RESEARCH

UDOT Keeping Utah Moving

Utah Department of Transportation - Research Division
4501 South 2700 West - P.O. Box 148410 - SLC,UT 84114-8410

Report No. UT-24.11

A DATA-DRIVEN ANALYSIS OF TRANSPORTATION INFRASTRUCTURE EQUITY IN UTAH

Prepared For:

Utah Department of Transportation
Research & Innovation Division

Final Report
July 2024

DISCLAIMER

ACKNOWLEDGMENTS

The authors acknowledge the Utah Department of Transportation (UDOT) for funding this research, and the following individuals from UDOT on the Technical Advisory Committee (TAC) for helping to guide the research:

- Brad Loveless - UDOT Research, Project Manager
- Lisa Zundel - UDOT Region 2, Deputy Director
- Alana Spendlove – UDOT Rural Public Transit Manager
- Angelo Papastamos - UDOT Planning, TravelWise Program
- Eileen Barron - UDOT Planning and Investment Communications Manager
- Stephanie Tomlin – UDOT Trails Division Director
- Cristobal Villegas – Utah Transit Authority Community Engagement

TECHNICAL REPORT ABSTRACT

1. Report No. UT- 24.11	2. Government Accession No. N/A	3. Recipient's Catalog No. N/A
4. Title and Subtitle A DATA-DRIVEN ANALYSIS OF TRANSPORTATION INFRASTRUCTURE EQUITY IN UTAH		5. Report Date April 2024
		6. Performing Organization Code
7. Author(s) Shaunna Burbidge, PhD; Collin Gee, MS; and Emma Abel		8. Performing Organization Report No.
9. Performing Organization Name and Address Avenue Consultants 6605 South Redwood Rd. Suite 200 Taylorsville, Utah, 84123		10. Work Unit No. 5H092 78H
		11. Contract or Grant No. 23-9186
12. Sponsoring Agency Name and Address Utah Department of Transportation 4501 South 2700 West P.O. Box 148410 Salt Lake City, UT 84114-8410		13. Type of Report & Period Covered Final Jan 2023 to June 2024
		14. Sponsoring Agency Code PIC No. UT22.408

15. Supplementary Notes

Prepared in cooperation with the Utah Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

Transportation investments vary across geographic areas. Currently, there is no mechanism in place to ensure that those investments are equitable. This project examined transportation investments and infrastructure quality (e.g., pavement conditions, presence of bike lanes, transit access, speed limits, etc.) in urban and rural Utah and correlated existing conditions with community demographic characteristics (e.g., mean income, people of color, ethnic makeup, people with disabilities, primary household language, household type, etc.) to identify areas where additional infrastructure investment may be needed to support vulnerable populations. Several datasets were used to create a database which could be utilized to identify areas that could benefit from additional investment. Datasets were compiled from a variety of sources, including the UDOT Data Portal, contact with UDOT personnel, the Utah Geospatial Resource Center (UGRC), and datasets generated from a previous Vulnerable Road Users (VRU) project, and national Social-Vulnerability Index (SVI) Data. The analysis found that highly vulnerable population areas exhibit differences in infrastructure quality and investment. Factors including historical redlining, fewer kindergarten-through-12th-grade (K-12) schools (but more higher-education institutions), and more signalized intersections are more likely to exist within more vulnerable demographic areas. Vulnerable tracts also typically have more roadway lanes present on roads (as well as more basic stripe bike lanes) and experience lower pavement quality than other areas.

17. Key Words Equity, Society, Culture, Transportation, Traffic, Inequities, Development, Pedestrians, Demographics, Infrastructure		18. Distribution Statement Not restricted. Available through: UDOT Research Division 4501 South 2700 West P.O. Box 148410 Salt Lake City, UT 84114-8410 www.udot.utah.gov/go/research		23. Registrant's Seal N/A
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 103	22. Price N/A	

TABLE OF CONTENTS

LIST OF TABLES ... vi
LIST OF FIGURES ... vii
UNIT CONVERSION FACTORS ... ix
LIST OF ACRONYMS ... x
EXECUTIVE SUMMARY ... 1
1.0 INTRODUCTION ... 3
1.1 Problem Statement ... 4
1.2 Objectives ... 6
1.3 Scope ... 7
1.4 Outline of Report ... 8
2.0 RESEARCH METHODS ... 9
2.1 Overview ... 9
2.2 Literature Review ... 9
2.2.1 Evaluation of Equity in Transportation Applications ... 10
2.2.2 Integration of Equity in Transportation Applications ... 13
2.2.3 Challenges ... 17
2.2.4 Conclusion ... 19
2.3 Existing Equity Programs and Previous Utah-Based Efforts ... 19
2.3.1 Existing Federal Strategies and the "Opportunity for All" Project ... 20
2.3.2 RAISE Funding Opportunities ... 20
2.3.3 USDOT Programs ... 21
2.3.4 UTA Equity Efforts and Recognition ... 21
2.3.5 Utah Healthy Places Index ... 22
2.3.6 Research Methods Discussion ... 23
2.4 WFRC EFA and SVI Index Values ... 23
2.4.1 WFRC Equity Focus Areas Index ... 24
2.4.2 CDC/ATSDR Social Vulnerability Index ... 24
2.5 Summary ... 26
3.0 DATA COLLECTION ... 28
3.1 Overview ... 28

3.2 Datasets Utilized ... 28
3.2.1 Demographics Data and Census Tracts (SVI Dataset) ... 28
3.2.2 Infrastructure Data ... 30
3.3 Built Environment and Infrastructure Variables Final Dataset Compilation ... 32
3.3.1 Infrastructure Variables ... 33
3.4 Summary ... 34
4.0 DATA EVALUATION ... 35
4.1 Overview ... 35
4.2 Descriptive Statistics of Demographics ... 35
4.3 Descriptive Statistics of the Built Environment ... 37
4.4 WFRC Equity Focus Areas (EFAs) and the Built Environment ... 39
4.4.1 Summary Statistics of Demographic and Built Environment Characteristics ... 39
4.4.2 Built Environment EFAs Independent Samples *t*-Test ... 42
4.4.3 WFRC EFA Mapping Results ... 42
4.5 Social Vulnerability Index (SVI) and the Built Environment ... 52
4.5.1 Summary Statistics of Demographic and Built Environment Characteristics ... 53
4.5.2 Built Environment High SVI Independent Samples *t*-Test ... 56
4.5.3 SVI Census Tract Mapping Results ... 57
4.6 EFA and SVI Summary Statistics Comparison ... 67
4.7 Built Environment Value Scoring and SVI Overlay ... 68
4.7.1 BE Scoring Criteria ... 69
4.7.2 Mapping and Results ... 72
4.8 Summary ... 76
5.0 CONCLUSIONS ... 77
5.1 Summary ... 77
5.2 Findings ... 77
5.2.1 Redlining ... 77
5.2.2 Presence of Schools ... 79
5.2.3 Signalized Intersections ... 80
5.2.4 Roadway Characteristics ... 80
5.2.5 Safety Concerns ... 82

5.2.6 Utah Timeline 82
5.3 Limitations and Challenges 84
6.0 RECOMMENDATIONS AND IMPLEMENTATION 85
6.1 Recommendations..85
6.2 Implementation Plan...85
REFERENCES 87
APPENDIX A: SVI/BE Scoring Census Tracts 91

LIST OF TABLES

Table 3.1. SVI Demographic Variables Utilized in Statistical Analysis 29
Table 3.2. Calculated Infrastructure Variables 33
Table 4.1. Utah Census Tracts by County 35
Table 4.2. Statewide Demographic Information..36
Table 4.3. Statewide Built Environment Information...38
Table 4.4. EFA Demographic Characteristics and Other Tracts 40
Table 4.5. Built Environment Characteristics for WFRC EFAs and Other Tracts.......................41
Table 4.6. Independent Samples *t*-Test: EFAs and Built Environment Characteristics 42
Table 4.7. High SVI Demographic Characteristics and Other Tracts..................................54
Table 4.8. Mean Transportation Characteristics for High SVI and Other Tracts 55
Table 4.9. Independent Samples *t*-Test: High SVI and Built Environment Characteristics..........56
Table 4.10. Comparison of Summary Statistics – High SVI and EFAs 67
Table 4.11. Comparison of Built Environment Statistics – High SVI and EFAs..........................68
Table 4.12. Comparison of BE Scoring Criteria – High SVI and EFAs 69
Table A.1. High SVI and BE Scoring Utah Census Tracts 91

LIST OF FIGURES

Figure 2.1 CDC/ATSDR SVI Variables....26
Figure 4.1 Utah EFA Census Tracts....39
Figure 4.2 EFA Tracts – Bike Lanes....44
Figure 4.3 EFA Tracts – Driveways....44
Figure 4.4 EFA Tracts – EPM Projects....45
Figure 4.5 EFA Tracts – Higher Education....45
Figure 4.6 EFA Tracts – K-12 Schools....46
Figure 4.7 EFA Tracts – Signalized Intersections....46
Figure 4.8 EFA Tracts – Paved Shoulders....47
Figure 4.9 EFA Tracts – Pavement Messages....47
Figure 4.10 EFA Tracts – Historical Redlining....48
Figure 4.11 EFA Tracts – Transit Ridership....48
Figure 4.12 EFA Tracts – Roadway Lanes....49
Figure 4.13 EFA Tracts – UDOT Safety Comments....49
Figure 4.14 EFA Tracts – Signal Maintenance....50
Figure 4.15 EFA Tracts – Road Sign Condition....50
Figure 4.16 EFA Tracts – Speed Limits Over 40 MPH....51
Figure 4.17 EFA Tracts – Trails and Paths....51
Figure 4.18 EFA Tracts – Pavement Quality....52
Figure 4.19 SVI Tracts – Census Tracts....53
Figure 4.20 SVI Tracts – Bike Lanes....59
Figure 4.21 SVI Tracts – Driveways....59
Figure 4.23 SVI Tracts – Higher Education....60
Figure 4.24 SVI Tracts – K-12 Schools....60
Figure 4.25 SVI Tracts – Signalized Intersections....61
Figure 4.26 SVI Tracts – Roadway Lanes....61
Figure 4.27 SVI Tracts – Paved Shoulders....62
Figure 4.28 SVI Tracts – Pavement Messages....62
Figure 4.29 SVI Tracts – Historical Redlining....63
Figure 4.30 SVI Tracts – Transit Ridership....63

Figure 4.31 SVI Tracts – Signal Maintenance....64
Figure 4.32 SVI Tracts – Road Sign Condition....64
Figure 4.33 SVI Tracts – Speed Limits Over 40 MPH....65
Figure 4.34 SVI Tracts – Trails and Paths....65
Figure 4.35 SVI Tracts – UDOT Safety Comments....66
Figure 4.36 SVI Tracts – Pavement Quality....66
Figure 4.37 Built Environment Scoring Overview....70
Figure 4.38 Built Environment Scoring City Views....71
Figure 4.39 BE Scoring and SVI Overlay....74
Figure 4.40 BE Scoring and SVI City Views....75
Figure 5.1 Utah Timeline Part I: Early Years....83
Figure 5.2 Utah Timeline Part II: Postwar Era....83
Figure 5.3 Utah Timeline Part III: Modern Era....83

UNIT CONVERSION FACTORS

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. (Adapted from FHWA report template, Revised March 2003)

LIST OF ACRONYMS

AADT	Annual Average Daily Traffic
ATSDR	Agency for Toxic Substances and Disease Registry
BE	Built Environment (particularly the scoring system)
CDC	Centers for Disease Control
DOT	Department of Transportation
EDI	Equity, Diversity, and Inclusion
EFAs	Equity Focus Areas (Wasatch Front Regional Council)
ePM	Electronic Program Management
FHWA	Federal Highway Administration
I	Interstate
LiDAR	Light Detection and Ranging Technology
MPH	Miles Per Hour
NGO	Non-Governmental Organization
NOFO	Notice of Funding Opportunity
RAISE	Rebuilding American Infrastructure with Sustainability and Equity Grant Program
SVI	Social Vulnerability Index
TAC	Technical Advisory Committee
TIF	Transportation Investment Fund
TTIF	Transit Transportation Investment Fund
UDOT	Utah Department of Transportation
UGRC	Utah Geospatial Resource Center
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
VRU	Vulnerable Road Users
WFRC	Wasatch Front Regional Council

EXECUTIVE SUMMARY

This project examined transportation investments and infrastructure quality (e.g., pavement conditions, presence of bike lanes, transit access, speed limits, etc.) in urban and rural Utah and correlated existing conditions with community demographic characteristics (e.g., mean income, people of color, ethnic makeup, people with disabilities, primary household language, household type, etc.). Using demographic data (U.S. Census, etc.) for urban and rural areas in Utah, correlations with transportation infrastructure and built environment factors were identified (signalized intersections, pavement condition, maintenance, etc.). Spatial statistical analysis then demonstrated the correlation between infrastructure quality and social demographics which may assist in identifying areas that may benefit from additional transportation investment. While this research is widely interdisciplinary, it may be useful for planning and project programming as the department evaluates current funding programs and whether alternate funding mechanisms might be applied to meet Opportunity for All customer service objectives.

To conduct this analysis, the research team utilized several existing datasets on transportation infrastructure, demographics, and other topical data items. These datasets were used to create a database that could be used to examine factors which could be utilized to identify areas that could benefit from additional investment. Datasets were compiled from a variety of sources, including the UDOT Data Portal, contact with UDOT personnel, the Utah Geospatial Resource Center (UGRC), and datasets generated from a previous Vulnerable Road Users (VRU) project, and national Social-Vulnerability Index (SVI) Data. Census tracts in Utah were utilized to categorize the data. The research team identified demographic and built environment (BE) variables and classified each by census tract. Datasets were imported into ArcGIS Pro software and BE data was joined spatially to demographic data. R software was utilized to calculate ratios for each variable in each census tract; then datasets were joined into a comprehensive dataset for analysis.

An analysis of transportation characteristics was conducted comparing more vulnerable population areas. The CDC defines vulnerable populations by socio-economic status, geography, gender, age, disability status, and risk status related to age and gender. For this project, a

vulnerable population or census tract indicates where there is a greater likelihood that a given population or community will have limited access to certain resources including transportation.

Using an independent sample *t*-Test, statistical analysis found that there are significant differences in infrastructure between highly vulnerable tracts and in other areas. Highly vulnerable population areas exhibit significant differences in infrastructure quality and investment. Factors including historical redlining, fewer kindergarten-through-12th-grade (K-12) schools (but higher-education institutions), and more signalized intersections indicate more vulnerable areas. Vulnerable tracts also typically have more roadway lanes present on roads (as well as more basic stripe bike lanes) and experience lower pavement quality than other areas. This study found that communities living within or near busy roadway segments where more infrastructure is present may experience more impact from traffic (pollution, noise, etc.).

The conditions and characteristics described above are interconnected and cannot be examined in isolation. While these characteristics were identified as significant for vulnerable areas, other factors may play a role as well. It is recommended that all characteristics be considered systemically, and that highly vulnerable areas be examined more holistically with such research moving forward.

1.0 INTRODUCTION

The Utah Department of Transportation (UDOT) seeks to "give all users of the transportation system choices, so they can get where they want, when they want, in the way they want – safely," through their mission of enhancing quality of life through transportation (UDOT, 2024). Over the past five years, UDOT has taken active steps toward achieving these goals. During the 2018 Utah Legislative Session, UDOT was directed to develop statewide strategic initiatives across all modes of transportation. As a result, UDOT convened more than 25 stakeholder agency representatives for a collaborative process called Utah's Transportation Vision, or UVision. The outcome of a series of discussions was that the shared statewide vision was a Pathway to Qualify of Life (see Figure 1). Quality of life as it relates to transportation was then defined by four outcome areas: Good Health, Connected Communities, Better Mobility, and Strong Economy. It was developed to be implemented by all transportation agencies in the state to bring local, regional, and statewide plans into alignment. UVision guides transportation policies and decision making with the shared stated intent for transportation to contribute to Utahns' Quality of Life.

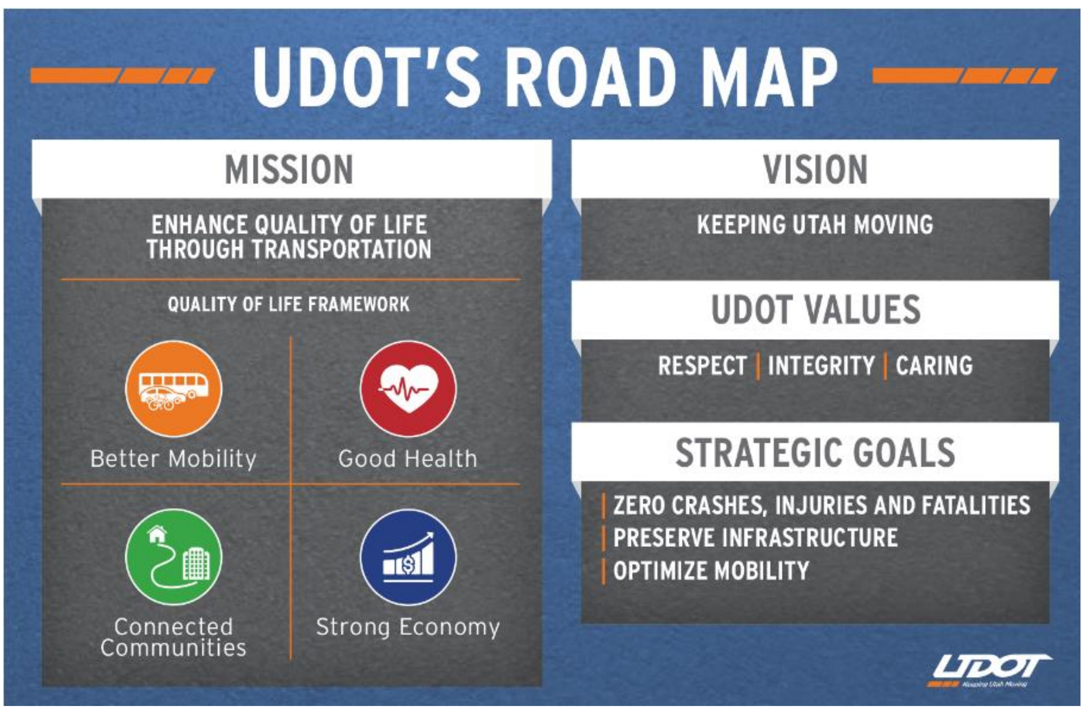

Figure 1. UDOT's Pathway to Quality of Life (UDOT, 2024)

Shortly after UVision, UDOT adopted the Quality of Life Framework as decision-making criteria and updated its mission statement to "Enhance quality of life through transportation." UDOT later identified an "All Users" mindset as the method to achieve quality of life through transportation. UDOT added an All Users goal to its Strategic Direction as an approach to achieving transportation equity. It reads, **"**UDOT's goal is to apply an 'All Users' mindset to transportation decision-making, responding to community needs to create a safer, more reliable, and accessible transportation system" (UDOT, 2022).

Again, guided by the Utah Legislature and the Governor's office, UDOT has embraced an "Expanding Opportunities for All" approach to delivery of public services. Along with the "All Users" mindset, a focus on "Opportunity for All" establishes a shared vision for equitable access to transportation for residents of Utah to achieve quality of life. The following problem statement and research was initialized, developed, and completed with these principles in mind.

1.1 Problem Statement

According to Utah's Unified Transportation Plan, "Utah's transportation agencies have together projected that between 2019 and 2050, the total transportation need in Utah is estimated at $108.5 billion in current dollars. This includes funding needed to operate our current transportation system, and to preserve and maintain the infrastructure in good condition. It also includes the funding needed to meet growing travel demands by increasing roadway capacity by building new roads and widening and making operational enhancements to existing roads; increasing transit capacity by building new transit lines, upgrading existing lines and providing more frequent rail and bus service; and increasing options to bike or walk by constructing new bikeways and improving existing trails and walkways."

Historically, capacity has been the major determinant of which projects are built and where funding is allocated. However, this approach typically focuses on larger scale projects in areas with new development and higher rates of growth. Older areas that are already built out may not have a need for capacity projects and are often overlooked when it comes to incorporating non-motorized facilities such as new sidewalks or bike lanes, or improvements to pavement, striping, etc. Because these areas are older and do not experience a large amount of development, they often do not have steady streams of new income from building permits, impact fees, etc., to make these improvements on their own. In lower income areas with lower cost housing, property taxes are likewise low, which exacerbates this income inconsistency. Additionally, many transportation funding sources (Transportation Improvement Fund [TIF], Transit Transportation Improvement Fund [TTIF], Safe Routes to School, Safe Sidewalks, etc.) projects require a local match (as much as 40 percent). This process can result in disparate distribution because communities with the greatest need may not have the means to provide matching funds, while more affluent areas can easily meet this requirement. For example, the city of West Wendover saved for more than seven years to provide the matching funds to access a Safe Routes to School Grant to build just a few hundred feet of sidewalk. Additionally, a study by RSG identified that the locations of rail transit stations (TRAX and FrontRunner) are directly adjacent to more affluent, largely metropolitan communities, while lower income minority neighborhoods have a significantly higher need for these facilities (2020).

In Feb. 2022, The Utah Division of Multicultural Affairs released a white paper examining "The State of Transportation Equity in Utah." Two of the major recommendations of that report include "finding opportunities for transportation investments in diverse and low-income communities," and "incorporating race, income, and English proficiency as consistent data variables across transportation projects to evaluate social impact," similar to the methods used in the Portland Equity Matrix and Blueprint Denver. UDOT is a signatory to the Utah Compact of Racial Equity, Diversity and Inclusion, and the department has committed itself to operationalizing inclusive principles by providing opportunity for all within the state's Quality of Life Framework. Building equitable solutions and practices within transportation will require increasing mobility access and choice so everyone has equitable opportunities to work, learn, play, socialize, and thrive.

This research will use demographic data (U.S. Census, American Communities Survey, etc.) for urban and rural areas in Utah and correlate it to transportation infrastructure and built environment quality (pavement condition and assets) and investment. Spatial statistical analysis will then verify if specific types of areas that have outdated infrastructure or a lack of infrastructure also experience financial need, have ethnic minority populations, or have other specific characteristics.

Ultimately this research will verify existing correlations between built environment and transportation system characteristics and the demographics in Utah census tracts. It will also determine which types of areas would benefit from additional investment, understanding that this investment may need to come from non-traditional methods or sources.

