshold must be met in order for light rail investments to be cost effective, depending on city size and the capital costs involved (on average, about 30 people per gross acre,[2] or 19,200 per gross square mile). Similarly, in Ryus et al.'s (2000) Transit Level of Service (TLOS) model, population and job density are important factors in determining the level of service in a given area (along with frequency of service and availability of pedestrian access to stations). Intuitively, if an area has more population and jobs, it is considered to have a greater level of service, as more people will benefit from the transit system. It is therefore important to measure the population density surrounding the new Green Line stations to determine whether or not their placement will be cost effective and beneficial to the area's residents. Job density would also be a useful indicator, but would require further research to find a suitable data source.

[1] An investment is determined to be cost effective if it can increase passenger mileage at a lower unit cost than other means (eg. increasing service on existing lines or decreasing passenger fares).
[2] Gross acreage measurements exclude undeveloped land, such as roads.

Furthermore, Banai (1998) finds that both population density and land use designations are important considerations for the placement of transit oriented development (TOD) (one of the goals of the GLE project). If density and mixed-use development are permitted to a greater extent by zoning codes, transit stations are more likely to be effectively utilized, as well as the surrounding TOD area. Like Banai, Schuetz et al. (2018) use zoning designations to determine their effect on TOD in Los Angeles, finding that both zoning and demand are key limiting factors to the extent of growth surrounding a station. Similarly, Taye (2016) emphasizes the importance of both population density and land use in the consideration of station placement for the construction of a new light-rail transit line in Addis Ababa. There is clearly precedent for measuring both population density and allowed land use (using zoning codes) in the viability of the GLE and its surrounding development.

Equitability

It is not only important to ensure that transit and its related development will be utilized, but also whether there will be a fair distribution of transit accessibility between socioeconomic groups. Foth et al. (2013) emphasize the importance of using indicators of social disadvantage, such as income, unemployment, immigration status, and rent-to-income ratio, that are relevant to the locational context in assessing whether transit is equitably distributed or not. According to their model, a transit system can only be vertically[3] equitable if access measures, such as accessibility of jobs through transit and transit time to important destinations, are greater for those with greater social disadvantage, who often have a harder time accessing transportation in general. Carleton and Porter (2018) similarly use various indicators of social disadvantage, such as youth or elderly population, nonwhite population, and poverty, but warn against aggregating such measures into indices, which can often obscure patterns of disadvantage within each individual category. It is thus important to consider various disaggregated social indicators within the catchment areas of the GLE, and to compare them to the metropolitan area as a whole, in order to determine whether the placement of the new line and stations is vertically equitable—distributed more to those who need it more.

Income is an important indicator, not only of social disadvantage in general (as indicated by both Foth et al. (2013) and Carleton and Porter (2018)), but also of acute need of public transportation, as it is often the case that fewer alternatives for mobility are available for people with lower incomes. This phenomenon is demonstrated by Klein and Smart (2019), who find that families living in poverty (income below a certain census-defined threshold) throughout the United States are less likely to own a car and are more likely to lose car access in response to major life events (such as changes in family, jobs, and health). Poverty status, based on income, is likely a better indicator of access to alternative means of transport than car ownership, as car ownership was not stable among families in the study, but rather varied according to the families' wealth. Furthermore, as Carleton and Porter (2018) point out, low car ownership could also be

[3] That is, distributing benefits according to need rather than on an equal basis to all.

due to lifestyle choices of wealthier individuals with greater discretion on their locations of travel living in areas with already greater transit access.

Finally, Karner and Niemeier (2013) emphasize the need to account for racial disparities when conducting transit equitability analyses. As the authors find, it is important to consider race disaggregated from other social indicators, as racial effects on transportation behavior and need are often distinct from those of other social indicators—such as the concentration of black workers in central city areas, farther away than white workers from rapidly suburbanizing jobs, due to the ongoing effects of residential segregation. Furthermore, it is important to consider the spatial distribution of people of color at a spatially disaggregated scale, as travel behavior is not necessarily defined by one's neighborhood, but by individual needs. For instance, a white commuter in a predominantly black neighborhood may have a very different commuting pattern than a black commuter in the same neighborhood. Thus, the model for the GLE will consider the percentage population of color nearby each station, disaggregated from other social indicators, and at the smallest scale at which data are available, census blocks.

Other considerations

Two major considerations about the study area itself must be made. First of all, it must be determined how far the catchment area around each station will extend. Catchment areas vary between the studies mentioned above from a quarter mile radius (Ryus et al. 2000; Schuetz et al. 2018; Carleton and Porter 2018), to 400-500 meters (Taye 2016), to 2000 feet (Banai 1998), and to a half mile (Guerra and Cervero 2012). As a compromise, it might be reasonable to use a 500 meter radius. Finally, as Ryus et al. (2000) note, it is important to consider the impact of pedestrian network connectivity on transportation accessibility; after all, it is not the Euclidean distance to a station that matters, but the distance that must be covered on the walk there. Both Banai (1998) and Taye (2016) include considerations for street connectivity and proximity in their analyses; however, this does not change the extent of their catchment areas. To account for differences in pedestrian network connectivity, I would propose to use network distance isolines to indicate the extent of the catchment area. That way, features that are nearby a given station but not connected by a convenient pedestrian route will be excluded from the model.

Methods

This model will thus characterize all 16 GLE stations by four variables: population density, allowed density (zoning), percent living in poverty, and percent people of color. Values will be assigned by interpolating these spatial variables into 500-meter network distance isoline catchment areas from their respective datasets. These values will then be compared to their overall levels in a 20-km radius from the GLE's origin (roughly the distance to the terminal).