1.2 Objectives

Transportation investments vary across geographic areas. Currently, there is no mechanism in place to ensure that those investments are equitable. The Equity Focus Areas framework defined by the Wasatch Front Regional Council (WFRC) is one approach to establish the Equity Areas for the analysis. Equity Focus Areas are those census block groups where any of the following criteria is met:

- Greater than 25 percent Low Income: Low-income populations are highlighted, as a lack of access to reliable and efficient transportation can be a major barrier to economic mobility.
- Greater than 40 percent Persons of Color: Racial-ethnic minority populations comprise this criterion, as many land use and transportation investments in the U.S. have had disproportionate adverse impacts upon communities of color.
- Greater than 10 percent No-Vehicle Households: No-Vehicle Households are included in this criterion as these are populations, including those with disabilities, that depend more on transit, paratransit, walking, and bicycling to reach employment and other destinations.

In addition to the Equity Focus Area framework, this research also utilized the Social-Vulnerability Index (SVI), created by the U.S. Centers for Disease Control (CDC) to define areas of analysis. This criterion utilizes 16 variables from the U.S. Census to help identify tracts that may need more support to prepare for and recover from external stressors, which can be considered ‘high vulnerability.’ This includes demographic information, measures of income and poverty, vehicle ownership, home ownership, unit types, etc. The research team found the use of this criterion helpful in expanding the number of areas of analysis.

This project will examine transportation investments and infrastructure quality across the Equity Focus Areas and SVI tracts in both urban and rural Utah (e.g., presence of bike lanes, transit access, speed limits, etc.) and correlate existing conditions with community demographic characteristics (e.g., mean income, below the poverty line, people of color, ethnic make-up, people with disabilities, primary household language, journey to work, household type, vehicle ownership, municipal income per capita, etc.).

1.3 Scope

The findings of this research will use statistical analysis to confirm relationships between infrastructure quality and household characteristics to indicate potential locations for non-traditional investment. These findings will identify areas that may frequently be missed by existing paths for project funding that could benefit from infrastructure investment to improve quality of life and opportunity for all. This will allow UDOT to focus resources and projects on needs within those areas with a goal of providing transportation equity for residents of those areas. This may include recommendations for new infrastructure, improvements to existing facilities, improved signal operations, and maintenance to deliver inclusive and equitable systems that benefit all modes of transportation and all road users. This will also clearly highlight the types of areas that may not be able to implement extensive infrastructure improvements on their own or even provide matching funds for existing transportation funding options. Potential benefits to UDOT departments are summarized below.

- Traffic and Safety — Improved understanding of local modal needs and opportunities to improve safety features (e.g., pedestrian refuge or crossing treatments, transit facility access, lighting, etc.).
- Planning — Identify areas with specific needs to incorporate in future planning, and create plans tailored to individual community needs rather than attaching smaller improvements to larger capacity projects.
- Data Analytics — Uses existing UDOT and outside data sources to create a comprehensive dataset that can be managed for use across departments, including in collaboration with programs such as the Utah Healthy Place Index.

- Maintenance — Provide targeted locations with maintenance or improvement needs that do not have planned project-related improvements (e.g., pothole or pavement repair, shoulder issues, debris removal, etc.)
- Traffic Operations — Improve operations based on local needs, such as increased green signal time for pedestrians, improved timing, or priority for transit vehicles, etc.

1.4 Outline of Report

The report is organized into five additional sections, as follows:

- Section 2 provides a literature review examining characteristics on evaluating equity factors in transportation applications, integrating equity within a transportation framework, and potential challenges in the implementation of transportation equity initiatives.
- Section 3 presents collected data and equity information gathered from various locations in Utah.
- Section 4 presents a quantitative analysis of data pertaining to equity initiatives.
- Section 5 provides conclusions based upon the data analysis.
- Section 6 outlines recommendations and the implementation plan.

2.0 RESEARCH METHODS

2.1 Overview

A literature review was conducted relative to transportation equity factors within the transportation sector. This review examined methods of both evaluating equity indicators regarding transportation and integrating equity plans and strategies into transportation programs. The literature review examined challenges that may also be faced in working with transportation equity indicators. The research team also worked with UDOT and Utah Transit Authority (UTA) personnel to determine the best way to proceed with the study and ensure that effective review of equity indicators in Utah transportation would be conducted within this research.

2.2 Literature Review

Ensuring that elements of equity are properly integrated into transportation infrastructure and planning is of great importance to a modern Department of Transportation (DOT). Organizations in the United States have become more conscious of the necessity of inclusive workplaces, and in recent years, the development of equity initiatives in the workplace are more commonplace than in the past (Keen, et al., 2021). Agencies have worked to implement initiatives to ensure that persons of varying backgrounds, ethnicities, and economic status are acknowledged, included in planning, and treated fairly. This is true in the transportation sector as well. UDOT has taken a number of steps over the last five years to integrate equity and quality of life into their mission and decision-making principles (as described in the Introduction of this report).

Equity typically refers to the fairness with which impacts of benefits and costs are distributed among a population (Litman, 2023). The Federal Highway Administration (FHWA) has defined several groups as traditionally underserved populations which require equity investment strategies, including low-income, minority, older adults, limited English proficiency, and persons with disabilities (Standt et al., 2016). Measuring impacts of transportation policies and reconciling these impacts with equity initiatives is difficult, given that equitable factors are intangible and affect different socio-economic groups in varying degrees (Manaugh et al., 2014).

As a result, different theories and recommendations exist for how to best measure existing transportation equity conditions and how to best implement new strategies.

Significant literature exists on the subject of equity initiatives and the field of transportation oversight. These include evaluation studies on measuring equity performance, suggestions on implementation strategies for equity initiatives, and other topics. Understanding of equity-related initiatives in relation to external factors is also a topic of interest; the recent COVID-19 pandemic overlapped with a push for more social justice initiatives, and likewise disrupted data and understanding of transportation use at that time (Keen et al., 2021). Overall, existing literature displays a variety of research and attempted analysis of equity and transportation. The following sections detail a review of existing literature and what studies have been carried out.

2.2.1 Evaluation of Equity in Transportation Applications

Brown writes that no single definition of ‘equitable transportation’ truly exists, leading to the question of if equity should be evaluated as a process, opportunity, or outcome (2022). This question may be difficult to answer for an organization (see ‘Challenges’). However, the focus on equity factors in recent years has provided a study which may help an organization such as a department of transportation evaluate the status of equity and fairness present within a transportation network. Litman writes that equity within transportation is not a singular issue but consists of interrelated concerns (2023). Litman notes that different types of transportation equity must also be considered, which includes the following: horizontal equity (people with comparable needs and abilities be treated equally), vertical equity (improvements favoring disadvantaged persons), and social justice (consideration of structural injustices such as racism and sexism) (2023). Standards of accessibility of transportation infrastructure and their correspondence to individual rights must be considered as well (Pereira et al., 2016). As a result, any attempt at evaluation must consist of a comprehensive approach that will review possible impacts to equity objectives from multiple sources. Litman has composed a set of equity analysis steps which provide such an overview (2023):

- Define the type of equity to be considered (horizontal, vertical, social justice).

- Define the impacts (benefits and costs) to be considered (funding, facility supply, cost burdens, etc.).
- Define what distribution of impacts is considered fair and appropriate.
- Define the population groups considered (demographics, income, geography, mode users), and which are disadvantaged.
- Evaluate the degree to which the distribution of impacts is considered fair and appropriate.

Again, some issues of definition may be present in such efforts. But an equity evaluation can utilize such an approach to better understand where gaps exist within a transportation network, and where improvement may be needed. A comprehensive plan to measure equity analysis should consider equity types, perspectives, impacts, and population groups; and impacts should be measured per person (as opposed to per mile or other types of measurement) (Litman, 2023). Evaluation of equity performance in a transportation system should also contain a review of the minimum standards of accessibility to key destinations and their respect to individual rights and opportunities (Pereira, 2016).

Brown writes that applicable data will be essential to any attempt to evaluate the equity present in organizational programs and policies within transportation (2022). Data collection and analysis should be built into program evaluations and utilized to determine the equity present in existing systems. Data collection should focus on equity indicators for the program in question (e.g., trip data for e-scooters and bikeshare programs, bus on-time performance for public transit) (Brown, 2022). Quality data will provide evidence for equity objectives and allow agencies to identify where transportation facilities, infrastructure, and other factors may be insufficient for the needs of disadvantaged communities.

Due to some of the inherent difficulties in attempting to define and evaluate equity objectives, strategies may utilize new technologies and capabilities to measure equity performance. A New York-based study utilized social media, particularly the application Twitter (now known as X), to analyze tweets between residents, looking for complaints and conversation about transportation using language processing. This was then compared to socio-demographic census tract data and identified that areas with higher percentages of low-income, female, Hispanic, and Latino populations shared more equity-based concerns about transportation on social media (Rista et al., 2022). This study highlights how social media can be utilized to identify equity indicators through interactions in the public sphere. The study authors note that this method could be an improvement over survey-based methods which require more time and investment to identify equity indicators and evaluate where public concerns over equity-based transportation issues are concentrated (Rista et al., 2022). The use of social media to evaluate public concern about equity issues may provide an effective solution for DOTs and other governing agencies to identify more quickly where to implement equity-related strategies. Using social media does have some limitations, but in general, research has found that such use of social media can help identify where equity issues need to be addressed based on community concerns (Rista et al., 2022).

A major aspect of equity in transportation is the integration of bicycle infrastructure and facilities. Cycling provides many socio-economic, environmental, and health benefits; however, underserved communities do not always have access to robust cycling infrastructure, or infrastructure that is safe (Doran et al., 2021). Simply providing a striped bike lane on a busy roadway may not be adequate for providing safe transportation options for the local population. Because of this, it is important that DOTs and transportation planners include considerations for cyclist infrastructure which is accessible to the population at large. Doran, et al., conducted a study which utilized a comprehensive review to evaluate how bicyclist equity is addressed within Canadian transportation plans. They ultimately found that most transportation plans did not include cycling equity or did so in an ineffective way (Doran et al., 2021). Such findings show that more effort will generally be required to implement cycling equity in planning. The study utilized analysis of four major points related to cycling equity in transportation planning: robust socio-spatial network analysis; consideration of equity in projects and priorities; incorporation of equity-oriented funding mechanisms; and incorporation of accessibility design and safety measures (Doran et al., 2021). This research strategy allowed for an effective review of the status of cycling equity in major transportation plans. Such focus could be used at other organizations to review the status of cycling equity within overall transportation planning in a similar way.

The use of mobility data is another use of technology which could help improve the evaluation of equity status and assist in equitable transportation planning. A study by Sanguinetti and Alston-Stepnitz detailed an initiative known as the Mobility Data for Safer Streets (MDSS), which supplied mobility data tools to active transportation advocates in various cities across the U.S. (2023). The study found that community groups and advocates could use mobility data—often sourced from smartphones—to coordinate with city planners and provide useful data on where better equity performance within transportation is needed. The use of mobility data tools specifically allowed users to demonstrate locations of highest concentrations of cyclists within urban areas, for example, and the relation to equity indicators (Sanguinetti and Alston-Stepnitz, 2023). Overall, the study demonstrates how communities can use existing mobility data to strengthen equity initiatives, highlight issues, and provide needed evidence on where equity strategies must be implemented. There are challenges present in mobility data use—particularly based around access, cost, and training—but even with these issues, the use of mobility data could provide improvement in equity evaluation and planning.

2.2.2 Integration of Equity in Transportation Applications

Many reports and studies exist which describe potential strategies and theories on how to best integrate equity into transportation decision-making and applications. Traditionally, transportation planning and development has been approached with mobility in mind, over other factors (Manaugh et al., 2015). As a result, strategies to implement equity within transportation have been developed more recently with consideration to social equity goals.

There are inherent difficulties in the implementation of equity initiatives within a transportation framework (see "Challenges"). As a result, it is important that planners and managers of equity-based initiatives ensure that objectives are well laid out. Manaugh, et al., stresses the importance of clearly specifying objectives and measures that capture the dynamics of social equity, e.g., ensuring that initiatives truly incorporate understanding of policy impacts and transportation impacts on individuals and communities (2014). Through this, a better understanding of overall equity impacts and achievement toward objectives is known. The authors also recommend a series of measures, or indicators, to be used to capture social equity objectives over time (Manaugh et al., 2014). These indicators (presented on the page that follows) will allow for a more straightforward capturing of equity-related information and make working toward equity-related objectives more tangible.

Indicators to capture social equity objectives over time:

- Changes in accessibility to desired destinations for disadvantaged groups.
- Difference in journey times for work trips and essential service trips, individual vehicle and public transportation use, top and bottom income quintiles.
- Difference between top and bottom income quintiles in the percentage share of household expenditure on transport.
- Difference between vehicle users and non-motorized users in traffic deaths and injuries.

Given the amount of research which exists on equity-based factors and their evaluation in transportation contexts, the methods for putting previous study into practice must be explored. Strategies in theory and on paper can often appear effective but may experience difficulties in real-world applications. Keen, et al., suggests a series of actions which organizations responsible for the implementation of equity-focused strategies can take (see below) to ensure that they can take place as intended (2021). Such actions can help an organization navigate potential challenges in implementation and develop effective and long-term equity-focused strategies:

- Precise implementation at all organizational levels.
- Employee-driven, equity-focused committees.
- Internal microsites.
- Consistent, tailored training.
- Retaining an equity-focused consultant.

Once an agency has determined how equity plans and actions will be organized, decisions about the detailed strategies must be made. Going further into specific actions which agencies can implement, Litman has developed a series of specific strategies which relate to transportation equities. These strategies contribute to five overall equity goals: Fair Share, External Costs, Inclusivity, Affordability, and Social Justice (2023).

The strategies are listed as follows:

- Comprehensive data and analysis.
- Accessibility-based analysis.
- Multimodal planning.
- Smart growth policies.
- Subsidization of public transportation.
- Complete Streets policies.
- Universal design.
- Prioritize affordable-efficient modes.
- Vehicle travel reduction targets.
- Commute trip reduction programs.
- Efficient road and parking pricing.
- Parking cash out and unbundling.
- Subsidization of electric vehicles.
- Subsidization of cars for low-income motorists.
- Improve public engagement.
- Affirmative Action programs.
- Compensation for past harms.

The strategies listed above contribute to the development of one or more of the five equity goals. These strategies cover a wide range of different aspects of transportation planning. They include roadway design, infrastructure, growth strategies, vehicle use, community involvement, and other initiatives. According to Litman, these strategies will shift favor in planning practices away from a vehicle-centric focus and create a more diverse and efficient transportation system (2023).

The research shows that community involvement is also a key to equity initiatives. Gaining knowledge of the experience of disadvantaged communities affected by equity issues related to transportation, and taking stock of community-based solutions, will allow an equity-related project to improve these issues in affected communities. Boisjoly and Yengoh suggest that community groups should be provided with resources to participate actively in the transportation planning process, which can then promote social equity within a transportation context (2017). This study also noted the need for a skilled facilitator to direct equity implementation. A skilled facilitator can ensure that diverse perspectives from municipal, private, and community groups can be integrated within planning and transportation initiatives (Boisjoly and Yengoh, 2017). Community involvement within equity-related strategies already appears to be widespread; a national survey of equity practices within different municipalities and state DOTs revealed that a majority of agencies (more than 70 percent) integrate community composition in planning and actively work with underserved communities in project decision-making (Burkin, 2023).

Non-vehicle-oriented transportation also factors into equity considerations. Many research studies suggest that steps should be taken to ensure that infrastructure and planning for bicyclists, pedestrians, and other non-motorists incorporate equity initiatives to ensure that equitable development is present in these transportation types. Standt, et al., has developed a series of high-level concepts to ensure that planning and development for bicyclists and pedestrians includes equity initiatives (2016). The author's strategies are based around four principal areas: foster inclusive public involvement, examine organizational practices and policies through the lens of equity, leverage data to identify concerns and opportunities, and design universal streets/facilities for all road users. This study highlights the importance of factors such as community involvement in planning to create social equity, while also highlighting the importance of developing organizational culture based on equitable principles (Standt et al., 2016). Such actions will ensure that equitable transportation practices can be integrated within non-motorist transportation planning and development.

It is important to note that implementation of equity-focused strategy and policy has become widespread in the U.S. More than 70 percent of state and municipal transportation agencies indicate they have documented policies and/or processes which address equity in their planning processes (Burkin, 2023). While some processes may be required by legislation, agencies have shown some proactive approaches. More than 60 percent of state agencies and 40 percent of municipalities indicate they use undocumented (unrequired) practices which consider equity in transportation planning (Burkin, 2023). Given that equity has gained an increasing amount of attention in the public sphere, it is probable that equity-related practices will continue to grow and develop in the near future, whether stemming from regulation or from the actions of agencies themselves.

2.2.3 Challenges

Commitment to equity initiatives promises much improvement and progress in the field of transportation planning and infrastructure. However, many challenges exist within this objective, which may complicate the effective implementation of such initiatives. Many of these issues revolve around the exact definition and interpretation of equity initiatives. Measurement of progress toward equity objectives can also create difficulty for agencies. These challenges have been identified in existing literature and are discussed below.

Perhaps the principal challenge within efforts to incorporate equity measures into transportation planning is the definition of objectives and the measuring of progress toward these objectives. A study by Manaugh, et al., found that social equity goals and objectives in a transportation context are often not translated into clear objectives, while measures for assessing objective achievement are insufficient (2014). Litman writes that "A decision may seem equitable when evaluated one way, but not if evaluated another. There is no single correct way to evaluate transportation equity" (2023). Some research has suggested that definitions of diversity and inclusion should not be tied solely to demographics, but also consider unique individual characteristics (communication, physical characteristics, comprehension, etc.), adding more complexity to the definition of what equity initiatives entail (Keen et al., 2021). Such findings demonstrate the difficulty that may arise when an organization attempts to create and drive progress toward improved equity-related performance. An organization's ability to ensure that equity initiatives are properly developed and achieved may be clouded by difficulties in definition and evaluation, and this may subsequently hamper the indication of successful implementation.

Further complicating the issues of defining and evaluating equity-related issues is disagreement on how to solve them. Agencies and communities often have conflicting ideas about what should be measured and how to interpret the results. (Liu et al., 2023). Several studies have worked to address this issue and have provided ways to define and evaluate equity objectives better. However, it may be expected that an agency would experience some issues with creating proper definitions of equity-related initiatives and ways to evaluate progress toward achieving them. Consideration and research must be applied to this issue to avoid overly theoretical applications and ensure that real-world progress can be achieved on equity-related strategies.

As discussed previously, emerging technologies and capabilities of information sharing may provide effective ways of evaluating and implementing elements of transportation equity. However, there are challenges that may emerge in attempts to use technology. Social media has provided a way to identify equity indicators and gauge community opinion more quickly (Rista et al., 2022). However, the use of social media may present its own challenges. Not everyone uses social media, and issues over privacy policies and restrictions on exact location sharing may reduce the accuracy of geolocation (Rista et al., 2022). Such issues will potentially reduce the ability of social media to be considered an accurate indicator. Regarding more advanced data types, the use of mobility data to identify equity issues has been explored. However, issues are also present within such data use. The use of more advanced data requires significant training to ensure it is utilized properly, while costs may be prohibitive to cities and advocacy organizations (Sanguinetti and Alston-Stepnitz, 2023). Such issues may limit the ability of organizations to utilize more advanced data in equity contexts. Also, mobility data may not accurately represent equity indicators; data may be treated as representative of an overall group, where in the real world it is not (Sanguinetti and Alston-Stepnitz, 2023). These issues must be recognized—and strategies developed and implemented to mitigate them—if data is to be used effectively in equity evaluation and implementation.

There may be challenges to equitable transportation which originate from within equity-focused strategies themselves. Litman has noted that highly targeted strategies may achieve fewer broad equity goals and can have negative impacts (2023). While good intentioned, such strategies may not lead to real-world improvement if they are not developed comprehensively. For example, automobile subsidies may be touted as a potential strategy to reduce inequities, however, they provide no benefit to persons without automobiles and contribute to increased vehicle traffic which may create further issues (Litman, 2023). As another example, programs to increase availability of e-scooters and bikeshare opportunities within cities may require a credit card or other account to access the program, to which some users may not have access (Brown, 2022). Examples of strategy issues have also been identified in wider applications as well. A review of bus-network redesigns (used to improve ridership rates) in major cities found that the baseline accessibility to bussing systems remained low for disadvantaged groups (Liu et al., 2023). Organizational challenges may also be faced when implementing equity strategies. Keen, et al., has identified several barriers which may inhibit equity initiatives, including effectiveness of training, logistical barriers to participating in activities and meetings, inconsistent collection of data, employee/vendor concerns about equity as a concept, and others (2021). Such challenges may be overcome through comprehensive planning and considerations for these strategies and initiatives to succeed.

2.2.4 Conclusion

Equity performance is an increasingly important subject in public consciousness. Public and private corporations and agencies alike have increasingly worked to identify and implement initiatives aimed at improving equity within their operations. Given the impact that transportation has on public life, the importance of equity initiatives within a transportation context is important to understand. Significant research has been conducted on the evaluation of equity performance and the implementation of such initiatives to ensure that organizations and agencies have equitable practices in place. Many different strategies have been explored and suggested for both evaluation and implementation of equity measures, generally. However significant challenges remain. Equity is difficult to define and evaluate in an organizational sense, and real-world implementation may be difficult for this reason. Effective data collection, community involvement, organizational recognition, and other strategies will likely be needed as a part of the plan. This will enable agencies to better understand the current state of equity-related efforts within their processes and how to improve equity initiatives moving forward.

2.3 Existing Equity Programs and Previous Utah-Based Efforts

Several additional programs and initiatives exist which are aimed at developing equity efforts within transportation contexts. These programs stem from both public and private sources and provide numerous resources to agencies engaged in pursing equity goals. This may include funding sources, strategy discussion, research, etc. This section describes some of these notable resources, as well as a previous equity-focused effort by UTA and recognition that followed.

2.3.1 Existing Federal Strategies and the "Opportunity for All" Project

Developing methods of integrating equity principles, particularly into lower-income areas and areas with higher minority populations, is a topic of great interest to many activists, federal agencies, non-governmental organizations (NGOs) and others. As noted in the literature review, successfully implementing equity-focused initiatives can be a great challenge, and difficulties may be encountered, particularly in measuring and implementing strategies designed to improve transportation equity. Resources which can help counteract this problem exist. The Urban Institute has developed a series of essays as part of the "Opportunity for All" Project (which seeks to see equity more effectively engrained in neighborhood areas) to provide examples of strategies the federal government can pursue to improve equity generally. Such strategies include suggestions on closing equity gaps in neighborhood systems, creating investment in public safety, creating equity in zoning law, etc. These essays were not created solely with transportation in mind, but they highlight how many areas both within and connected to transportation can benefit from investment in equity initiatives. Such projects can help provide the resources that agencies such as UDOT and UTA can utilize to implement strategies more effectively.

2.3.2 RAISE Funding Opportunities

The federal government provides federal aid and funding to agencies specifically for the development and implementation of equity-focused strategies. In 2024, the United States Department of Transportation (USDOT) published a Notice of Funding Opportunity (NOFO) in grant funding as part of the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grant program. RAISE grants provide project sponsors with assistance to complete transportation infrastructure projects which consider how equity initiatives can be positively implemented to a greater degree. In 2024, $1.5 billion will be available in grant funding. Utah-based agencies such as UDOT and UTA can take advantage of this type of grant funding to assist in developing infrastructure which will help to ensure that equity considerations are integrated within transportation planning and projects. While it is beyond the scope of this study to plan specific infrastructure projects, it is recommended that UDOT and UTA consider applying for

RAISE funding, and other potential federal funding sources, for future projects that incorporate equity components.

2.3.3 USDOT Programs

USDOT has recently placed more emphasis on equity measures within transportation systems and has a dedicated website with resources (USDOT, n.d.). The department has also sought to implement numerous programs and plans under the equity banner, some of which include the following (USDOT, n.d.):

- Equity Action Plan
- Justice40
- Tribal Consultation Plan
- Reconnecting Communities Pilot Program
- Rural Opportunities to Use Transportation for Economic Success
- Thriving Communities Program

These different programs provide support by investing in underdeveloped areas, establishing equity goals and strategies, providing funding for equity-oriented projects, and they generally serve to improve the accessibility and performance of transportation systems for all users (USDOT, n.d.). These programs also provide funding and support opportunities for state agencies, municipalities, and other organizations to carry out equity-oriented projects.

2.3.4 UTA Equity Efforts and Recognition

UTA has previously been engaged in equity initiatives through their work with Via, the company that developed the 'TransitTech' technology program. This program uses technologies to develop public mobility systems that are accessible to all road users. UTA was named a "Leader in Equity-Focused Innovation" as part of the 2022 Via Impact Awards. These awards recognize cities and transit-oriented agencies that utilize Via TransitTech technologies to make a positive impact in developing equity initiatives. Specifically, UTA was recognized for its efforts to create (with Via technology) the UTA On Demand service to provide on-demand shared rides for Salt Lake City area residents (and non-resident visitors). In particular, the On Demand service was recognized for providing access to transportation for people of color below the poverty level, and for expanding access and connections for users to jobs, social events, educational facilities, and other necessary destinations.

2.3.5 Utah Healthy Places Index

In 2018 using a grant from the Centers for Disease Control and Prevention (CDC), the Utah Department of Health brought together a diverse group of stakeholders, including UDOT, to create the Utah Health Improvement Index. Over time this evolved into the Utah Healthy Places Index (HPI). The HPI is a "powerful and easy-to-use data and policy platform created to advance health equity through open and accessible data. It is an evidence-based and peer-reviewed tool that can help support efforts to prioritize equitable community investments, develop critical programs and policies across the state, and much more" (DHHS, 2024). This Index incorporates several transportation variables and conditions such as those shown below.

- Automobile Access - Lack of access to a car should not limit people's access to opportunities.

- Bike Lane Access - Active commuting by foot, bike, and transit creates opportunities for physical activity, provides transportation options for those without a car, encourages social cohesion, and reduces contributions to climate change and air pollution.

- Traffic Volumes - Living near freeways and major roadways that generate high traffic volume and cut through communities can discourage physical activity, exacerbate air and noise pollution, and disconnect people from the places that matter most.

- Diesel Particulate Matter - Since diesel particulate matter is so small, it can reach deep into people's lungs.

- Fine Particulate Matter (PM 2.5) - Since fine particulate matter is so small, it can reach deep into people's lungs leading to adverse health outcomes.

- Ozone - When ozone levels in the air are high, it can cause lung inflammation and more serious respiratory issues.

- Public Transit Access - Transit access has been linked to improved physical and mental health, physical activity, employment outcomes, medical care, and resiliency during disasters.

The HPI also incorporates local demographic and neighborhood data and can be incredibly useful as a tool for identifying areas that may need additional attention or investment.

2.3.6 Research Methods Discussion

As part of this project, the research team had discussions with various UDOT and UTA personnel who are connected with equity efforts and transportation infrastructure. These discussions helped to determine what methodologies and data would provide the most effective study of transportation-equity indicators in Utah. Conversations focused primarily on determining the extent of the study area and what data types would be most useful. The group discussed whether a limited study extent to urban areas, a combination of urban and rural areas, or an overall statewide review would be most effective; group members subsequently determined that looking at statewide data would provide the best indication of the state of equity throughout Utah's transportation systems. The group also determined that demographic information in combination with data on infrastructure presence and quality would provide a good overview of transportation-equity status throughout the state and highlight areas that might need improvement. See section 3 for a discussion on the data that was included in this study.

2.4 WFRC EFA and SVI Index Values

Data collected over the course of this project provides context for a more in-depth analysis of transportation system infrastructure and its relationship to demographic conditions across Utah. Certain areas in Utah may be more susceptible to issues and challenges within transportation as they relate to local demographic conditions. The research team and UDOT/UTA personnel collaborated on the best method of collecting data to confirm areas in the state where transportation challenges may most impact vulnerable demographic groups, including minority and low-income populations, and others. After discussion, it was determined that Equity Focus Area (EFA) index values from the Wasatch Front Regional Council (WFRC) would be utilized. Later, the Social-Vulnerability Index (SVI) values identified by the Centers for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) were utilized to provide a more robust and complete look at potential equity factors within Utah's transportation system. These values are described in the following subsections.

2.4.1 WFRC Equity Focus Areas Index

As part of their efforts to include equity criteria in planning and development, the WFRC utilizes criteria to identify certain census tracts as Equity Focus Areas (EFAs) (WFRC, n.d.). Census tract population criteria utilized to define these EFAs consists of the following (WFRC, n.d.):

- Greater than 20 percent Low-Income Households
- Greater than 40 percent Persons of Color
- Greater than 10 percent No-Vehicle Households

The WFRC uses these EFAs to target inclusivity and equity goals within transportation contexts. For this study, the WFRC EFA criteria were selected to identify Utah census tracts which, due to their demographic characteristics, may see greater challenges in transportation access, management, quality, and other quality of life indicators, etc. This allowed the research team to focus on these EFAs and confirm relationships between transportation conditions in those locations.

2.4.2 CDC/ATSDR Social Vulnerability Index

WFRC's EFA variables are effective at identifying areas which require greater focus on equity, but they may be somewhat limited due to only including a few variables. The CDC/ATSDR define social vulnerability as potential negative effects on communities and their residents caused by external stressors to human health (ATSDR, 2024). These may include natural/human-caused disasters, disease outbreaks, and other issues. The SVI system utilizes 16 variables from the U.S. census to help identify census tracts that may need more support to prepare for and recover from external stressors, which can be considered ‘high vulnerability.’ Figure 2.1 illustrates the variables suggested by the CDC/ATSDR for SVI analysis. These variables allow census tracts to be identified by variables such as poverty, unemployment, racial demographics, age, language, and other factors, which may indicate higher levels of social vulnerability to health stressors. These variables also tie in well with the Utah Healthy Places Index (HPI) which has a more holistic focus on equity and overall quality of life and wellbeing.

The research team determined that the SVI values would allow for a more comprehensive view of Utah social vulnerability than those employed by the WFRC. The tracts identified as high vulnerability through the SVI variables would be more susceptible to challenges and issues within transportation. The more detailed variables included in the SVI allowed for more tracts to be labeled as “high vulnerability” versus those identified as EFAs by the WFRC and would allow for more in-depth research and analysis. As a result, the analysis described in Section 4 includes both EFA and SVI variables when confirming relationships of census demographic data to transportation infrastructure.

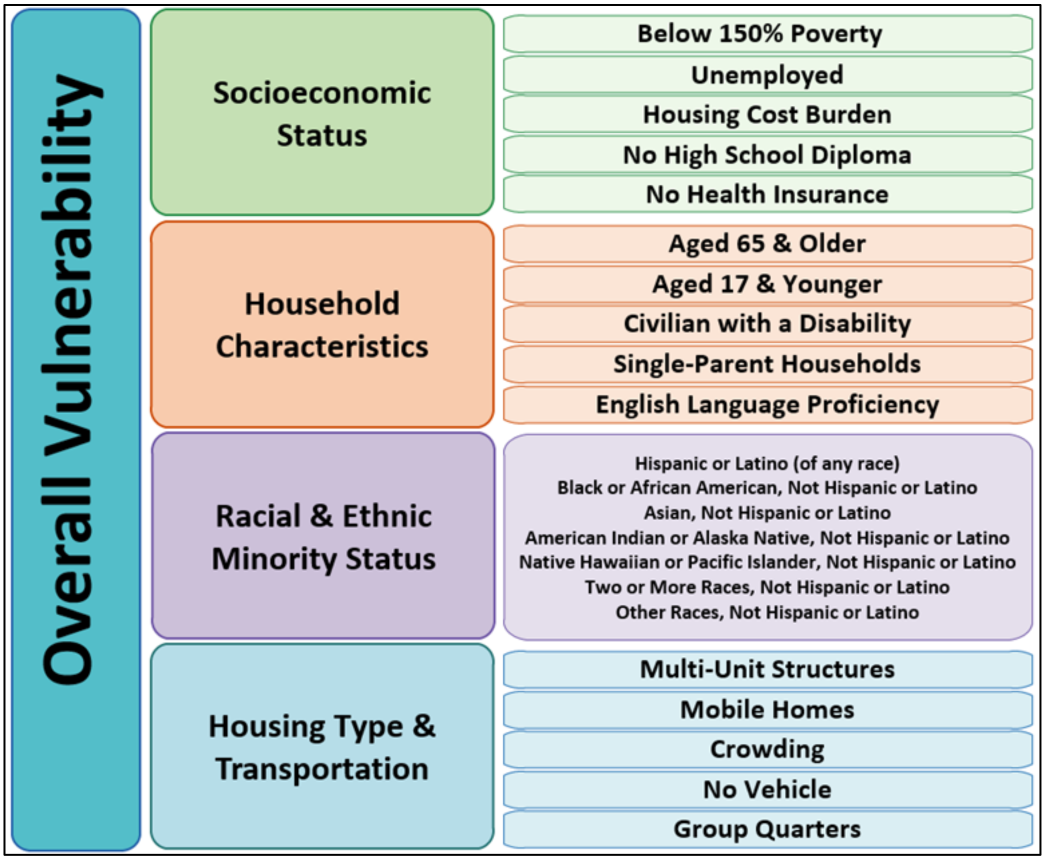

Figure 2.1 CDC/ATSDR SVI Variables

2.5 Summary

The literature review of equity in the field of transportation found that many methods have been explored to evaluate and integrate equity, opportunity, and quality of life into transportation planning and strategy. Effective evaluation of transportation equity utilizes a data-driven approach which includes information on all aspects of the roadway such as infrastructure, pedestrian accessibility, cyclist infrastructure, distribution of infrastructure, demographic data, etc. Integrating equity into transportation projects requires a balance between emphasizing mobility while also ensuring that transportation benefits are distributed equally, and that negative impacts are not disproportionate in who is affected. Community involvement and accurate data should be included within transportation projects to ensure that accuracy and real-world impacts are fully understood. While some challenges integrating equity into transportation remain, a comprehensive strategy can effectively ensure that the system provides necessary benefits and mitigates negative impacts. The research team and UDOT/UTA personnel then determined that this study would examine statewide data to confirm where equity indictors are positive, and where improvement may be needed, using a variety of transportation and demographic data.

3.0 DATA COLLECTION

3.1 Overview

Using background research and coordinating with UDOT personnel, the research team developed a list of datasets that could be utilized in this study. The following sections contain descriptions of the datasets included in this research. These datasets have been used to create a comprehensive database with information that is relevant to equity and quality of life, and which can be used for validation analysis and potentially for future projects. These datasets were compiled from a variety of sources, including the UDOT Data Portal, contact with UDOT personnel, the Utah Geospatial Resource Center (UGRC), and datasets generated from a previous Vulnerable Road User (VRU) project. The datasets were combined into a single comprehensive data set which was utilized for evaluation later described in Section 4.

3.2 Datasets Utilized

The research team reviewed a large amount of data for potential use in this project. Many data types provide valuable information for validating existing relationships and conditions; these include infrastructure data (roadways, intersections, signals); infrastructure quality data (pavement, signage, etc.); demographic information; and others. With feedback from UDOT and UTA personnel, the research team ultimately identified data types thought to provide the most relevant information. These data types are discussed in the following subsections.

3.2.1 Demographics Data and Census Tracts (SVI Dataset)

Demographic information provides important context to this study and is critical for properly correlating transportation infrastructure and equity indicators. These layers include census tract information and other data types which can be used to measure demographic indicators for different locations in the study area and compare them to the infrastructure and maintenance data gathered for the study. This allows for analysis of relationships between transportation characteristics and demographic information.

The research team initially began by exploring individual demographic datasets which could be added to this analysis. However, in reviewing resources, the SVI dataset (sourced from the CDC/ATSDR) categorized by census tract, was selected. This data is organized by Utah census tracts and contains a wide range of information including population and percentage estimates for demographic characteristics, percentiles for different categories, racial makeup, economic characteristics, etc., organized by census tract (716 tracts in total). A selection of the SVI variables deemed most pertinent to this study were selected by the research team, which include the following:

Table 3.1. SVI Demographic Variables Utilized in Statistical Analysis

SVI Variables
% Persons Below 150% Poverty Rate
% Unemployment Rate
% Housing Units with Occupants earning less Than $75,000 per year
% No High School Diploma
% Uninsured
% 65 Or Older
% 17 Or Younger
% Disabled
% Single-Parent Household
% Limited English Proficiency
% Minority Population
% 10+ Unit Housing
% Mobile Homes
% Units Housing More People than Rooms
% Households With No Vehicle
% Persons In Group Quarters
% Other Race (Not Hispanic/Latino)
% Households Without Internet
% Black/African American
% Hispanic or Latino
% Asian
% American Indian/Alaskan Native
% Native Hawaiian/Pacific Islander
% Two or More Races Not Hispanic/Latino
% Other Race Not Hispanic/Latino

3.2.2 Infrastructure Data

These layers contain locations and information for various elements of transportation infrastructure and built environment assets on roadways and intersections within the study area. This includes information on projects, pedestrian infrastructure, roadway infrastructure, transit information, and others. The data here can be compared to the other categories of transportation infrastructure to examine the presence of infrastructure against maintenance and demographic characteristics. This highlights where transportation infrastructure has greater presence, and where gaps or deficiencies may exist within the study area.

- Bike Lanes
    - This dataset shows the location of all bike lanes on state routes and collector roads throughout the state of Utah.
    - Source: VRU Safety Assessment previously conducted by Avenue Consultants.
- Driveways (Asset Data)
    - This dataset is a snapshot of the asset inventory conducted by Mandli Communications in 2019 and includes the location of driveways along state routes. It was collected in the summer of 2019 via LiDAR and Photolog imagery.
    - Source: UDOT Data Portal
- Electronic Program Management (ePM) All Projects
    - This dataset displays all projects in the following categories: past, present, future proposed, funded, and unfunded projects. These project extents are spatially represented from ePM.
    - Source: UDOT Data Portal
- Intersections
    - This dataset contains intersections located along state routes. Descriptive information includes signalization and state route intersection flags.
    - Source: UDOT Data Portal

- Lanes
  - This dataset is a snapshot of the asset inventory conducted by Mandli Communications in 2019 and details the location of lanes along state routes. It was collected in the summer of 2019 via LiDAR and Photolog imagery.
  - Source: UDOT Data Portal
- Pavement Quality
  - Indicates the quality of pavement segments along state routes. Condition field indicates quality as ‘Good,’ ‘Fair,’ ‘Poor,’ and ‘NA’ (not available).
  - Source: This data is sourced from the FHWA and made available from UDOT. It dates from 2017; newer data could not be located during coordination with UDOT.
- Redlining
  - A dataset which contains information regarding historical redlining, which may correspond to historically disadvantaged areas. Redlining data in Utah was available for Salt Lake City and Ogden City.
  - Source: University of Richmond
- Schools - Higher Education
  - Dataset containing the location of higher education institutions throughout the state.
  - Source: UDOT Data Portal
- Schools - K-12
  - Dataset containing the location of K-12 schools throughout the state.
  - Source: UDOT Data Portal
- Shoulders
  - Dataset containing information on shoulder infrastructure on state routes.
  - Source: UDOT Data Portal
- Signal Timing Maintenance
  - Dataset containing information on signal timing maintenance performed during the last five years throughout the state.
  - Source: UDOT Data Portal

- Signs
    - Summary of signs along state roads. Includes a condition field (‘Good,’ ‘Fair,’ and ‘Poor’) and comments describing condition of the sign.
    - Source: UDOT Data Portal
- Speed Limit
    - Dataset containing information on speed limits on state routes throughout the state.
    - Source: UDOT Data Portal
- Transit Stops and Boardings
    - This dataset shows transit stops within the overall transit network. The data includes transit stop name, route, mode, as well as a record of boardings and alightings. Records of boardings were utilized for this study.
    - Source: UTA Data Portal
- UDOT Safety Comments
    - This dataset contains comments on potential hazards, safety issues, infrastructural observations, and other concerns related to transportation from UDOT personnel. The data used in the study stems from June 2023.
    - Source: VRU Safety Assessment previously conducted by Avenue Consultants.

3.3 Built Environment and Infrastructure Variables Final Dataset Compilation

The datasets and files described in previous sections were stored within an ArcGIS Pro project. The spatial join function was utilized to join the various BE and infrastructure data to the SVI census tract information, resulting in several datasets which contained infrastructure variables attached to demographic information. These datasets were extracted into the software R. Then, R software was used to clean the data and calculate infrastructure variables for each of the 716 census tracts within the state, which is further described below.

3.3.1 Infrastructure Variables

After performing spatial joins within ArcGIS Pro, several separate datasets containing SVI demographic data combined with a particular infrastructure variable (e.g., shoulders, transit stops, etc.) needed to be compiled into a single dataset. The research team discussed how to represent infrastructure variables the best within each census tract. The team determined that the presence of each variable within each SVI census tract would be calculated in the best way to conduct statistical evaluations described in Section 4, typically by calculating a percentage or a hard count. The table below describes how each infrastructure variable was calculated for each census tract.

Table 3.2. Calculated Infrastructure Variables

Infrastructure Type	Measured Variable within Census Tract
Bike Lanes	% of roads with bike lanes
Driveway	Total number
ePM All Projects	Number
Intersections	% of signalized intersections
Lanes	Average number of lanes on roads
Pavement Messages	Total number
Pavement Quality	% of condition in fair/poor
Redlining	Yes/No
Schools Higher Education	Total number
Schools K-12	Total number
Shoulders	% of paved shoulders
Signal Timing Maintenance	Total number
Signs	% of condition in fair/poor
Speed Limit	% of roads with speed limit above 40 MPH
Trails and Pathways	Total number
Transit Stops and Boardings	% above 20 boardings
UDOT Safety Comments	Total number

These variables were calculated for each infrastructure data type in each of the 716 census tracts statewide in the R software. The resulting variables were then rejoined back with the SVI variables identified in subsection 3.2.1. The resulting dataset consists of demographic information for each census tract, along with infrastructure variables. This final data set was then utilized for analysis described in Section 4.

3.4 Summary

The research team determined that using SVI demographic data and infrastructure datasets from UDOT would provide the best opportunities to validate statewide transportation conditions in correlation with census tract data. An SVI demographic dataset based on Utah census tracts was obtained, and the UDOT data portal and other sources were utilized to gather various datasets related to infrastructure and other equity indicators. ArcGIS Pro software was utilized to spatially join each infrastructure dataset to the demographic information, and R software was utilized to calculate a ratio (either a percentage, count, or other value) of each variable for each census tract in the state (e.g., percentage of signalized intersections). After values were calculated, the data was all joined into a single comprehensive dataset which contained demographic information and infrastructure variables for each census tract in Utah. These calculated values could provide an indication of investment in transportation infrastructure in each census tract. This would allow the research team to identify where transportation investment has occurred and highlight potential equity disparities geospatially.

4.0 DATA EVALUATION

4.1 Overview

The data for this study was collected as described throughout Section 3. As noted previously, the research team gathered and organized data by census tracts in Utah. Within Utah's 29 counties, there are 716 total census tracts. The number of census tracts by county is displayed in Table 4.1, which shows that a majority of census tracts are found in more urban areas, with Salt Lake and Utah counties accounting for more than half (56 percent). Rural areas typically have significantly fewer tracts. Summary statistics for demographic and built environment information in these tracts are described in Sections 4.2 and 4.3.

Table 4.1. Utah Census Tracts by County

County	Tract #	County	Tract #
Beaver	2	Piute	1
Box Elder	12	Rich	1
Cache	28	Salt Lake	251
Carbon	5	San Juan	4
Daggett	1	Sanpete	7
Davis	66	Sevier	5
Duchesne	4	Summit	14
Emery	3	Tooele	17
Garfield	2	Uintah	8
Grand	3	Utah	156
Iron	12	Wasatch	10
Juab	2	Washington	35
Kane	2	Wayne	1
Millard	3	Weber	58
Morgan	3		
Total: 716			

4.2 Descriptive Statistics of Demographics

As described in Section 3, demographic information from this study was obtained from the Utah SVI dataset, which organizes demographic information by census tracts. Demographic variables included in the analysis included percentages based on race, income, housing type, and other factors. To provide an overview of statistics for these variables throughout the state, percentages across the census tracts were averaged; Table 4.2 displays statewide means for demographic information in Utah. Standard deviation (SD) for each variable was also included.