Variable data

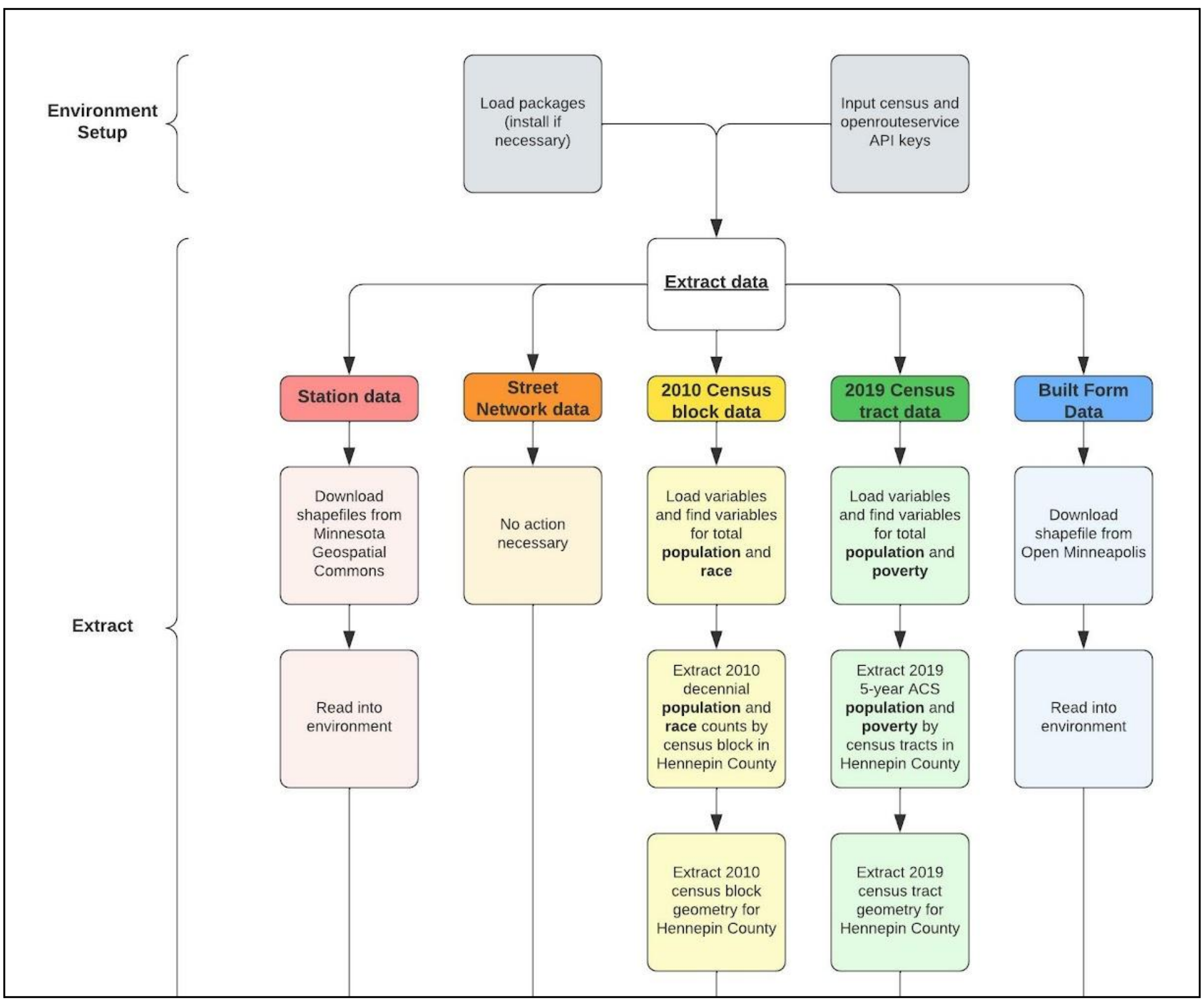
- For population density, 2010 U.S. Census counts were used (U.S. Census Bureau 2010), later divided by the area of the catchment areas in order to calculate density.

- For allowed density, a map of the Minneapolis zoning code was used (Minneapolis GIS 2019). The variable of interest was "Built_Form", which roughly indicates the maximum number of stories a building is allowed to be, and is used as a proxy for allowed density. Note these data only cover 5 of the stations, as suburban zoning data were not digitized.
- For poverty, 2019 U.S. Census American Community Survey (ACS) estimates were used (U.S. Census Bureau 2019). The number of people living in poverty was divided by the total population in each tract in order to estimate the proportion in poverty.
- For race, 2010 U.S. Census counts were used. (U.S. Census Bureau 2010). The number of white residents was divided by the number of total population in each block and then subtracted from 1 in order to estimate the proportional population of color.

Spatial data

- Station locations were extracted from Metropolitan Council (2022) Geospatial Commons
- Street network data were accessed through the OpenRouteService R package