Table 4.2. Statewide Demographic Information

Demographic Variable	Mean	SD
% of Impoverished Persons	17.33	13.16
% of Unemployed Persons	3.66	2.70
% of Households with Income Under $70,000 per Year	23.01	11.02
% of Persons with No High School Diploma	7.09	6.32
% of Uninsured Persons	9.14	6.72
% of Persons Over 65 Years of Age	11.42	6.74
% of Persons Under 17 Years of Age	28.23	9.04
% of Disabled Persons	10.05	4.43
% of Single-Parent Households	5.05	4.02
% of Persons with Limited English Proficiency	2.16	3.01
% of Minority Population	21.82	15.62
% of Housing in 10 or More Unit Structures	10.58	16.60
% of Housing in Mobile Homes	2.78	5.66
% of Overcrowded Households*	3.48	4.58
% of Households with No Vehicle	3.79	4.78
% of Persons in Group Quarters	2.04	8.51
% of Households with No Internet	8.47	8.91
% African American Population	1.15	2.26
% Hispanic Population	13.98	11.99
% Asian Population	2.28	3.20
% Native American Population	0.97	5.17
% Native Hawaiian/Pacific Islander Population	0.90	1.93
% Two or More Races Population	2.52	2.14
% Other Race Population	0.21	0.58

*Defined in the SVI as more than one person per room.

Notable statistics across Utah include a much higher younger population (under 17 years) than older (over 65 years); a significantly higher Hispanic population versus other minority groups (roughly 14 percent versus less than 3 percent for all others); and 17 percent impoverished persons. Higher occurrences of these variables may indicate areas which are more vulnerable to negative impacts and/or are underserved, and as such would be sensitive to impacts from transportation systems.

These statistics vary by census tract; variables may change between urban and rural areas, different parts of urbanized areas, etc. The standard deviation measure provides an indication of how much variation may occur in a variable across the 716 census tracts. Notable variables with high standard deviations include Percentage of Impoverished Persons, Percentage of Households with annual income Under $70,000, Percentage of Minority Population, Percentage of Housing in 10 or More Unit Structures, and Percentage Hispanic Population. These variables will see a high degree of change between different census tracts. More consistent variables include Percentage of Unemployed Persons, Percentage of Persons with Limited English Proficiency, and Population Percentage of African-American, Asian, Native Hawaiian/Pacific Islander, Two or More Races, and Other Races. These variables are less likely to vary from tract to tract, indicating that they are clustered more heavily in a few census tracts across the state.

4.3 Descriptive Statistics of the Built Environment

Built environment variables were gathered as described in Section 3 and calculated for each census tract, similar to the process used for the demographic information. To provide an overview of these built environment variables across the state, variables were averaged along with a standard deviation measure. Table 4.3 provides the results.

Table 4.3. Statewide Built Environment Information

Built Environment Variable	Mean	SD
% of Tracts with Historical Redlining	0.11	0.32
Number of K-12 Schools	1.73	1.50
Number of Higher Education Institutions	0.11	0.37
% of Intersections That Are Signalized	0.24	0.30
Number of Safety Comments	0.35	0.93
Number of Trails or Paths	60.35	180.71
% of Roads with Speed Limits Over 40 Mph	0.74	0.36
% of Roads with Paved Shoulders	0.67	0.35
% of Signs That Are in Fair/Poor Condition	0.09	0.08
Number of Signals That Have Received Maintenance	1.94	2.45
% of Roads with Bike Lanes	0.09	0.08
Number of Driveways	56.95	90.10
Average Number of Roadway Lanes	3.91	2.12
Number of Pavement Messages	59.33	63.89
% of Transit Stops With 20+ Boards Per Day	0.36	0.37
% of Pavement Segments in Fair/Poor Condition	0.55	0.34

Similar to the summary statistics for demographic information, these variables will differ heavily across the state. Notable statistics include a very low percentage of roads with bike lanes overall (less than 10 percent), a high percentage of pavement in fair or poor condition (55 percent), and a low average number of signals which have received maintenance (1.94). Historical redlining was also fairly low (11 percent), however, it should be noted that redlining data in Utah is limited to the cities of Ogden and Salt Lake City, where redlining was historically present and more impactful.

Standard deviation measures help indicate if variables are more likely to vary between census tracts. Notably, Number of Trails or Paths, ePM Projects, Driveways, and Pavement Messages have high standard deviations, indicating that these variables will change in presence significantly across the state. For example, trails and paths are likely much more prevalent in southern and rural Utah than in urbanized areas, while pavement messages would likely be more prevalent in places of higher street density. Educational institutions, speed limits, signs in fair/poor condition, transit stops with 20+ boardings per day, and pavement segments in fair/poor condition had two standard deviation measures.

4.4 WFRC Equity Focus Areas (EFAs) and the Built Environment

The WFRC EFAs include areas with greater than 25 percent low-income households, greater than 40 percent persons of color, and greater than 10 percent zero-car households. Out of the 716 census tracts in Utah, 16 of them (2.2 percent) meet these criteria. These 16 tracts are represented in Figure 4.1 below. As the figure shows, a majority of the 16 tracts are in the Salt Lake City area, with several additional tracts in central Ogden, and two tracts in San Juan County in the southeastern portion of the state.

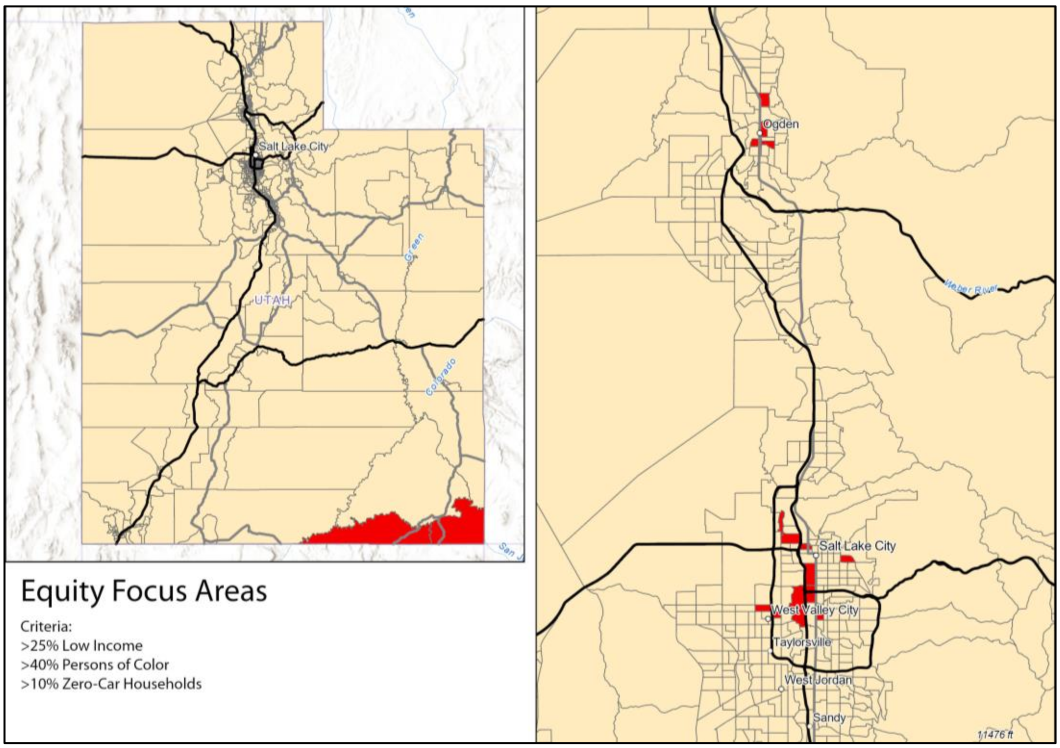

Figure 4.1 Utah Census Tracts that Meet EFA Criteria

4.4.1 Summary Statistics of Demographic and Built Environment Characteristics

Summary statistics were created based upon the EFA tracts throughout Utah. These statistics provide greater insight into the state of transportation infrastructure, demographic information, and other factors within EFAs, and can be compared to information in other census tracts. Table 4.4 provides descriptive statistics based on demographic information in the EFA tracts, along with the same measures for all other tracts for comparative purposes.

Table 4.4. EFA Demographic Characteristics and Other Tracts

	WFRC EFAs		Other Tracts	
Demographic Variable	**Mean**	**SD**	**Mean**	**SD**
% of Impoverished Persons	41.54	10.53	16.78	12.69
% of Unemployed Persons	9.14	6.85	3.53	2.39
% of Households with Annual Income Under $70,000	37.79	12.13	22.67	10.77
% of Persons with No High School Diploma	19.73	6.66	6.80	6.01
% of Uninsured Persons	20.98	9.25	8.87	6.41
% of Persons Over 65 Years of Age	8.39	4.27	11.49	6.77
% of Persons Under 17 Years of Age	24.19	8.39	28.33	9.04
% of Disabled Persons	13.99	6.45	9.96	4.33
% of Single-Parent Households	10.10	4.79	4.93	3.93
% of Persons with Limited English Proficiency	7.43	4.21	2.04	2.87
% of Minority Population	61.34	18.33	20.92	14.35
% of Housing in 10 or more Unit Structures	33.33	27.86	10.06	15.91
% of Housing in Mobile Homes	4.68	9.61	2.74	5.54
% of Overcrowded Households*	10.12	6.35	3.33	4.42
% of Households with No Vehicle	16.03	6.04	3.51	4.37
% of Persons in Group Quarters	7.11	17.87	1.93	8.16
% of Households with No Internet	25.76	24.02	8.07	7.86
% African American Population	5.28	4.46	1.06	2.09
% Hispanic Population	30.90	16.95	13.59	11.58
% Asian Population	5.54	7.78	2.21	2.99
% Native American Population	13.01	30.77	0.69	1.85
% Native Hawaiian/Pacific Islander Population	2.88	4.20	0.85	1.82
% Two or more Races	3.26	2.11	2.50	2.14
% Other Race Population	0.46	0.67	0.20	0.58
N=716	N=16		N=700	

*Households where there are more occupants than rooms

As Table 4.4 shows, EFAs have much higher percentages of variables such as poverty, single-parent households, minority populations, non-single-family housing types (such as multi-unit dwellings and mobile homes), overcrowded or overburdened housing, and other variables. This indicates that these populations may be more vulnerable to negative impacts from transportation and other inequities. Standard deviation measures also indicate that EFAs see more variability from tract to tract than other non-EFA tracts, though this is not always the case. These results were largely expected as they are in line with the WFRC's criteria for determining EFAs.

A similar comparison was made for BE factors, by averaging summary statistics for each EFA. Table 4.5 shows the mean percentages and values for each of the BE variables for the EFAs, as well as other census tracts for comparative purposes.

Table 4.5. Built Environment Characteristics for WFRC EFAs and Other Tracts

	WFRC Equity Focus Areas		All Other Census Tracts	
	Mean	SD	Mean	SD
Number of K-12 Schools	2.00	1.414	1.73	1.50
Number of Higher Education Institutions	0.25	0.44	0.11	0.37
Percentage of Intersections That Are Signalized	0.39	0.34	0.24	0.30
Number of Safety Comments	0.75	1.53	0.34	0.91
Number of Trails or Paths	14.00	16.87	61.41	182.61
Percentage of Roads with Speed Limits Over 40 MPH	0.65	0.24	0.73	0.36
Number of ePM Projects	65.19	77.85	52.30	61.50
Percentage of Roads with Paved Shoulders	0.76	0.21	0.66	0.36
Percentage of Signs That Are in Fair/Poor Condition	0.12	0.07	0.08	0.08
Number of Signals That Have Received Maintenance	2.69	3.30	1.92	2.42
Percentage of Roads with Bike Lanes	0.15	0.09	0.09	0.08
Number of Driveways	47.25	34.54	57.17	90.97
Average Number of Roadway Lanes	4.84	1.65	3.89	2.12
Number of Pavement Messages	71.06	64.50	59.06	63.90
Percentage of Transit Stops With 20+ Boards Per Day	0.44	0.24	0.36	0.37
Percentage of Pavement Segments in Fair/Poor Condition	0.79	0.27	0.55	0.34
N=716	N=16		N=700	

There is notable variety in results regarding built environment factors. EFAs in many cases have more traffic infrastructure types present than non-EFA tracts. Higher percentages of infrastructure include signalized intersections, paved shoulders, and pavement messages. EFAs also have more instances of signal maintenance, and fewer roadways with speed limits over 40 MPH. EFAs also see more instances of roads with bike lanes available. However, EFAs have roadways with more lanes on average, more signs in fair/poor condition, and more safety comments and concerns noted by UDOT previously. Another notable result is that EFAs see a significantly lower presence of trails and pathways; this is likely due to many EFAs being in urban areas where such routes are not as prevalent and are more difficult to build.

4.4.2 Built Environment EFAs Independent Samples *t*-Test

An independent samples *t*-Test was conducted to further compare WFRC EFAs to non-EFA census tracts. Results of the *t*-Test are included in Table 4.6 below.

Table 4.6. Independent Samples *t*-Test: EFAs and Built Environment Characteristics

	Mean Values		Statistics		95% Confidence Interval	
	EFAs	**Other**	***t***	***Sig***	**Lower**	**Upper**
Redlining (% of Tracts)	0.56	0.10	-5.816	<0.001	-0.334	0.034
Number of K-12 Schools	2.00	1.73	-0.715	0.237	-1.017	0.474
Number of Higher Ed Institutions	0.25	0.11	-1.492	0.06	-0.321	0.044
Percentage of Intersections That Are Signalized	0.39	0.24	-2.001	0.023	-0.296	-0.002
Number of Safety Comments	0.75	0.34	-1.735	0.042	-0.865	0.053
Number of Trails or Paths	14.00	61.41	1.038	<0.150	-42.293	137.110
Percentage of Roads with Speed Limits Over 40 mph	0.65	0.73	0.931	0.176	-0.094	0.264
Number of ePM Projects	65.19	52.30	-0.824	0.205	-43.609	17.834
Percentage of Roads with Paved Shoulders	0.76	0.66	-1.089	0.138	-0.272	0.078
Percentage of Signs That Are in Fair/Poor Condition	0.12	0.08	-2.118	0.017	-0.077	-0.002
Number of Signals That Have Received Maintenance	2.69	1.92	-1.244	0.107	-1.983	0.445
Percentage of Roads with Bike Lanes	0.15	0.09	-2.945	0.002	-0.095	-0.019
Number of Driveways	47.25	57.17	0.435	0.332	-34.834	54.668
Average Number of Roadway Lanes	4.83	3.89	-1.771	0.038	-1.994	0.102
Number of Pavement Messages	71.06	59.06	-0.742	0.229	-43.725	19.728
Percentage of Transit Stops with 20+ Boardings per day	0.44	0.35	-0.900	0.184	-0.265	0.098
N=716	N=16		N=700			

4.4.3 WFRC EFA Mapping Results

Several maps were created which visualize data results regarding the EFA tracts in Utah. As stated previously, 16 census tracts in Utah qualify as EFAs. ArcGIS Pro software was utilized to map infrastructure variables in each of these census tracts. The figures below show mapping results. Analysis of the maps reveals several visual trends which can be compared to findings from statistical analysis. Generally, more investment in infrastructure has appeared to occur within tracts in urban areas, due to the needs of higher populations. More signalized intersections and pavement messages (Figure 4.7 and 4.9) are present in more urbanized areas generally, for example. Certain tracts have seen more projects initiated and maintenance performed (Figure 4.4 and 4.14). Salt Lake City EFAs appear to have seen higher levels of maintenance than the tracts in Ogden. Another note from these maps indicates that more infrastructure and projects are commonly found near the I-15 corridor and the EFAs in those areas.

The map of EFAs which are considered within historical redlined areas (Figure 4.10) reveals that nine of the 16 total tracts (including all the EFAs in Ogden) are areas of historical redlining, indicating that many of these areas historically have faced equity challenges. A review of road sign condition (Figure 4.15) shows that many of the EFAs have higher levels of road signs in ‘fair’ and ‘poor’ condition. Many of these EFA tracts also have a higher average number of roadway lanes present and higher speed limits (over 40 MPH), indicating busier roadways where residents may be exposed to more traffic (Figure 4.12 and 4.16). Figure 4.13 also shows the distribution of safety-related comments made by UDOT personnel across the EFAs in June 2023; most of these EFAs had one (or fewer) comment associated with the tract, however, two tracts in central Salt Lake County have two or more comments in total.

Data for bike lanes (Figure 4.2) and trails (Figure 4.17) shows that a fair number of roadways are present in most of the EFAs, particularly in Salt Lake County, while little to no bike lanes are present in the EFAs in San Juan County. In contrast, there are fewer trails and paths present in the city areas, while more are present in San Juan County. Some EFAs in northern Salt Lake City and central Ogden have a higher number of trails and paths than the other city EFAs. Overall key takeaways from mapping of the EFAs are that more activity in transportation projects and infrastructure has taken place around the I-15 corridor, however, these tracts may also see higher numbers of multi-lane roads, higher speed limits, and other factors that may impact residents. There is variation in the amount of maintenance and upkeep that has occurred in these EFAs; less appears to have been performed in Ogden than in Salt Lake City. Most of the EFAs fall within historical redlined areas.