ETL workflow



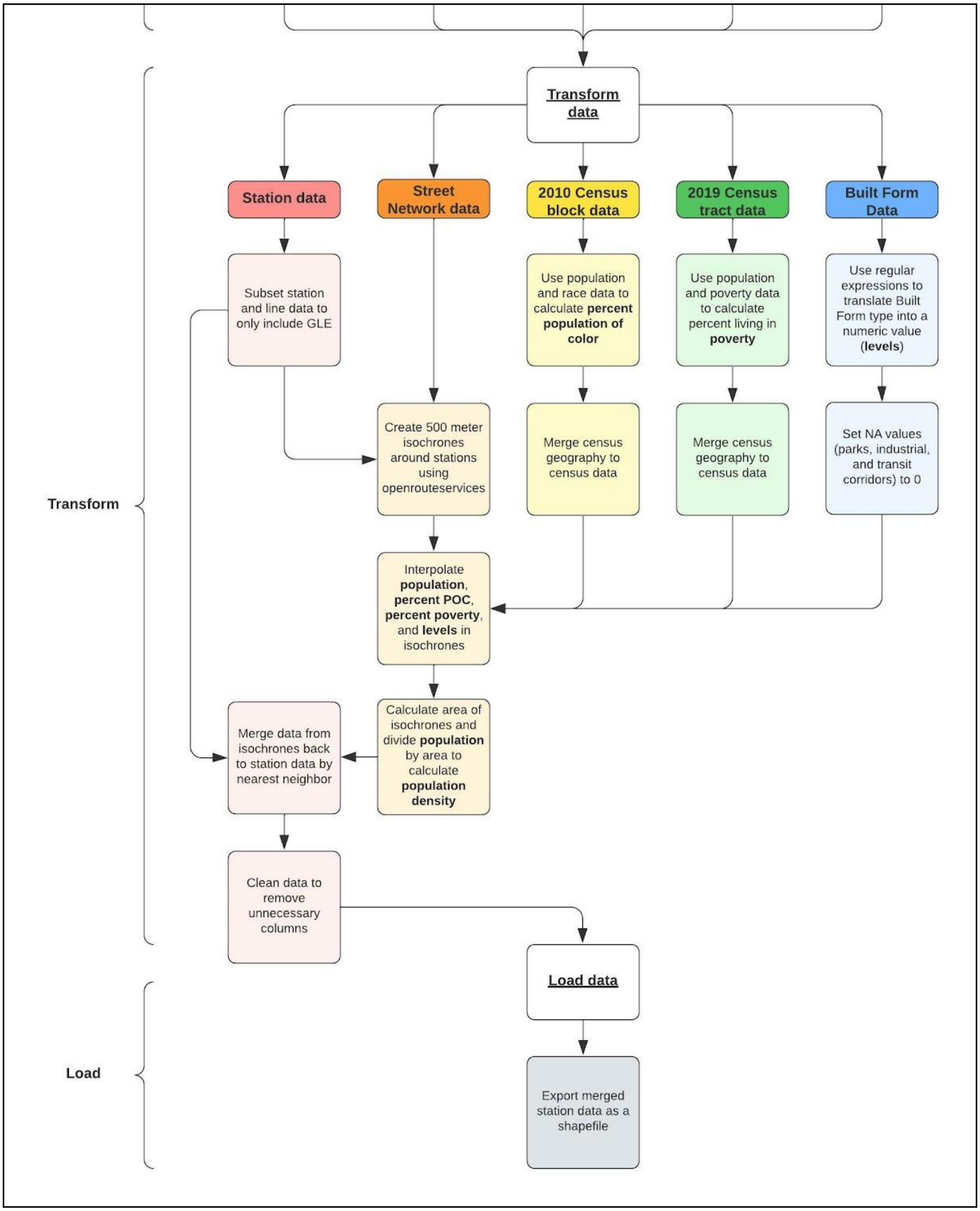


Figure 3: An ETL workflow for wrangling the necessary variable and spatial data. Created in Lucidchart.

Explanation

In the above workflow, all four variables are extracted from their respective datasets; population and race from 2010 decennial census block data, poverty from 2019 ACS census tract data, and allowed density (labeled as "Built Form", the city's classification system) from the Open Minneapolis data portal. While numerical values for census variables were simple to compute (eg. percent people of color was calculated as 1 - (white population / total population), allowed density had to be calculated by extracting the number at the end of each "Built Form" classification with regular expressions (eg. "Corridor 3" became "3"). These values were then interpolated from their respective geometries into 500-meter network distance isoline catchment areas surrounding each station, using a spatially extensive interpolation (area weighted sum) for population only. Population was also divided by the area of the catchment area in order to calculate population density. The catchment area data were finally merged back to their respective stations.

Several limitations to the spatial calculations used should be noted. First, network distance isolines are only as reliable as the data from which they originate. The data source used by OpenRouteService to construct these catchment areas, OpenStreetMap, is an open source worldwide geographic dataset contributed to by volunteers, and thus it can vary in data quality and accuracy. Furthermore, network distance isolines often include areas that are inaccessible, but are between accessible network links, adding further uncertainty to the locations of catchment areas. However, this method of estimating catchment areas is likely better than simply using buffers, which include all areas within a given radius even if they are inaccessible (eg. on the opposite side of a highway). Second, interpolation assumes that values are evenly distributed across the areal units used, when they may not be. For example, a census block may have a high population, but entirely concentrated on one side, in which case a catchment area that overlaps with the other side will still include that census block's population. However, the small size of the areal units for population (blocks), race (blocks), and zoning (lots) should minimize the resulting uncertainty. Unfortunately, poverty data were only available at the tract level, so results should be interpreted with caution.

Entity relationship diagram

The diagram on the following page summarizes the relationship between all entities and variables used.

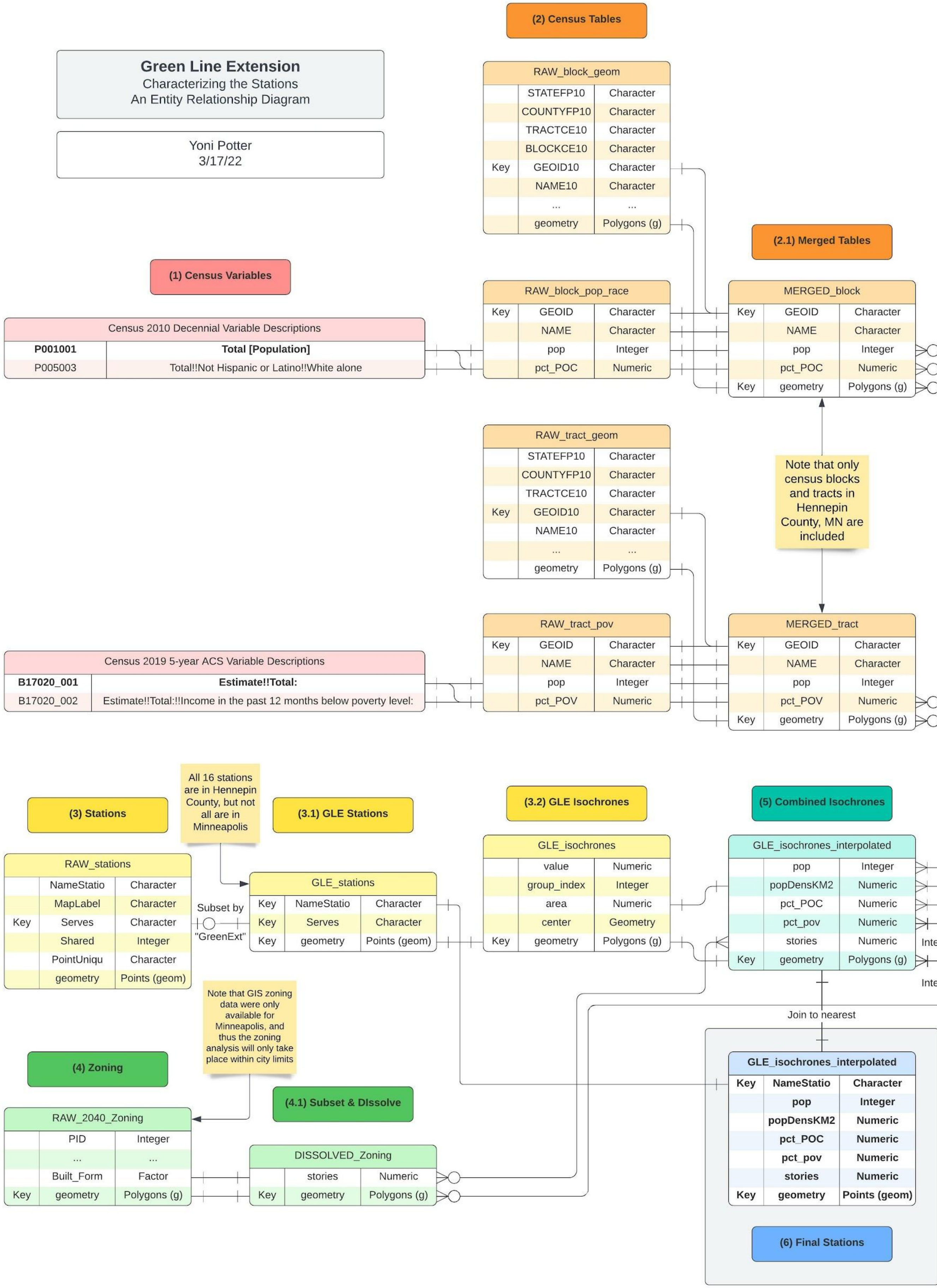


Figure 4: An entity relationship diagram for all entities and variables. Created in Lucidchart.

Study area comparison

In order to facilitate comparison between the GLE and the entire surrounding area, census blocks and census tracts were subset to only include those within a 20-kilometer radius from the GLE's origin in Downtown Minneapolis (20-km is slightly longer than the distance from the origin to the terminal). For zoning data, which were limited to Minneapolis, no subset operation was used. This was done in order to exclude more distant areas of Hennepin County, which are partially rural, and thus are not reasonable alternative locations for light rail transit to run. The purpose of this comparison is to evaluate whether the demographics and density of the population surrounding the GLE is representative of the population in the area overall.

Furthermore, block and zoning data were rasterized in order to be more effectively viewed. Zoning data were aggregated to a 200-foot raster, and census block data were aggregated to a 500-foot raster (lower resolution was used to account for the larger area covered).

Results

Study area summary statistics

Variable	Meaning	N	Min	Max	Mean	W. mean*	Std. Dev.
popDensKM2†	Population density per km^2	12132	1.52	48952.82	2693.18	1608.67	2657.28
LVLS	Allowed density	102566	0	50	2.59	NA	3.90
pct_POV	Pct. in poverty	280	0.00343	0.705	0.120	0.111	0.118
pct_POC	Pct. people of color	12132	0.00	1.00	0.257	0.314	0.251

Table 1: Summary statistics of each variable across the entire study area. Census blocks with 0 population were omitted.

*"pct_POV" and "pct_POC" are weighted by population, while "popDensKM2" is weighted by area. "LVLS" could not be weighted, as the dataset did not include information on population.

†Note that the high variation in population density is likely due to the very small area size (census blocks).

Catchment area summary statistics

Variable	Meaning	N	Min	Max	Mean	W. mean*	Std. Dev.
popDensKM2	Population density per km^2	16	0.0	3900.8	1282.9	1371.0	1134.2
LVLS	Allowed density	5	1.15	26.77	10.67	14.96	10.54
pct_POV	Pct. in poverty	16	0.0235	0.153	0.0776	0.0829	0.0428
pct_POC	Pct. people of color	15	0.0728	0.750	0.339	0.344	0.208

pop	Total population of catchment area	16	0.00	1090.20	398.04	474.42	393.81

Table 2: Summary statistics of each variable within catchment areas.

*"LVLS", "pct_POV", and "pct_POC" are weighted by population, while "popDensKM2" and "pop" are weighted by area.

Overall, population density and poverty are much lower in the catchment areas of GLE stations than in the study area overall, though the weighted average population of color is actually slightly higher than the overall area and the allowed density much higher.

Maps

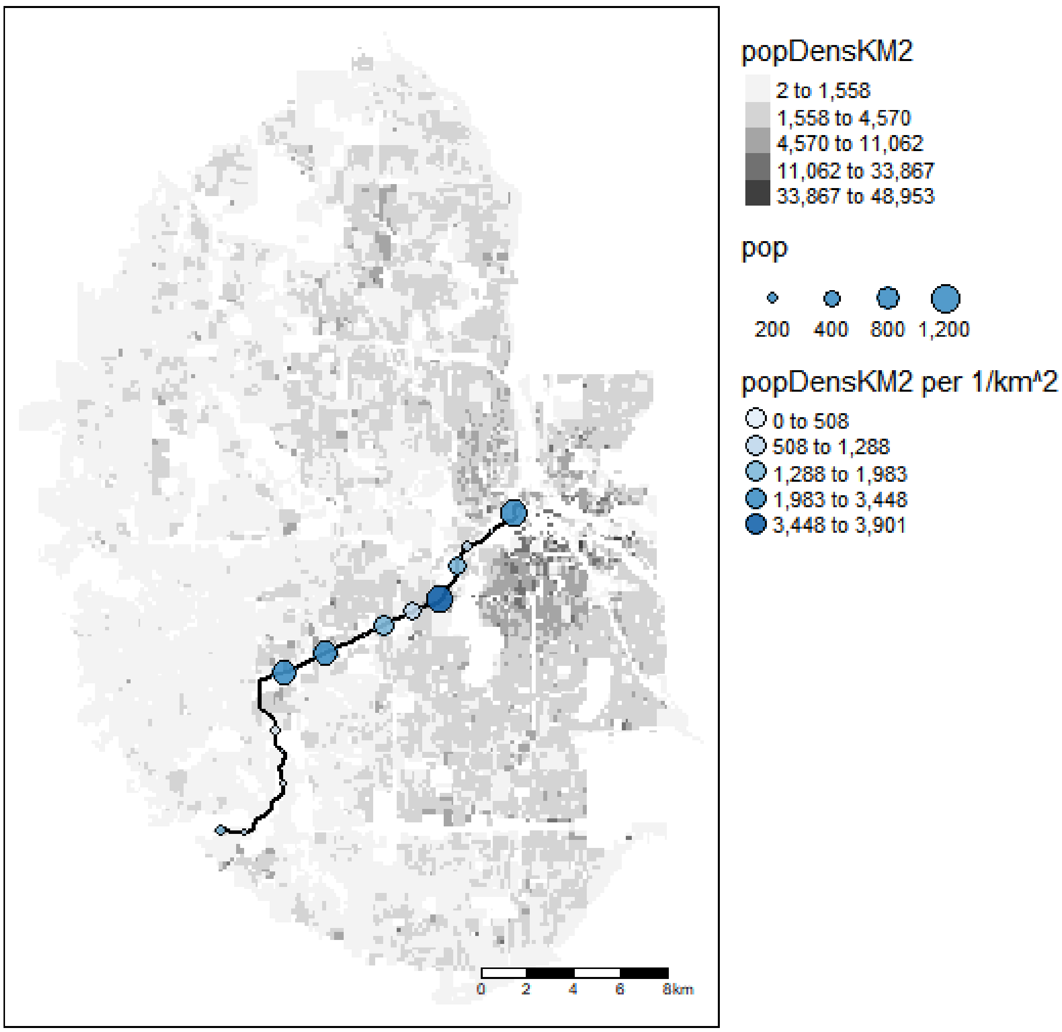


Figure 5: Population density in study area and along the GLE. Bubble size indicates population, NOT catchment area.