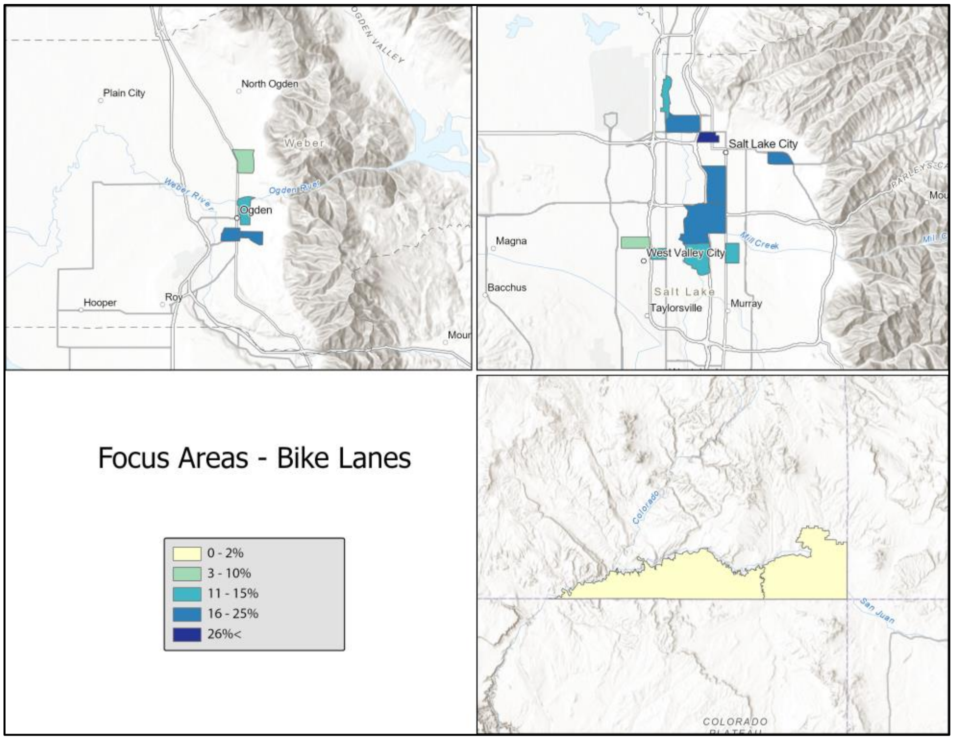

Figure 4.2 EFA Tracts – Bike Lanes

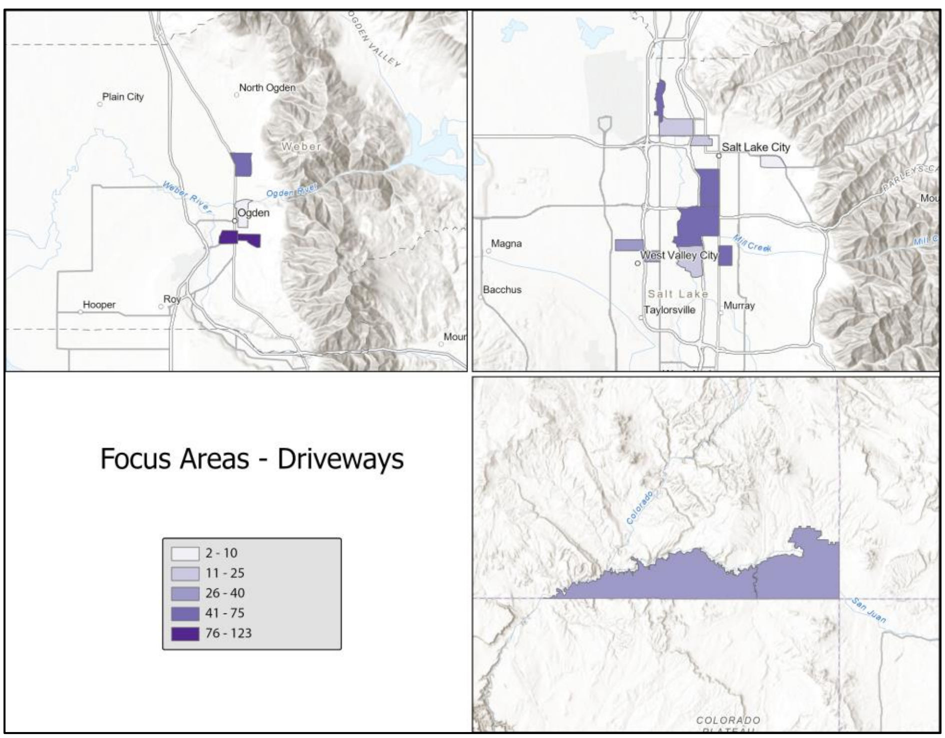

Figure 4.3 EFA Tracts – Driveways

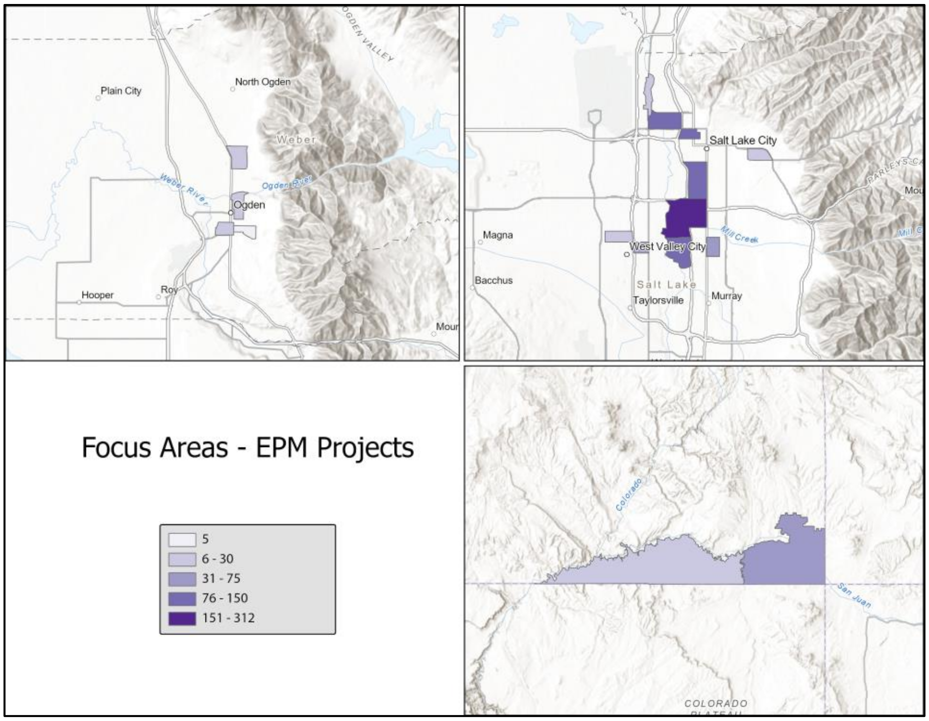

Figure 4.4 EFA Tracts – ePM Projects

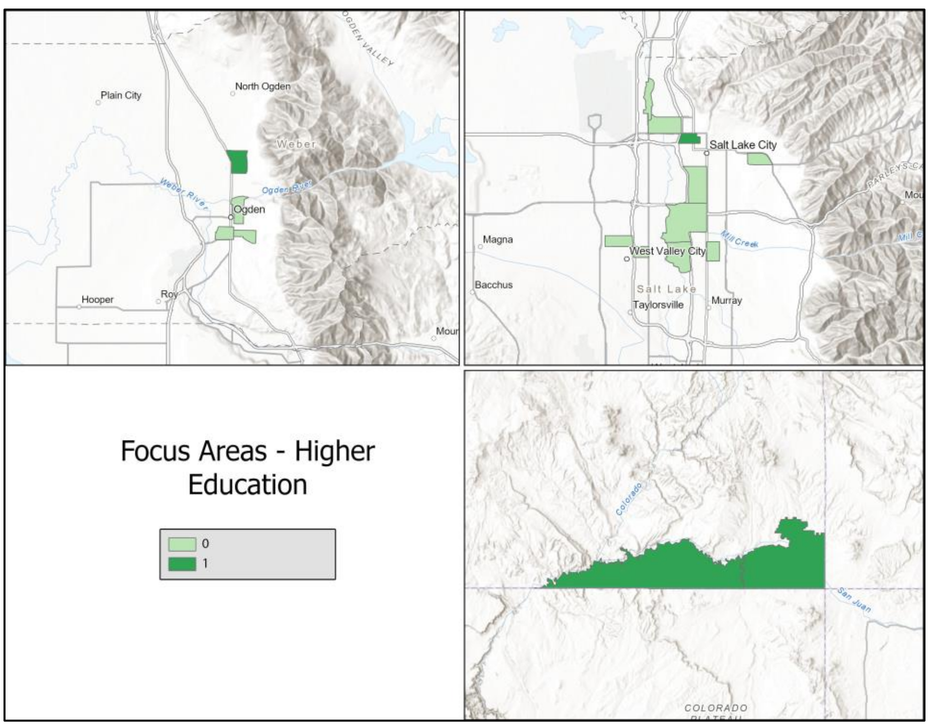

Figure 4.5 EFA Tracts – Higher Education

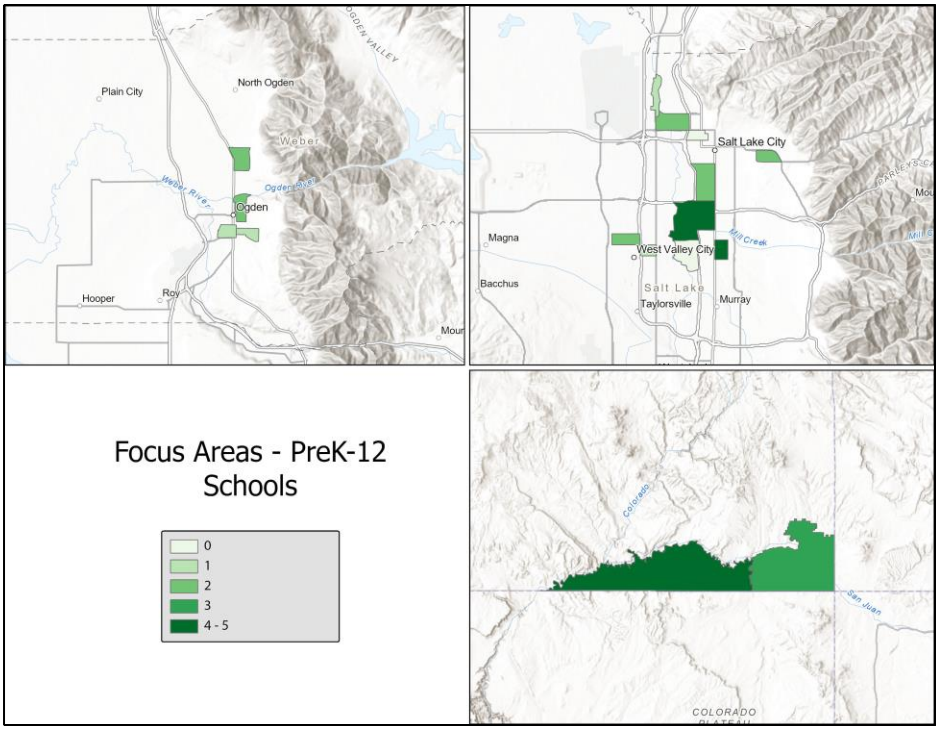

Figure 4.6 EFA Tracts – K-12 Schools

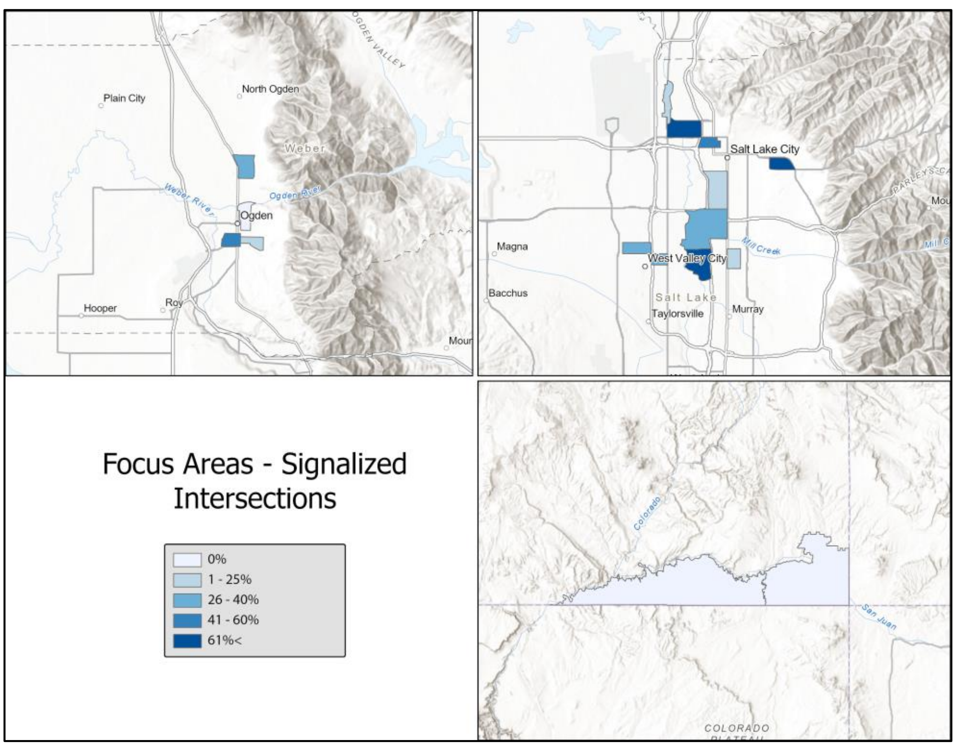

Figure 4.7 EFA Tracts – Signalized Intersections

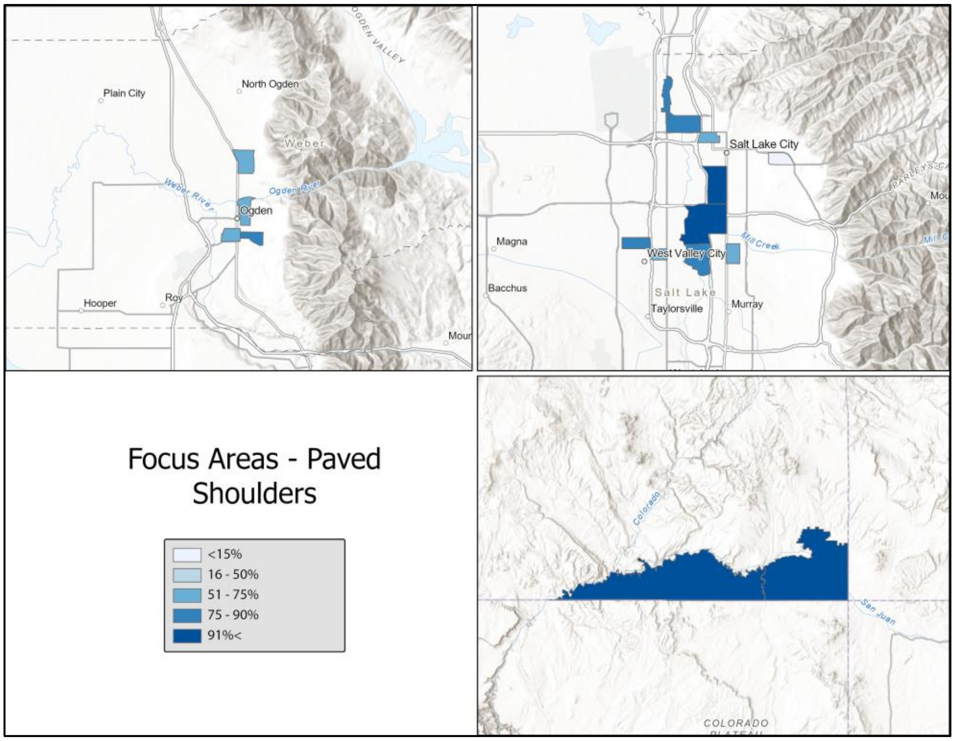

Figure 4.8 EFA Tracts – Paved Shoulders

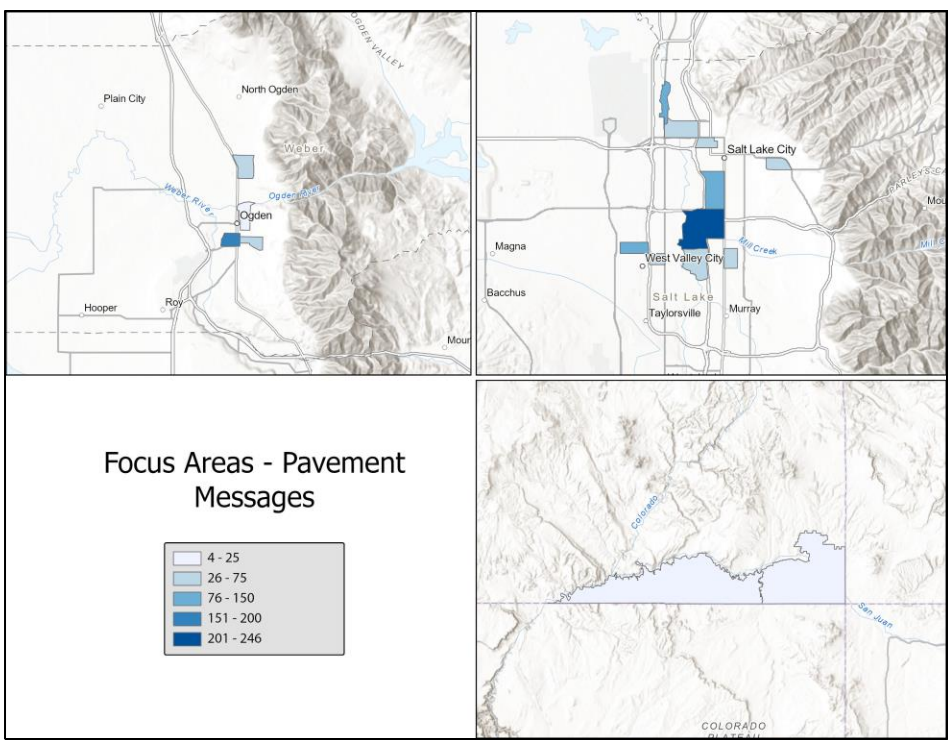

Figure 4.9 EFA Tracts – Pavement Messages

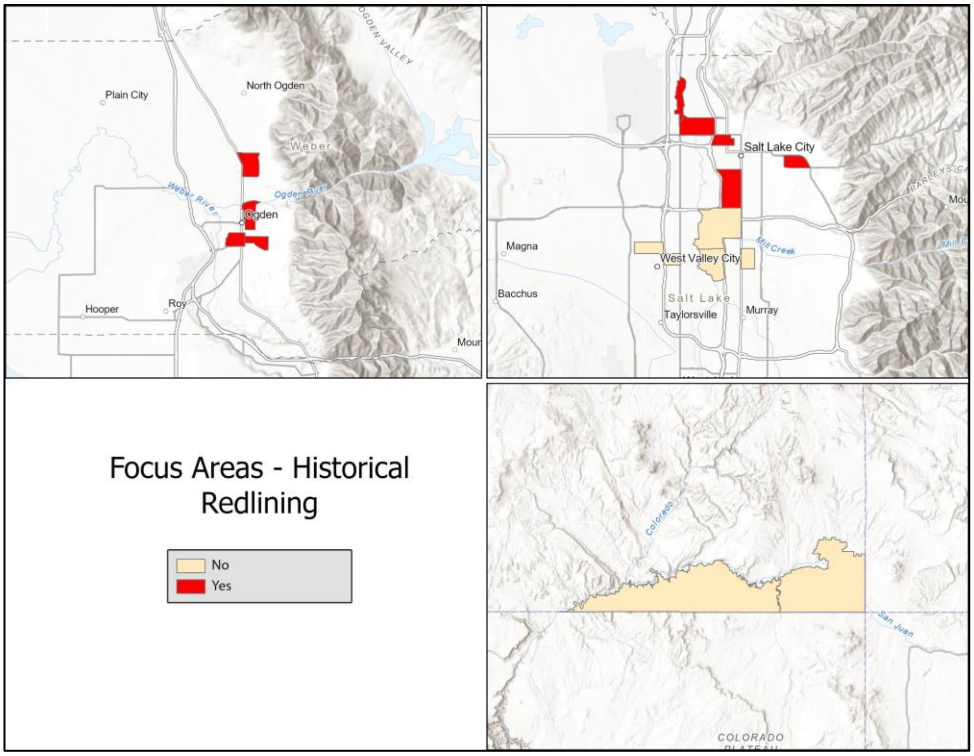

Figure 4.10 EFA Tracts – Historical Redlining

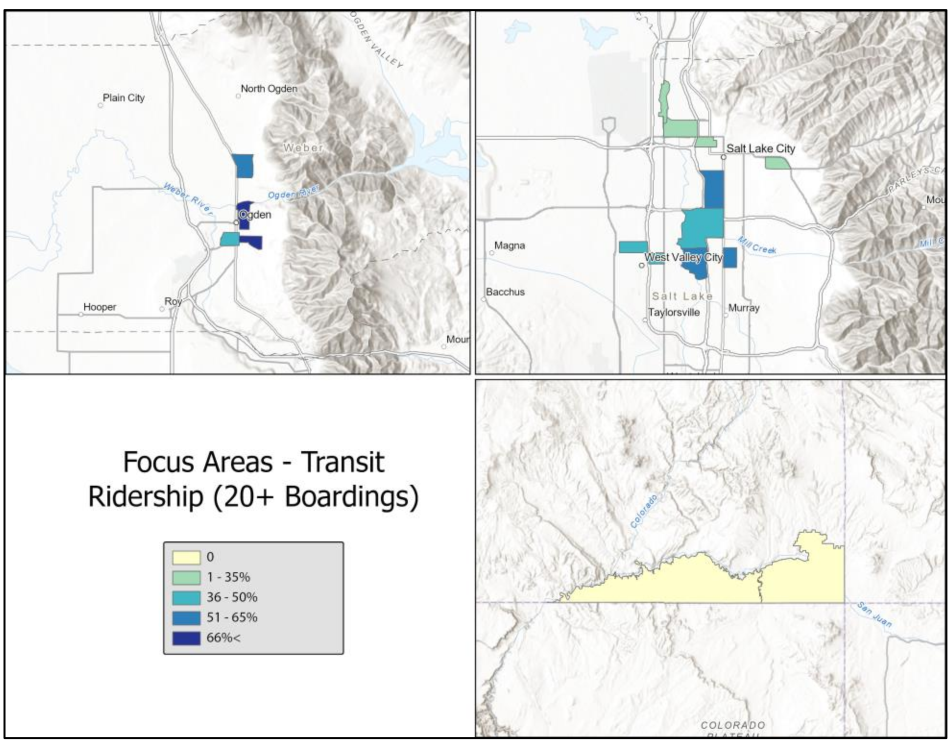

Figure 4.11 EFA Tracts – Transit Ridership

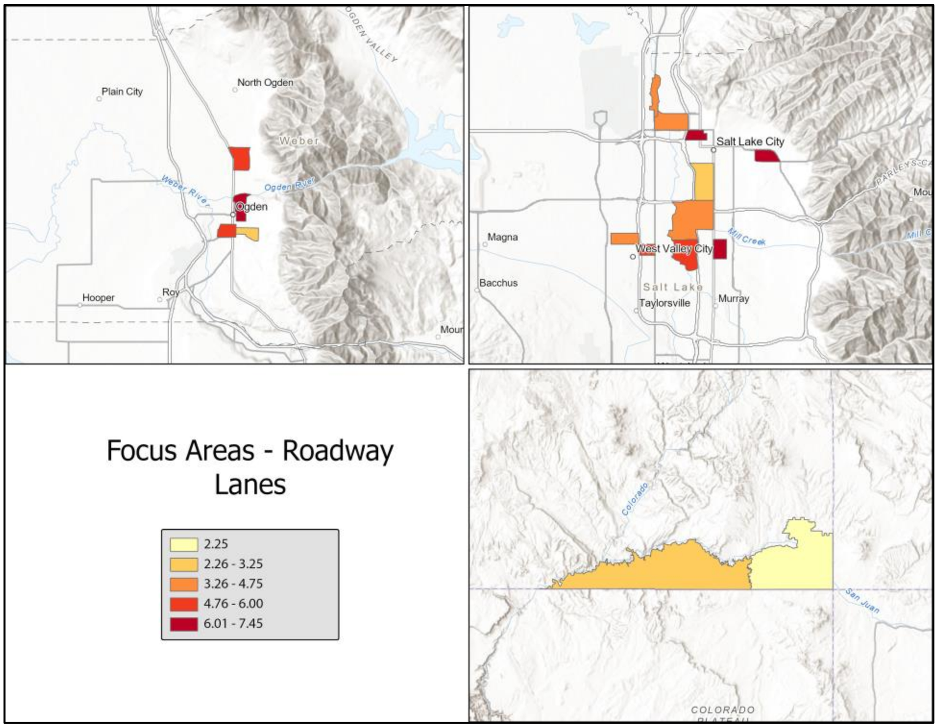

Figure 4.12 EFA Tracts – Roadway Lanes

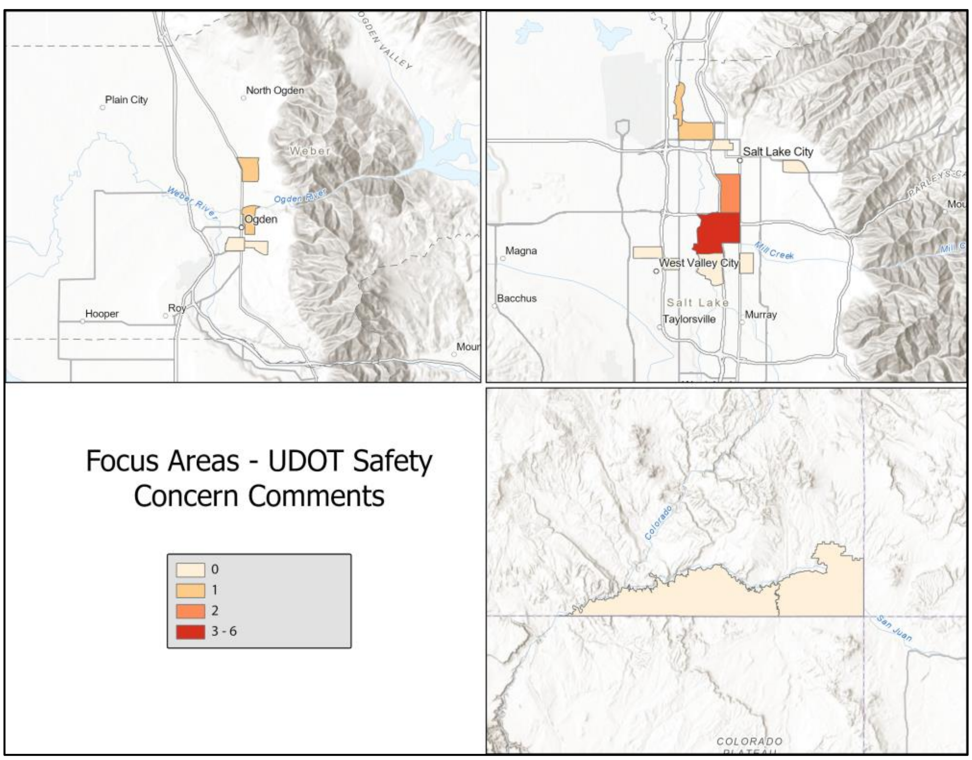

Figure 4.13 EFA Tracts – UDOT Safety Comments

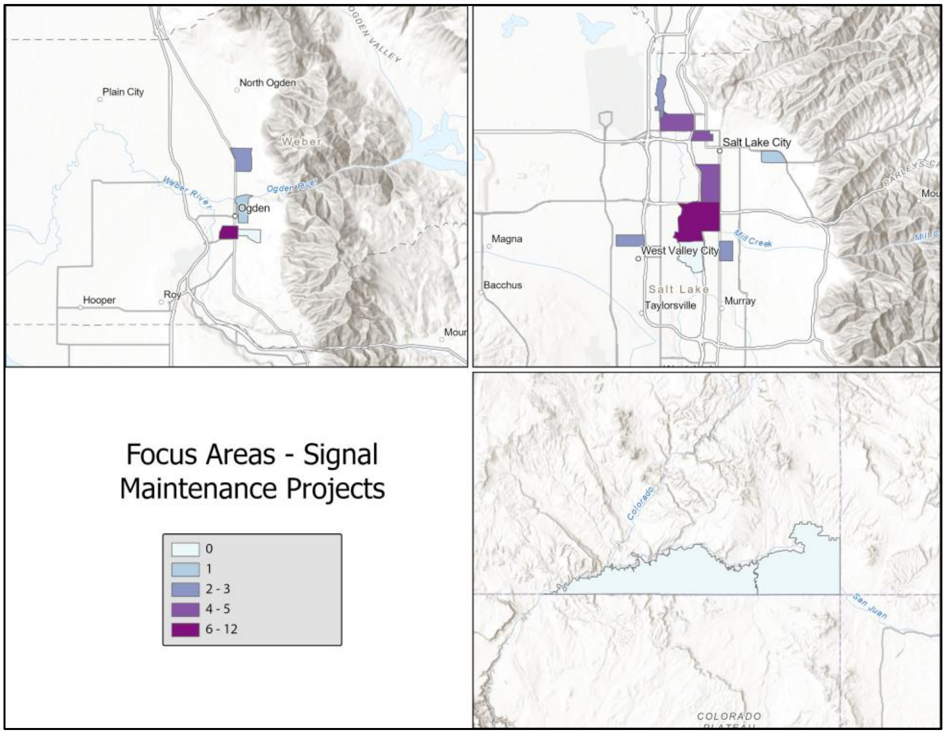

Figure 4.14 EFA Tracts – Signal Maintenance

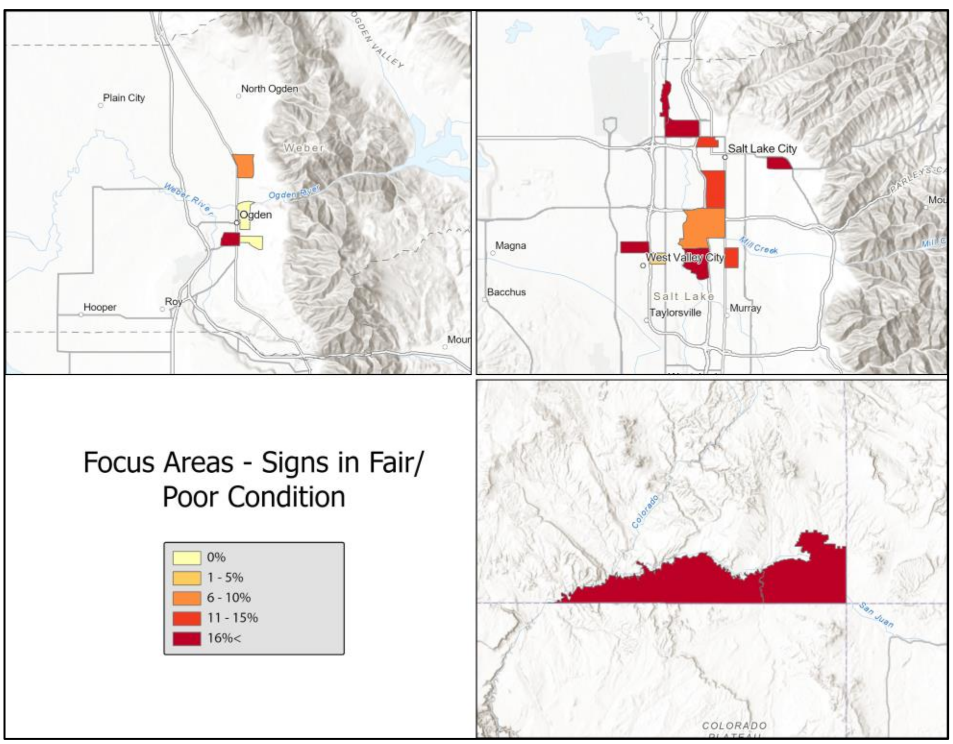

Figure 4.15 EFA Tracts – Road Sign Condition

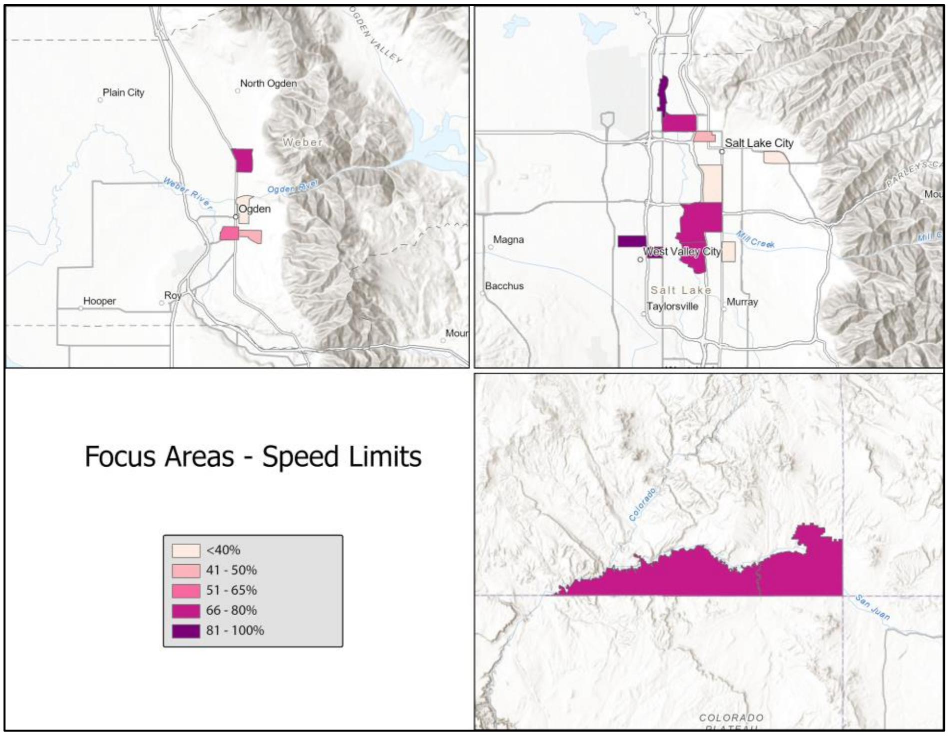

Figure 4.16 EFA Tracts – Speed Limits Over 40 MPH

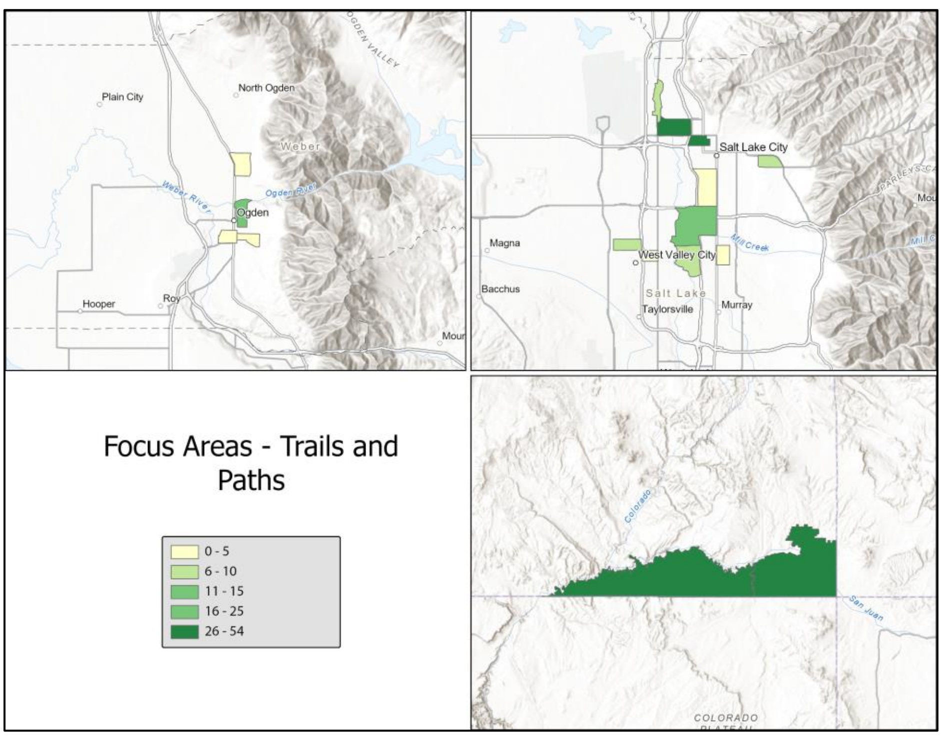

Figure 4.17 EFA Tracts – Trails and Paths

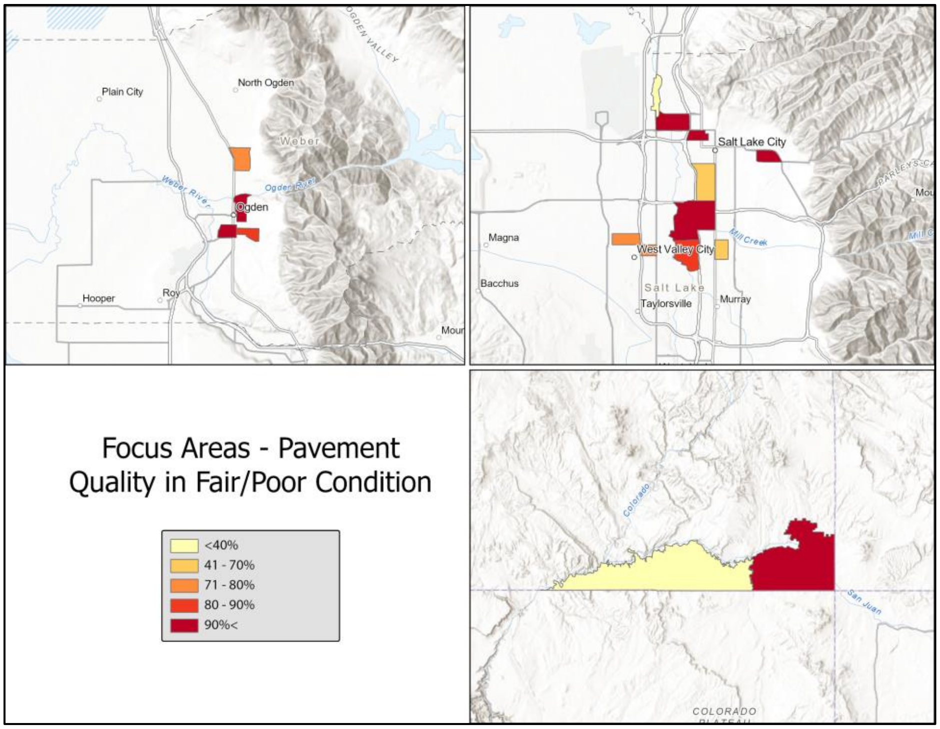

Figure 4.18 EFA Tracts – Pavement Quality

4.5 Social Vulnerability Index (SVI) and the Built Environment

The SVI, described in Section 3.2, evaluated demographic criteria within four major categories: socioeconomics, household characteristics, racial and ethnic minority status, and housing type/transportation. If a majority of the criteria within a category was recognized as high, the category was given a “red flag” for the tract. If a tract exhibited a “red flag” measure in three or more categories, the tract was determined to be of “high vulnerability.” The preliminary analysis of the dataset determined that 152 census tracts (21 percent) in Utah could be categorized as having high vulnerability. These tracts are shown in Figure 4.19. These tracts are well dispersed throughout the state, with many located in urban areas such as Salt Lake County, Ogden, Utah County, and St. George. Several rural census tracts are also identified as having a high vulnerability by SVI criteria.

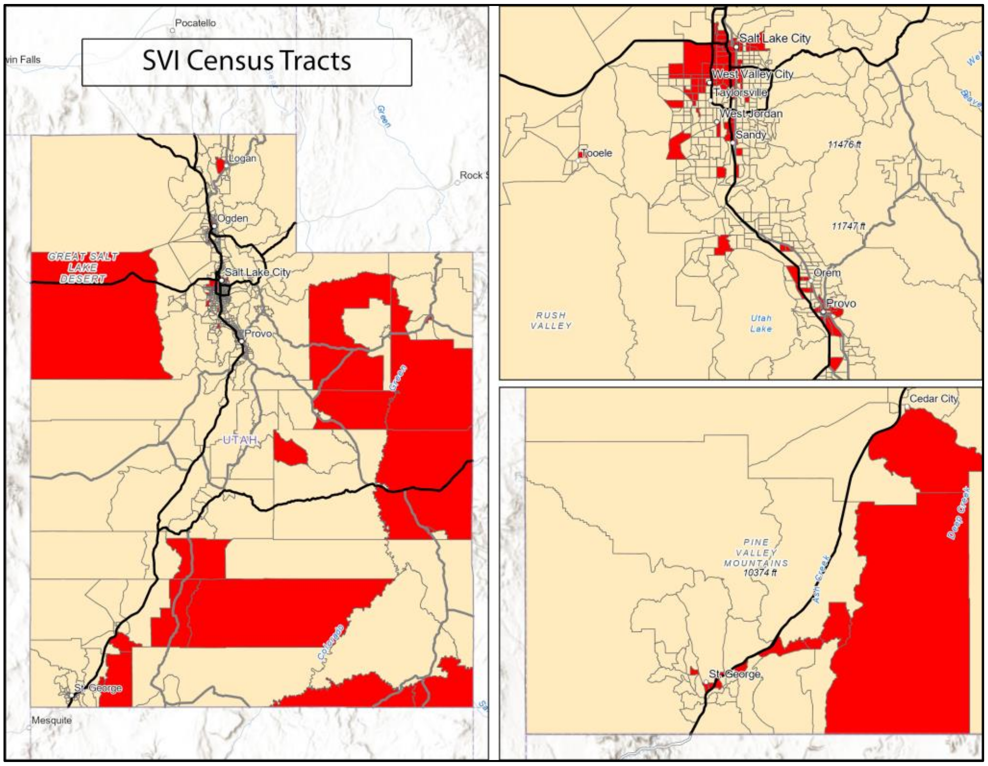

Figure 4.19 SVI Census Tracts

4.5.1 Summary Statistics of Demographic and Built Environment Characteristics

As with the EFA tracts, summary statistics were created for the tracts which were identified as high vulnerability according to SVI criteria. These statistics provide an overview of the state of transportation infrastructure and demographics within SVI tracts, and in the same manner as the EFAs can be compared to the other non-SVI tracts. Table 4.7 contains descriptive statistics based on demographic information in the high SVI tracts, along with the same measures for all other tracts for comparative purposes.

Table 4.7. High SVI Demographic Characteristics and Other Tracts

	High SVI Tracts		Other Tracts	
Demographic Variable	**Mean**	**SD**	**Mean**	**SD**
% of Impoverished Persons	32.68	15.30	13.20	8.75
% of Unemployed Persons	5.18	3.84	3.24	2.11
% of Households with Annual Income Under $70,000	34.38	12.47	19.94	8.26
% of Persons with No High School Diploma	13.56	8.38	5.33	4.15
% of Uninsured Persons	16.31	8.14	7.18	4.66
% of Persons Over 65 Years of Age	9.46	6.47	11.95	6.72
% of Persons Under 17 Years of Age	24.11	10.10	29.35	8.41
% of Disabled Persons	12.50	5.95	9.38	3.64
% of Single-Parent Households	7.26	5.72	4.45	3.17
% of Persons with Limited English Proficiency	5.13	4.39	1.36	1.81
% of Minority Population	38.72	19.98	17.27	10.25
% of Housing in 10 or More Unit Structures	24.88	24.80	6.72	10.71
% of Housing in Mobile Homes	5.46	8.33	2.05	4.42
% of Overcrowded Households*	7.43	7.57	2.42	2.43
% of Households with No Vehicle	7.96	7.24	2.66	2.98
% of Persons in Group Quarters	5.43	14.02	1.13	5.94
% of Households with No Internet	15.87	14.01	6.47	5.42
% African American Population	2.06	2.72	0.90	2.04
% Hispanic Population	25.35	16.32	10.88	8.12
% Asian Population	3.75	4.85	1.89	2.44
% Native American Population	2.64	10.74	0.52	1.33
% Native Hawaiian/Pacific Islander Population	1.72	3.09	0.67	1.38
% Two or More Races	2.97	2.88	2.40	1.87
% Other Race Population	0.24	0.51	0.19	0.60
N=716	N=152		N=564	

*Households where there are more occupants than rooms

As can be seen in Table 4.7, and similarly to EFAs, high SVI tracts have higher percentages of variables which indicate potential vulnerability. This includes higher rates of poverty, single-parent households, uninsured persons, minority populations, much higher rates of persons in mobile homes and multi-unit dwellings, and other similar variables. These findings indicate that the population in these SVI tracts may be more vulnerable to negative impacts from transportation and other inequities. Similar to the EFA tracts, there is often a higher standard deviation present among variables within SVI tracts, which indicates that variability in these characteristics is greater in high SVI areas.