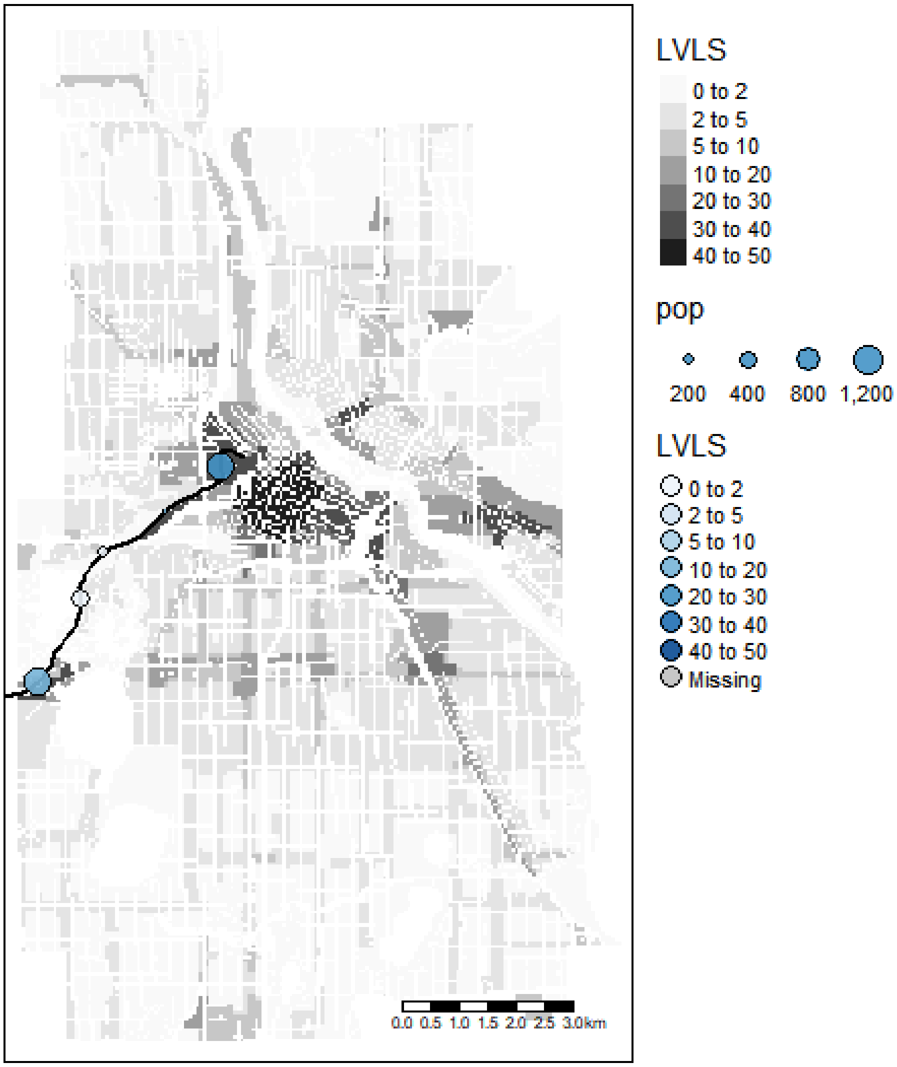


Figure 6: Allowed density (proxied by maximum stories) in Minneapolis and along the GLE. Bubble size indicates population, NOT catchment area.

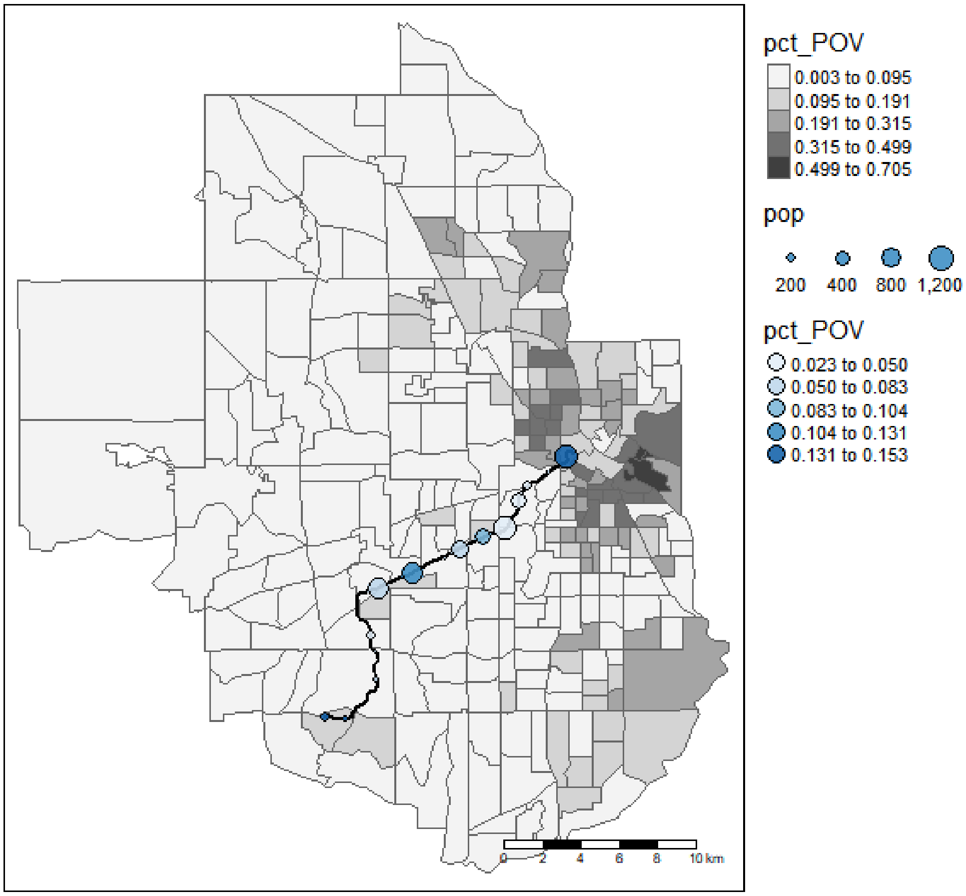


Figure 7: Poverty in the study area and along the GLE. Bubble size indicates population, NOT catchment area.