A similar comparison was made for built environment factors. Table 4.8 below shows the mean percentages and values for each of the built environment variables for the high SVI tracts, as well as other census tracts for comparative purposes.

Table 4.8. Mean Transportation Characteristics for High SVI and Other Tracts

	High SVI Tracts		All Other Census Tracts	
	Mean	**SD**	**Mean**	**SD**
Number of K-12 Schools	1.55	1.59	1.78	1.474
Number of Higher Education Institutions	0.19	0.44	0.09	0.34
Percentage of Intersections That Are Signalized	0.34	0.32	0.22	0.28
Number of Safety Comments	0.56	1.26	0.30	0.80
Number of Trails or Paths	58.17	224.81	60.94	167.08
Percentage of Roads with Speed Limits over 40 MPH	0.72	0.36	0.74	0.36
Number of ePM Projects	60.32	84.25	50.51	54.20
Percentage of Roads with Paved Shoulders	0.67	0.33	0.66	0.35
Percentage of Signs That Are in Fair/Poor Condition	0.09	0.07	0.08	0.07
Number of Signals That Have Received Maintenance	2.89	3.545	1.68	1.97
Percentage of Roads with Bike Lanes	0.13	0.10	0.08	0.07
Number of Driveways	56.22	86.90	57.14	91.01
Average Number of Roadway Lanes	4.49	2.11	3.75	2.09
Number of Pavement Messages	75.72	80.17	54.92	58.03
Percentage of Transit Stops with 20+ Boardings Per Day	0.40	0.31	0.35	0.37
Percentage of Pavement Segments in Fair/Poor Condition	0.64	0.33	0.53	0.33
N=716	N=152		N=564	

We see similar trends within the SVI built environment statistics that were shown with the EFA tracts. High SVI tracts in many cases have more traffic infrastructure types present than other tracts. Higher percentages of infrastructure types include signalized intersections, paved shoulders, pavement messages, and several others. High SVI tracts also have roadways with more lanes on average and more safety comments and concerns noted by UDOT previously. However, high SVI tracts often do not see as wide a difference as other census tracts as the EFAs do. This may be due to the much larger sample size of high SVI tracts versus EFAs (152 vs. 16), meaning that differences between the non-SVI and high-SVI tracts are spread more evenly across the larger sample. There are also more SVI variables which determine criteria, meaning that tracts which do not qualify for the EFA criteria may still qualify as high SVIs.

4.5.2 Built Environment High SVI Independent Samples *t*-Test

To identify significant differences between the transportation infrastructure in high vulnerability tracts and those located in tracts with less vulnerable populations, statistical analysis was employed. Table 4.9 shows results of multiple independent samples *t*-Tests conducted in SPSS statistical software identifying significant differences between the SVI high-vulnerability tracts and those that were not recognized as such for the major transportation indicators examined in this study.

Table 4.9. Independent Samples *t*-Test: High SVI and Built Environment Characteristics

	Mean Values		Statistics		95% Confidence Interval	
	High SVI	**Other**	***t***	***Sig***	**Lower**	**Upper**
Redlining (% of Tracts)	0.27	0.07	-6.989	<0.001	-0.252	-.142
Number of K-12 Schools	1.55	1.78	1.686	0.046	-0.038	0.500
Number of Higher Ed Institutions	0.19	0.09	-2.897	0.002	-0.162	-0.031
% of Intersections That Are Signalized	0.35	0.22	-4.793	<0.001	-0.180	-0.075
Number of Safety Comments	0.56	0.30	-3.105	<0.001	-0.427	-0.096
Number of Trails or Paths	58.17	60.94	0.167	0.434	-29.681	35.212
% of Roads with Speed Limits over 40 mph	0.72	0.74	0.721	0.236	-0.041	0.088
% of Roads with Paved Shoulders	0.67	0.66	-0.289	0.386	-0.072	0.054
% of Signs That Are in Fair/Poor Condition	0.09	0.08	-1.355	0.088	-0.022	0.004
Number of Signals That Have Received Maintenance	2.89	1.68	-5.520	<0.001	-1.639	-0.779
% of Roads with Bike Lanes	0.13	0.08	-7.605	<0.001	-0.065	-0.038
Number of Driveways	56.22	57.14	0.112	0.455	-15.252	17.102
Average Number of Roadway Lanes	4.49	3.75	-3.847	<0.001	-1.112	-0.360
Number of Pavement Messages	75.72	54.92	-3.592	<0.001	-32.170	-9.431
% of Transit Stops with 20+ Boardings per day	0.40	0.35	-1.436	0.076	-0.113	0.017
N=716	N=152		N=564			

First, nearly 30 percent of high vulnerability tracts experienced historic redlining compared to only 7 percent of non-vulnerable tracts ($p<0.001$). This suggests that redlined areas continue to face contemporary disparities (discussed further in Section 5.2). For example, there are significantly fewer K-12 schools and significantly more Higher Education institutions in highly vulnerable neighborhoods. The implications of this trend are explained in the conclusions section. Next, the analysis identified that 35 percent of intersections in high vulnerability tracts are signalized compared to only 22 percent of intersections in other tracts. However, nearly double the number of signals received maintenance in high vulnerability tracts compared to other areas (p=<0.001).