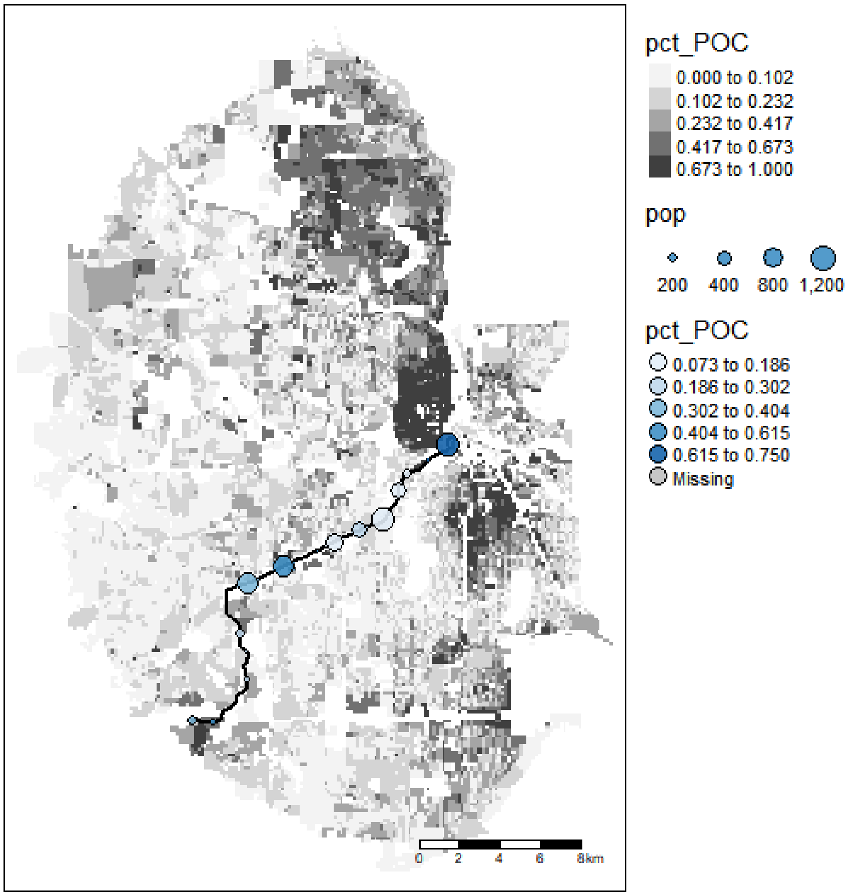


Figure 8: Percent people of color in the study area and along the GLE. Bubble size indicates population, NOT catchment area.

In the maps above, it is apparent that the GLE does not run through the areas where there is the highest population density, zoned density, poverty, or population of color; however, compared to other suburban locations, the areas surrounding the stations do have slightly higher values. Nevertheless, it is unclear whether there is even enough of a population to support each of the stations, on average 398, and 474 when weighted by the size of the catchment area.

The final table, presented below, shows the values of each variable at each station, going in order from northeast to southwest.

Name	pop	area	popDensKM2	pct_POC	pct_POV	LVLS
Royalston Ave/Farmers Market	1090.203	0.363861	2996.21	0.726019	0.145797	26.77234
Bassett Creek Valley	0.215167	0.303058	0.709985	0.75	0.066059	12.42217
Bryn Mawr	210.4631	0.329371	638.9846	0.157514	0.0425	1.150128

West 21st St	483.7693	0.335081	1443.74	0.072751	0.031228	1.162275
West Lake St	1047.6	0.268561	3900.784	0.131985	0.043003	11.81802
Beltline Blvd	519.9921	0.459002	1132.876	0.231518	0.091691	NA
Wooddale Ave	607.0948	0.344137	1764.106	0.142987	0.061402	NA
Louisiana Ave	54.48877	0.270348	201.5501	0.504128	0.072111	NA
Blake Road	901.9197	0.409466	2202.675	0.500586	0.115555	NA
Downtown Hopkins	872.4676	0.384071	2271.63	0.380612	0.056603	NA
Shady Oak	0	0.171824	0	NA	0.040175	NA
Opus	159.4337	0.423965	376.0535	0.236311	0.023478	NA
City West	50.2342	0.078275	641.768	0.214533	0.072532	NA
Golden Triangle	87.77724	0.293773	298.7928	0.284091	0.073646	NA
Eden Prairie Town Center	93.40955	0.100855	926.1803	0.426644	0.153096	NA
SouthWest Station	189.6209	0.109538	1731.101	0.320259	0.153096	NA

Table 3: Values at each station. Note that LVLS (allowed stories) only applies for the first 5 stations, which are in Minneapolis. Stations are sorted from northeast to southwest.

Discussion

Population density and total population

The first, rather concerning finding, is that the population density surrounding the GLE, on average 1282.9 people per km^2 (1371.0 if area-weighted), is even lower than the average population density for Minneapolis and its suburbs, 2693.18 per km^2 (1608.67 if area-weighted) (see Tables 1 and 2). Furthermore, most stations have very small populations overall in their catchment areas, on average 398.04 (474.42 if area-weighted), though this figure is far more strongly influenced by the size chosen for the catchment area itself, and does not necessarily reflect all people who will in fact use the transit station (as there is no hard distance cutoff in reality). Taking Guerra and Cervero's (2012) estimate that around 30 people per gross acre necessary to support light rail transit, and generously assuming gross acreage to only include half of total acreage, it is calculated that population densities below 3,707 people per square kilometer are insufficient to support light rail transit, almost three times the average population density around each station. The only station to exceed this figure is West Lake Street, and only by a narrow margin (see Table 3). However, it is unclear whether there are any locations in the study area that are conducive to effective light rail operation. Figure 9 below is the same as Figure 5, except that it only differentiates between areas with sufficient and insufficient population density (3,707 per km^2). As can be seen, no light rail line running more than a few stations away from the origin of the GLE would be cost effective according to Guerra and Cervero's (2012) findings, at least not without massive investments in transit-oriented development. However, this begs the question of whether such development is even possible according to current zoning codes.