Highly vulnerable tracts have significantly more roadway lanes (4.49) and simple bike lanes (13 percent) than other tracts (3.75 lanes and 8 percent bike lanes). Additionally, the pavement quality of roads in high vulnerability tracts is significantly lower than in other areas (p=<0.001). Nearly two thirds (64 percent) of roadways in highly vulnerable areas have “fair” or “poor” pavement quality, compared to 53 percent of roads in other tracts.

UDOT provides an avenue for the public to report safety concerns to the department and tracks the comments by location. Tracts that are highly vulnerable report significantly more safety comments than tracts in other areas (p=<0.001). However, significantly more UDOT projects (as measured in ePM) take place in highly vulnerable tracts than in other areas (p=0.041). Finally, the number of pavement messages on the roadway (e.g., slow down, right turn only, school zone, etc.) is significantly higher (75.72 total messages) in high vulnerability tracts versus the number in other tracts in the state (54.92 total messages).

4.5.3 SVI Census Tract Mapping Results

A similar mapping process as described in Section 4.4.3 was carried out for census tracts in Utah which meet the SVI criteria. ArcGIS Pro software was utilized to map and visualize the spatial distribution of infrastructure variables across the various SVI tracts. This allows for visual analysis of where various transportation infrastructure and other associated variables are present, and where their density is less by comparison. As more tracts qualify under SVI criteria, they allow for a wider view of variables across more tracts.

Similarly to the EFA maps, it can be seen that many types of infrastructure and many transportation projects have been carried out in urbanized areas. More signalized intersections (Figure 4.25) and pavement messages (Figure 4.28) are generally present in urbanized areas. Generally, there are fewer occurrences of these infrastructure types in Southern Salt Lake and

North Ogden than in other parts of those cities. Western and Northern Salt Lake have seen a higher number of signalized intersections (Figure 4.30) than other parts of the city. Central Ogden also has seen greater signal maintenance. Rural areas have not seen as many signal maintenance projects but have seen higher numbers of ePM projects than other tracts, including many urban tracts.

The SVI census tracts reveal that many areas which qualify as vulnerable under SVI criteria are in historically redlined areas, including most of the census tracts in Ogden and many in Salt Lake City. A review of road sign condition (Figure 4.31) shows that many tracts have higher instances of 'poor' or 'fair' sign conditions, particularly in the West Valley-Salt Lake City areas, and rural tracts in eastern and southern Utah. Similarly to the EFA maps, many SVI tracts have higher speed limit averages and lane averages, partially in western and southern Salt Lake County, and rural areas (Figure 4.32 and 4.25). Tracts near Interstate 15 (I-15) also have a higher number of lanes and higher speed limit averages. A review of UDOT Safety Comments (Figure 4.34) shows higher occurrences of safety comments in central and western Salt Lake City (and a portion of eastern Salt Lake City), as well as central Provo and West Ogden. Rural areas do not have a high presence of safety comments in any tracts.

Bike lanes (Figure 4.20) and trails (4.33) are similar to the EFA tracts and show higher occurrences of bike lanes in urbanized areas, with more trails in rural areas. Notably however, there are fewer bike lanes present in southern Salt Lake City and North Ogden. Overall mapping of these variables according to SVI criteria largely corresponds to that of the EFA tracts, however, the greater numbers of tracts allow for a wider view of the area to be examined. This way, some difference in transportation investment and infrastructure within city areas (and rural areas) can be seen. There are differences in how many projects have occurred in central parts of cities, such as Salt Lake City and Ogden. Again, many projects and a significant amount of infrastructure occur around the I-15 corridor, which is where variables such as speed limits and roadway lanes are notably higher as well.