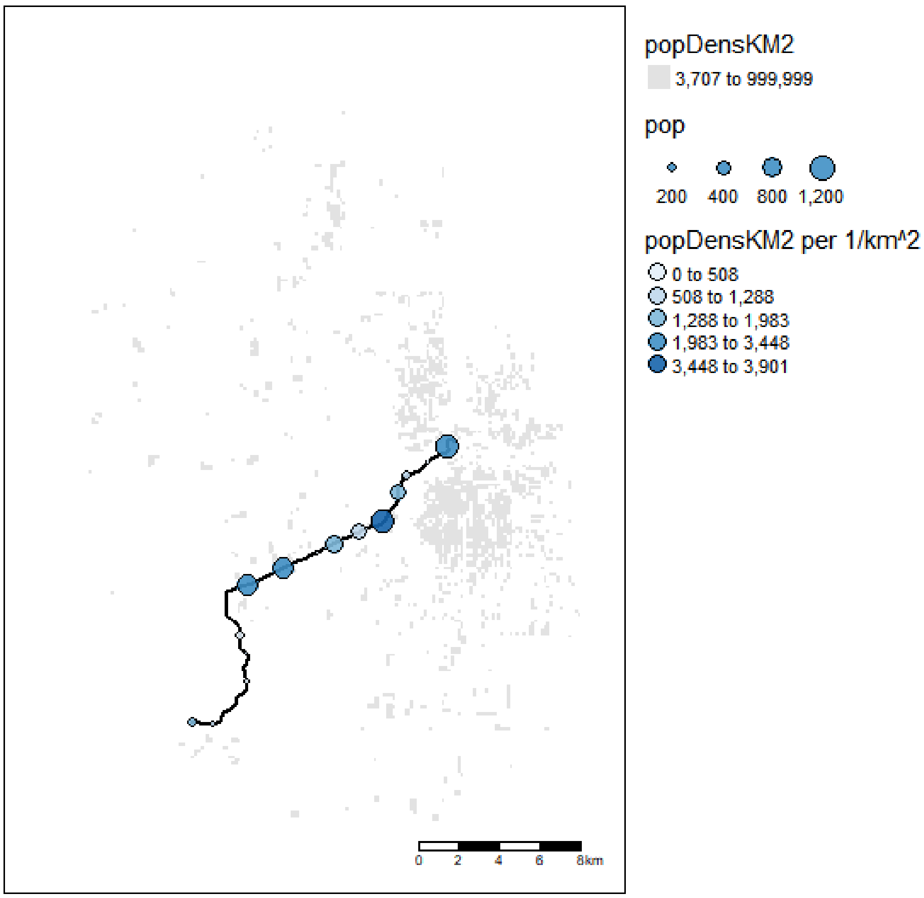


Figure 9: The GLE and all locations with sufficient population density to support light rail transit according to Guerra and Cervero's (2012) findings. It is quite notable that of all locations near downtown the route could have taken, it follows along one of the least dense corridors possible (along an isthmus between two lakes with small, scattered single-family homes).

Zoning and allowed density

Using maximum stories as a proxy for zoning density in Minneapolis (as it is both the main designation used to distinguish density in the city's most recent zoning code as is readily quantifiable), it appears that there is in fact far more room for development available, at least among stations within Minneapolis. As Tables 1 and 2 show, allowed density is 10.67 stories on average among Minneapolis stations, and 14.96 if population weighted (in order to reduce the influence of Bassett Creek Valley, with a surrounding population of almost 0), far greater than the city-wide average of 2.59. However, this average only applies to 5 out of the 16 stations, as the other 11 are outside of Minneapolis where digitized zoning data were not available. This average is also highly influenced by just two stations, Royalston Ave/Farmers Market and West Lake St, both of which are zoned for very dense development, while almost no development other than single-family homes is permitted around Bryn Mawr and West 21st St (see Table 3). It is possible that dense development could emerge around Bassett Creek Valley (with an average allowed density of 12.4 stories), but given that the surrounding area-weighted population sum is lower than 1, it is unlikely that anyone will benefit from the station in the short term.[4]

Poverty

Comparing Tables 1 and 2 again, it appears that poverty levels surrounding GLE stations (7.76%, and 8.29% if population-weighted) are low compared to the area as a whole (12.0%, and 11.1% if population-weighted). As is seen in Figure 7, much of the poverty in the area is clustered to the northwest, northeast, and southeast of the GLE origin in downtown, yet the GLE runs to the southwest where poverty is relatively low. Though the stations in the suburbs do tend to have slightly higher poverty than other suburban areas, they have much lower poverty levels than the city itself overall. However, it is unclear whether light rail transit would be able to only serve less affluent areas given their linear nature and the clustered nature of poverty in the area surrounding the city center.

People of color

Finally, a comparison of Tables 1 and 2 indicates that populations of color are actually slightly higher immediately surrounding GLE stations (33.9%, and 34.4% if population-weighted) than in the study area overall (25.7%, and 31.4% if population-weighted). At first glance, this seems contradictory to Figure 8, which shows high populations of color to the northeast and southeast of the GLE origin, and lower populations of color along the line itself. However, it seems that small-scale variation immediately along the light rail corridor itself, not visible in my preliminary analysis, contributes to a much larger population of color surrounding GLE stations than would be initially observed from the map. Furthermore, as Karner and Niemeier (2013) indicate, highly aggregated data on race (such as at the neighborhood level) may be less helpful in indicating access equitability anyway—in other words, it is less important that the GLE runs through a neighborhood with high populations of color than it is for people of color to be able to access the GLE to an extent representative of their population.

Conclusion

Overall, the areas immediately surrounding the GLE stations have a far lower population density than Minneapolis and its nearby suburbs, highly variable zoning designations (though evidence is lacking in suburban areas), lower poverty, and slightly higher populations of color.

[4] The area is almost entirely devoid of business as well. It is only near a highway, a small park, and an impound lot, as seen in Google Maps.

Thus, the GLE is not quite as inefficient as had been originally thought, especially considering the potential for further transit-oriented development around three of the stations in Minneapolis, though reliance on future development may be of greater risk and of lower benefit for current residents. Furthermore, though the GLE appears to be inequitable in terms of poverty, it does serve people of color at a rate representative of their population overall. Nevertheless, it is unclear whether the GLE will ultimately be economically viable given the currently low population density, and its placement does appear to be inequitable for people living in poverty, who often have greater difficulty in accessing private transportation (Klein and Smart 2019).

Several limitations to the research methods used in this paper bear mention. First, while economic viability was a consideration, capital and social costs were not. The GLE almost entirely runs along a freight rail corridor, where the right of way is already cheap and available. Alternate routes that run along streets (and thus closer to where people actually live) would likely be more expensive and disruptive to existing communities. In such a case rights of way could replace existing development, which could have a negative social impact. Thus, in order to compare the viability and equitability of the GLE to other possible locations, it is necessary to take the locations of existing developments and rights of way into account. Further research could also compare the GLE to the Blue Line Extension, a similarly planned light rail extension project focused on the city's northwest side. Finally, additional data on the locations of jobs and attractions would be a useful supplement to the station database, as well as data on other connected transit lines; after all, people do not only travel to and from homes, but to businesses, offices, parks, and tourist attractions too, while the GLE itself does not operate in an isolated transit environment.

Acknowledgements

OpenrouteService data © openrouteservice.org by HeiGIT and available from https://openrouteservice.org/

OpenStreetMap map data © OpenStreetMap contributors (available under the Open Database License: https://opendatacommons.org/licenses/odbl/) and available from https://www.openstreetmap.org

References

About the Green Line Extension. (n.d.). Metropolitan Council. Retrieved January 30, 2022, from https://metrocouncil.org/Transportation/Projects/Light-Rail-Projects/METRO-Green-Line-Extension/About.aspx

Banai, R. (1998). Transit-oriented development suitability analysis by the analytic hierarchy process and a geographic information system: a prototype procedure. *Journal of Public Transportation, 2*(1), 43-65. https://doi.org/10.5038/2375-0901.2.1.3

Carleton, P. R., & Porter, J. D. (2018). A comparative analysis of the challenges in measuring transit equity: definitions, interpretations, and limitations. *Journal of Transport Geography 72*, 64-75. https://doi.org/10.1016/j.jtrangeo.2018.08.012.

Foth, N., Manaugh, K., & El-Geneidy, A. M. (2013). Towards equitable transit: examining transit accessibility and social need in Toronto, Canada, 1996–2006. *Journal of Transport Geography, 29*, 1-10. https://doi.org/10.1016/j.jtrangeo.2012.12.008.

Guerra, E., & Cervero, R. (2012). Transit and the "D" Word. *Access Magazine, 1*(40), 2-8. https://escholarship.org/uc/item/83f6q2nv

Hopkins, Minnesota Zoning Map. (2021, October 19). City of Hopkins. Retrieved from https://www.hopkinsmn.com/DocumentCenter/View/212/Zoning-Map---85-by-11-Inches-PDF

Household Income in Hennepin County, Minnesota (County). (2018, September 4). The Demographic Statistical Atlas of the United States. Retrieved January 30, 2022, from https://statisticalatlas.com/county/Minnesota/Hennepin-County/Household-Income

Karner, A., & Niemeier, D. (2013). Civil rights guidance and equity analysis methods for regional transportation plans: a critical review of literature and practice. *Journal of Transport Geography 33*, 126-134. https://doi.org/10.1016/j.jtrangeo.2013.09.017.

Klein, N. J., & Smart, M. J. (2019). Life events, poverty, and car ownership in the United States: A mobility biography approach. *Journal of Transport and Land Use 12*(1), 395–418. http://dx.doi.org/10.5198/jtlu.2019.1482

Metropolitan Council. (2022). *Transitways Generalized (Alignments and Stations)* [Data set]. Minnesota Geospatial Commons. https://gisdata.mn.gov/dataset/us-mn-state-metc-trans-transitways-generalized

Minneapolis GIS. (2019). *Future land use and built form 2040* [Data set]. Open Minneapolis. https://opendata.minneapolismn.gov/datasets/cityoflakes::future-land-use-and-built-form-2040

Population of Hennepin County, Minnesota (County). (2018, September 4). The Demographic Statistical Atlas of the United States. Retrieved January 30, 2022, from https://statisticalatlas.com/county/Minnesota/Hennepin-County/Population

Race and Ethnicity in Hennepin County, Minnesota (County). (2018, September 4). The Demographic Statistical Atlas of the United States. Retrieved January 30, 2022, from https://statisticalatlas.com/county/Minnesota/Hennepin-County/Race-and-Ethnicity

Route and Stations. (n.d.). Metropolitan Council. Retrieved January 30, 2022, from https://metrocouncil.org/Transportation/Projects/Light-Rail-Projects/METRO-Green-Line-Extension/Route-Stations.aspx

Ryus, P., Ausman, J., Teaf, D., Cooper, M., & Knoblauch, M. (2000). Development of Florida's Transit Level-of-Service Indicator. *Transportation Research Record, 1731*(1), 123-129. https://doi.org/10.3141/1731-15

Schuetz, J., Giuliano, G., & Shin, E. J. (2018). Does zoning help or hinder transit-oriented (re)development? *Urban Studies, 55*(8), 1672-1689. https://doi.org/10.1177/0042098017700575

Taye, J. (2016). *Accessibility and Suitability Analysis of Light Rail Station Location by using (AHP) and GIS: Case study on Existing and Future Expansion of Addis Ababa LRT Respectively* [Master's thesis, Addis Ababa University]. https://scholar.archive.org/work/ihtxtdhlczerlpj2tfl2ei2yya/access/wayback/https://nadre.ethernet.edu.et/record/9266/files/GomejuTaye.pdf

U.S. Census Bureau. (2010). *2010 Decennial Census*

U.S. Census Bureau. (2019). *2015–2019 American Community Survey 5-year Estimates*

Zoning Code. (n.d.). City of St. Louis Park. Retrieved from https://www.stlouispark.org/business/zoning-code-241

Zoning Maps. (2021, September 15). City of Minneapolis. Retrieved from https://www2.minneapolismn.gov/business-services/planning-zoning/zoning-maps/