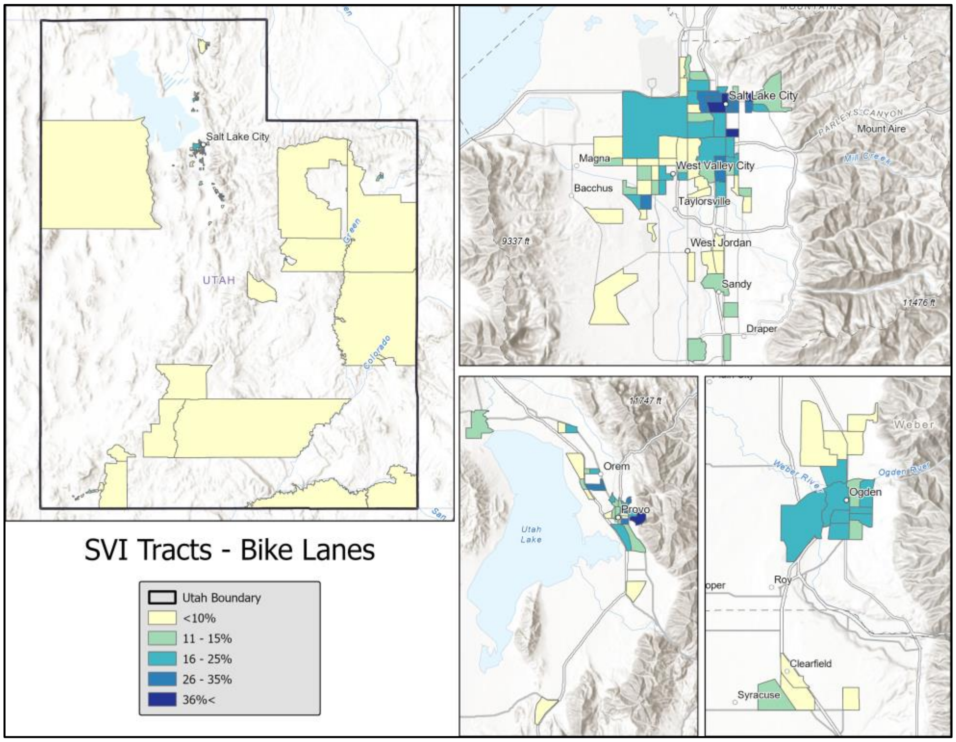

Figure 4.20 SVI Tracts – Bike Lanes

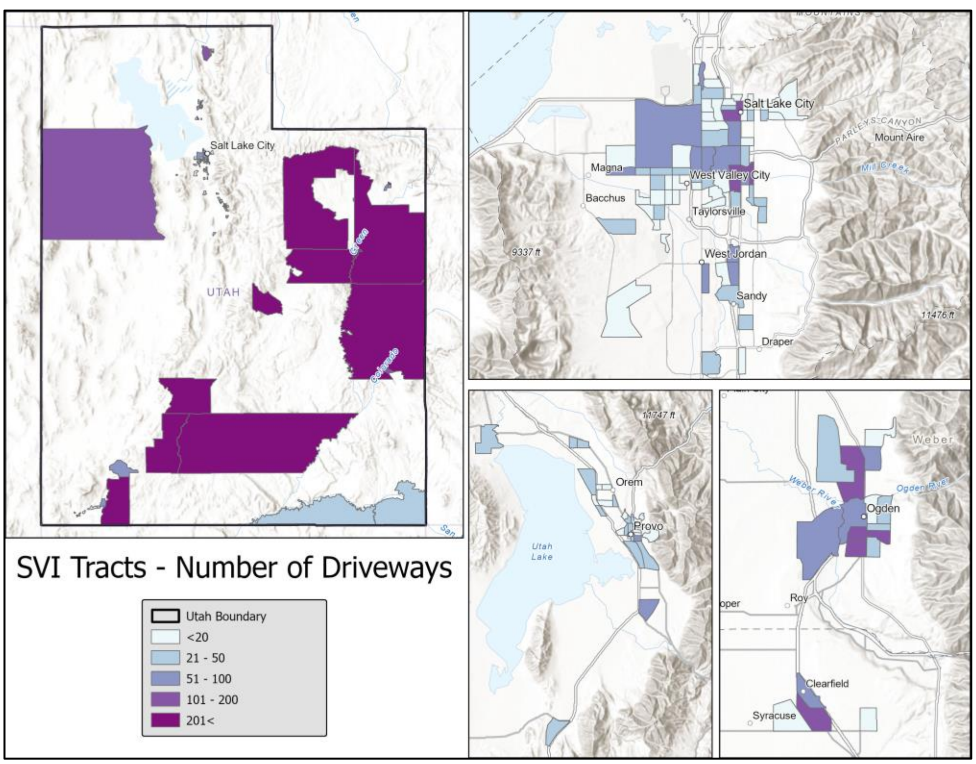

Figure 4.21 SVI Census Tracts – Driveways

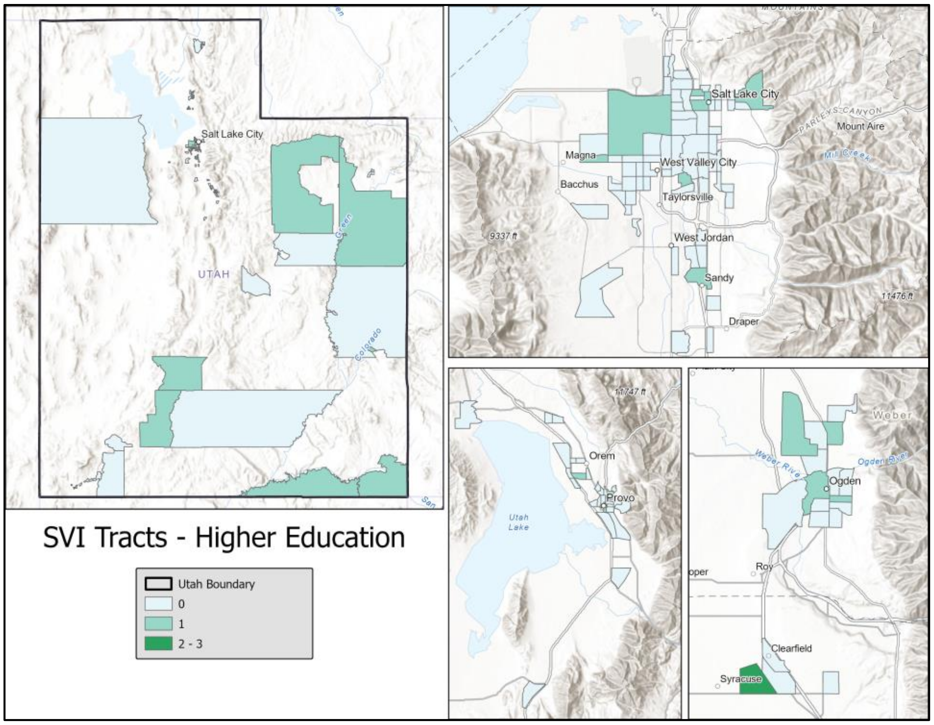

Figure 4.22 SVI Census Tracts – Higher Education

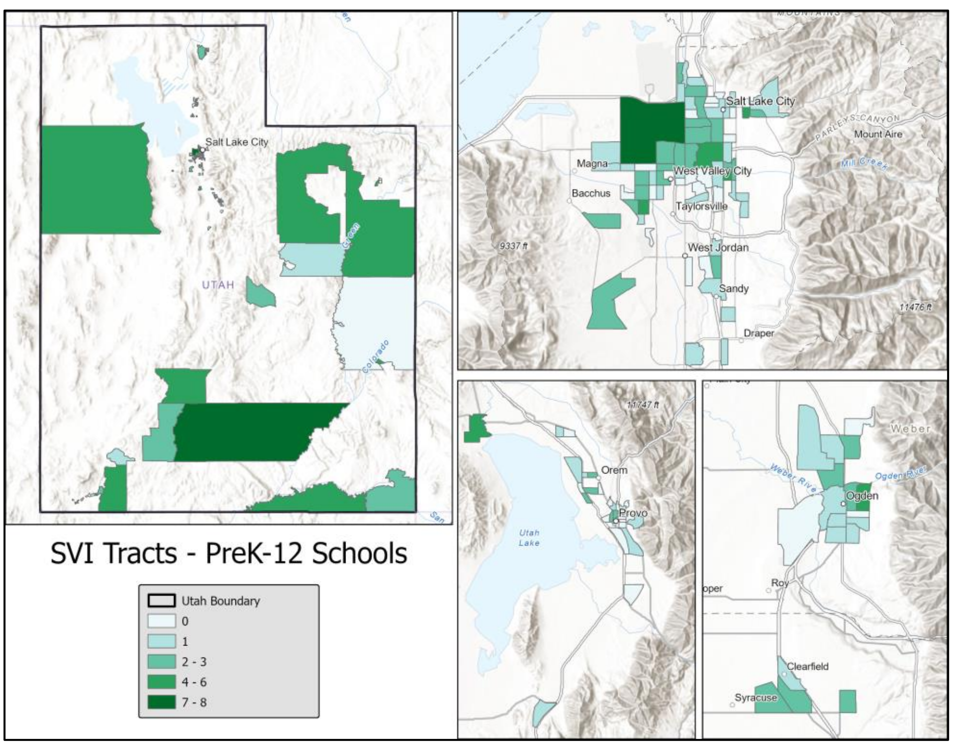

Figure 4.23 SVI Census Tracts – K-12 Schools

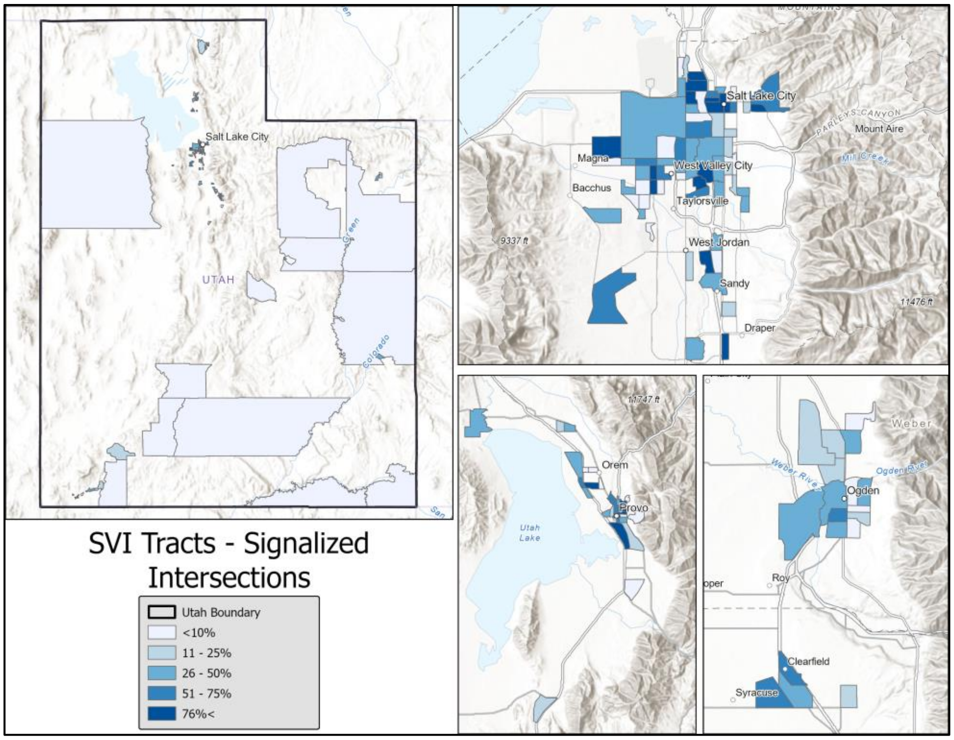

Figure 4.24 SVI Census Tracts – Signalized Intersections

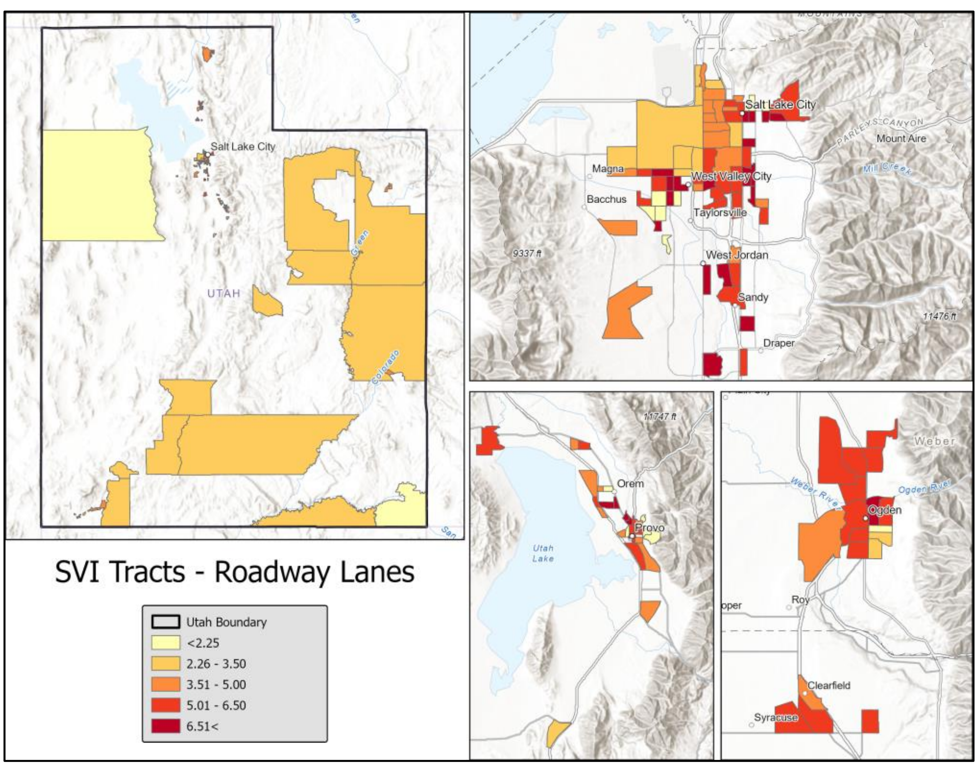

Figure 4.25 SVI Census Tracts – Roadway Lanes

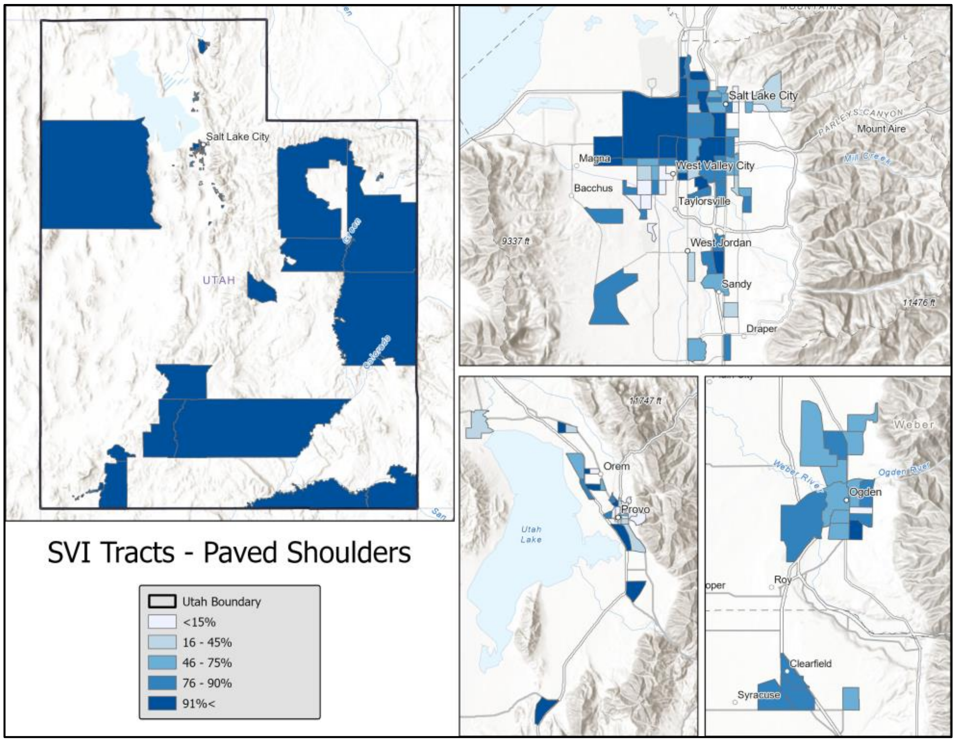

Figure 4.26 SVI Census Tracts – Paved Shoulders

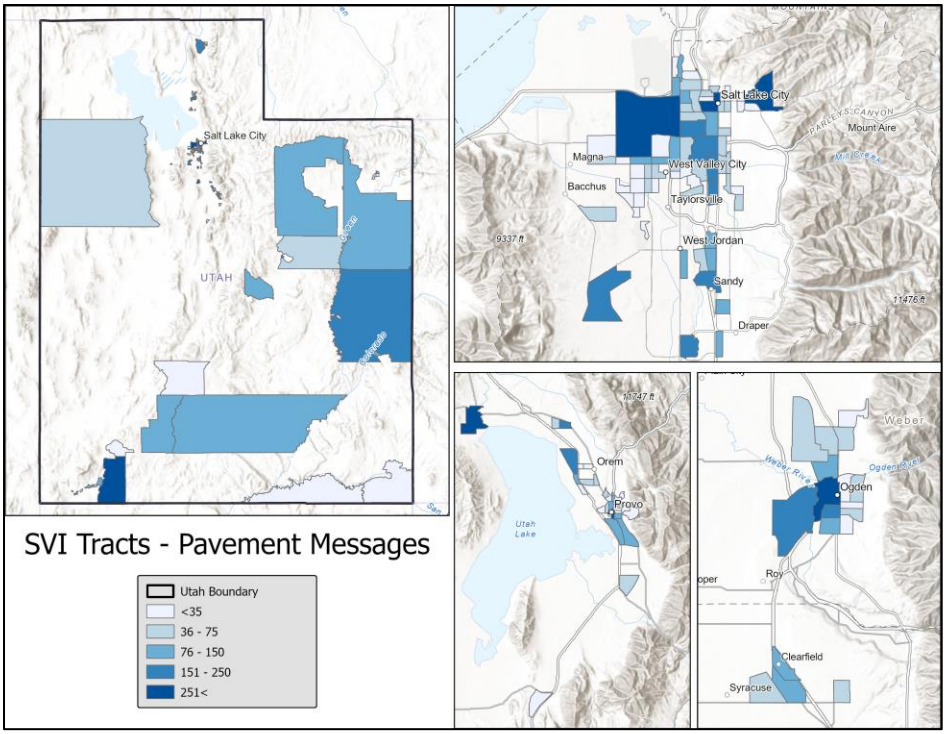

Figure 4.27 SVI Census Tracts – Pavement Messages

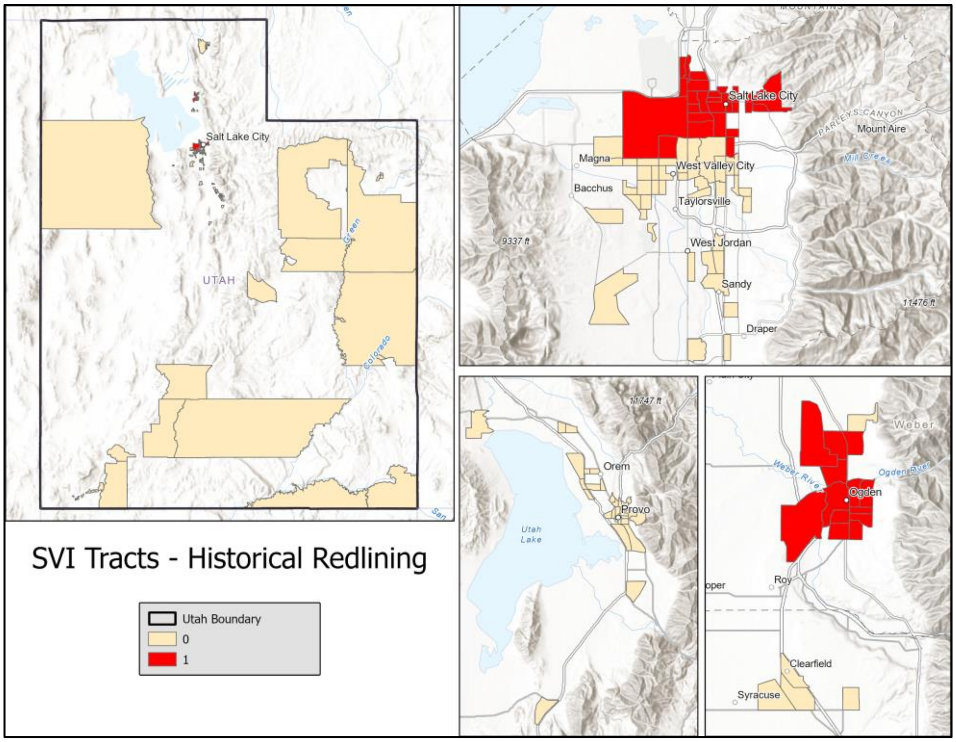

Figure 4.28 SVI Census Tracts – Historical Redlining

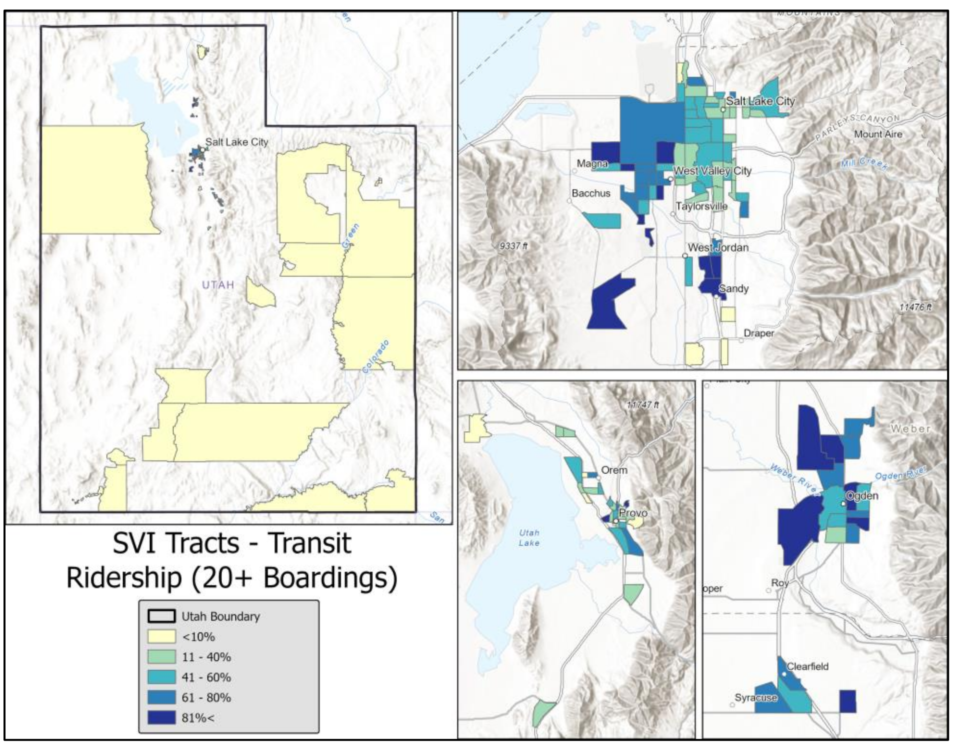

Figure 4.29 SVI Census Tracts – Transit Ridership

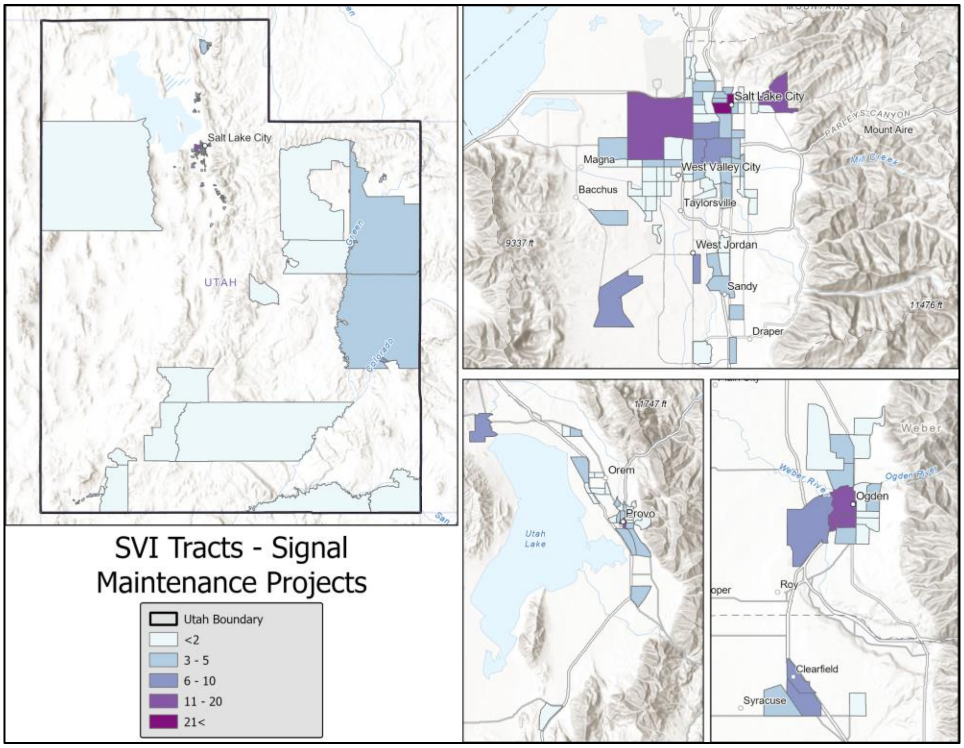

Figure 4.30 SVI Census Tracts – Signal Maintenance

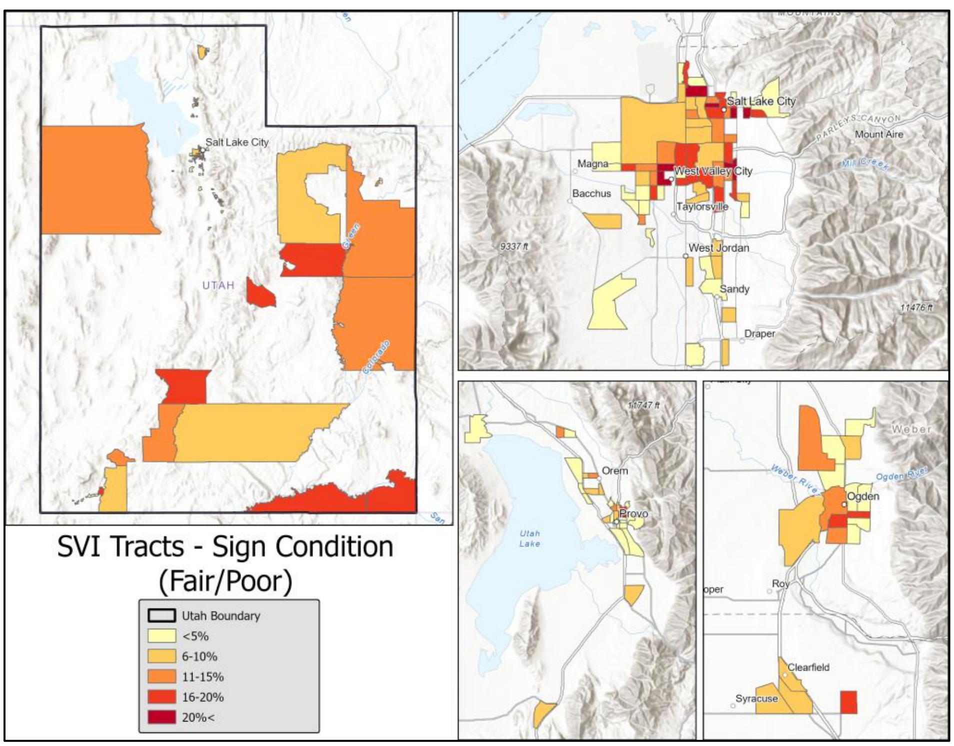

Figure 4.31 SVI Census Tracts – Road Sign Condition

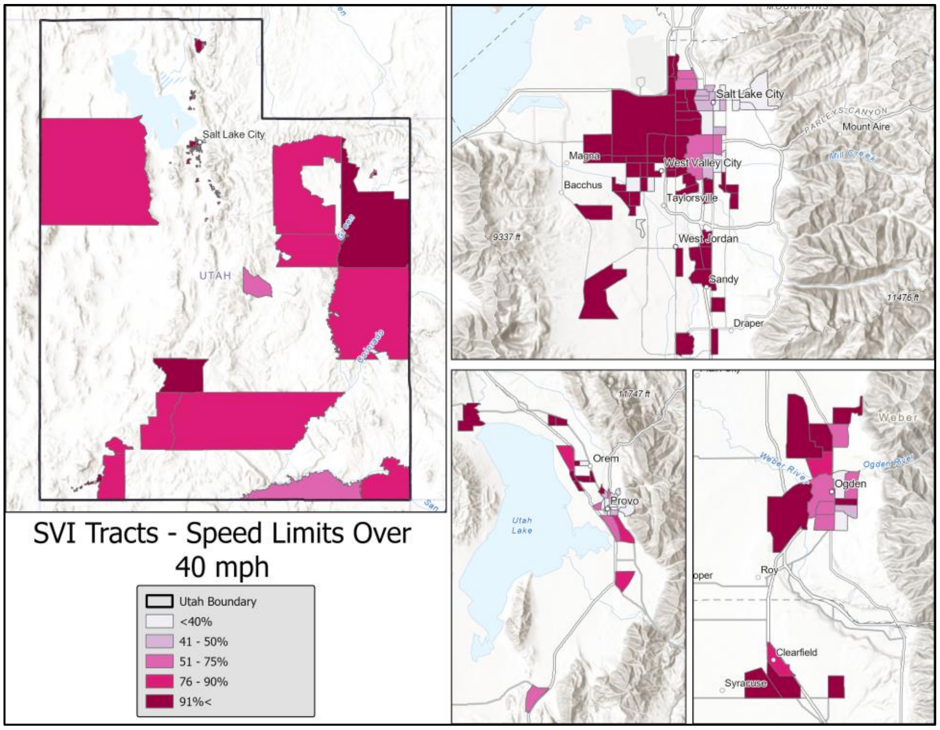

Figure 4.32 SVI Census Tracts – Speed Limits Over 40 MPH

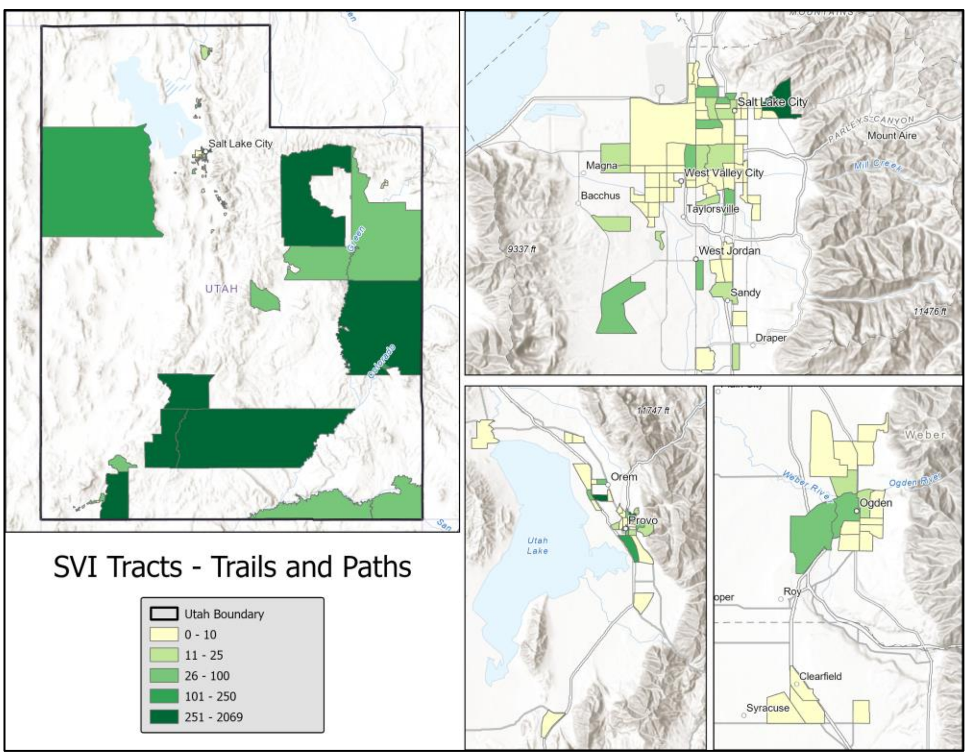

Figure 4.33 SVI Census Tracts – Trails and Paths

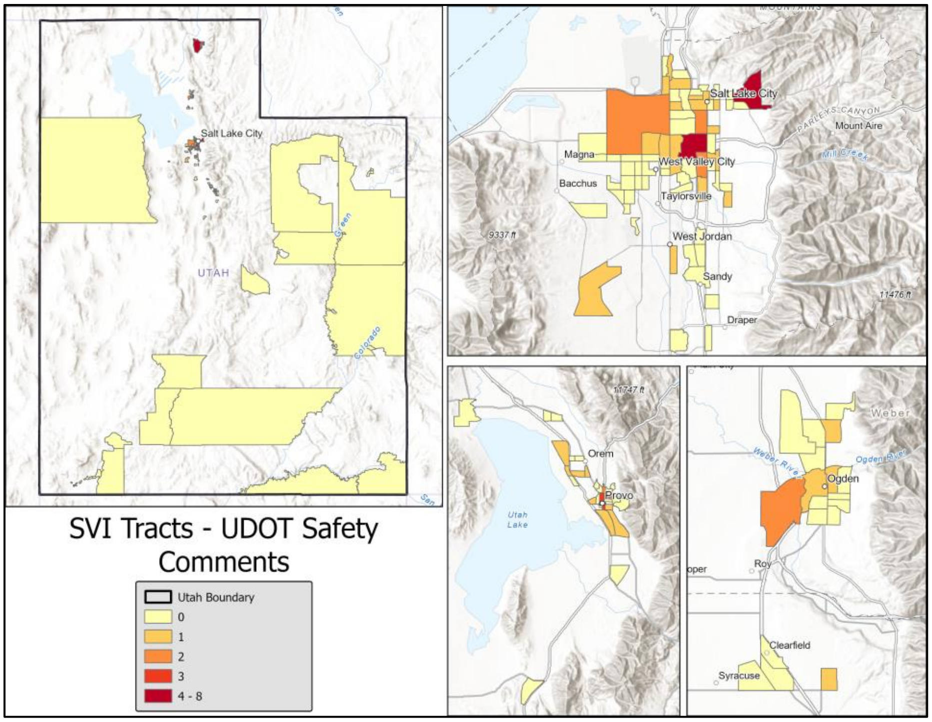

Figure 4.34 SVI Census Tracts – UDOT Safety Comments

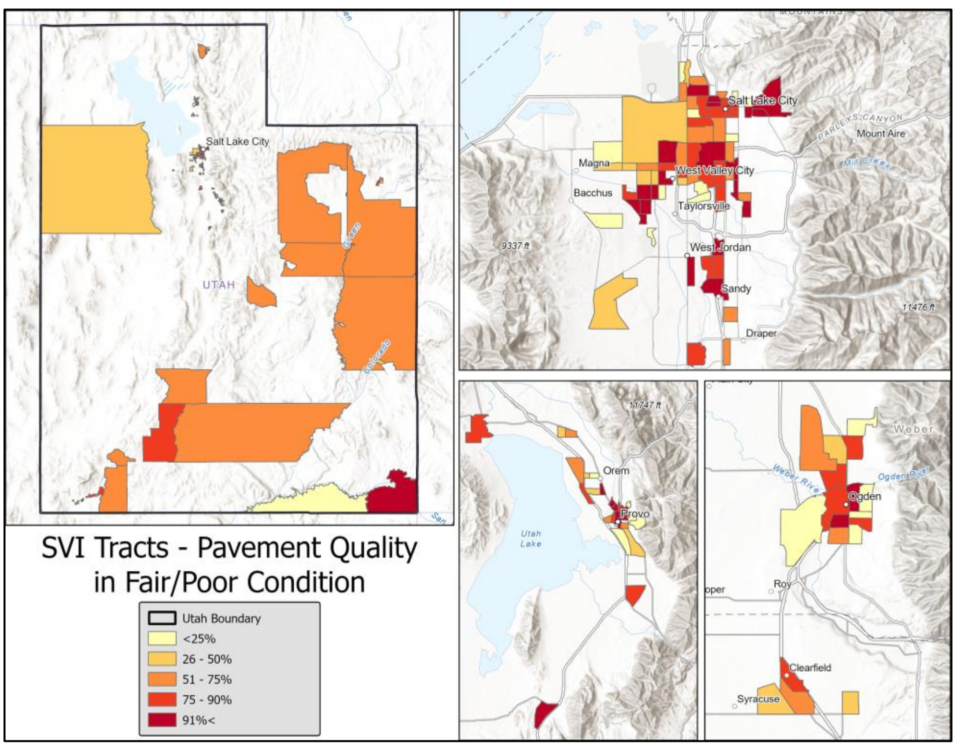

Figure 4.35 SVI Census Tracts – Pavement Quality

4.6 EFA and SVI Summary Statistics Comparison

For comparison purposes, Tables 4.10 and 4.11 display summary statistics for both the high SVI tracts and EFAs. This allows for an overview of the differences in demographic and built environment in these tracts and how they may differ based on varying criteria.

Table 4.10. Comparison of Summary Statistics – High SVI and EFAs

	High SVI Tracts		WFRC EFAs	
Demographic Variable	**Mean**	**SD**	**Mean**	**SD**
% of Impoverished Persons	32.68	15.30	41.54	10.53
% of Unemployed Persons	5.18	3.84	9.14	6.85
% of Households with Annual Income Under $70,000	34.38	12.47	37.79	12.13
% of Persons with No High School Diploma	13.56	8.38	19.73	6.66
% of Uninsured Persons	16.31	8.14	20.98	9.25
% of Persons Over 65 Years of Age	9.46	6.47	8.39	4.27
% of Persons Under 17 Years of Age	24.11	10.10	24.19	8.39
% of Disabled Persons	12.50	5.95	13.99	6.45
% of Single-Parent Households	7.26	5.72	10.10	4.79
% of Persons with Limited English Proficiency	5.13	4.39	7.43	4.21
% of Minority Population	38.72	19.98	61.34	18.33
% of Housing in 10 or More Unit Structures	24.88	24.80	33.33	27.86
% of Housing in Mobile Homes	5.46	8.33	4.68	9.61
% of Overcrowded Households*	7.43	7.57	10.12	6.35
% of Households with No Vehicle	7.96	7.24	16.03	6.04
% of Persons in Group Quarters	5.43	14.02	7.11	17.87
% of Households with No Internet	15.87	14.01	25.76	24.02
% African-American Population	2.06	2.72	5.28	4.46
% Hispanic Population	25.35	16.32	30.90	16.95
% Asian Population	3.75	4.85	5.54	7.78
% Native American Population	2.64	10.74	13.01	30.77
% Native Hawaiian/Pacific Islander Population	1.72	3.09	2.88	4.20
% Two or More Races	2.97	2.88	3.26	2.11
% Other Race Population	0.24	0.51	0.46	0.67
N=716	N=152		N=16	

*Households where there are more occupants than rooms

Both SVI and EFA tracts saw higher instances of many demographic variables than other tracts. When directly comparing statistics, it can be seen that most variables occur at a higher percentage within EFA tracts than SVI tracts, indicating that EFAs may have more vulnerable populations to negative impacts than SVI tracts. However, many of the variables are close in value.

Table 4.11. Comparison of Built Environment Statistics – High SVI and EFAs

	High SVI Tracts		EFAs	
	Mean	**SD**	**Mean**	**SD**
Number of K-12 Schools	1.55	1.59	2	1.414
Number of Higher Education Institutions	0.19	0.44	0.25	0.44
% of Intersections That Are Signalized	0.34	0.32	0.39	0.34
Number of Safety Comments	0.56	1.26	0.75	1.53
Number of Trails or Paths	58.17	224.81	14	16.87
% of Roads with Speed Limits Over 40 MPH	0.72	0.36	0.65	0.24
% of Roads with Paved Shoulders	0.67	0.33	0.76	0.21
% of Signs That Are in Fair/Poor Condition	0.09	0.07	0.12	0.07
Number of Signals That Have Received Maintenance	2.89	3.545	2.69	3.3
% of Roads with Bike Lanes	0.13	0.1	0.15	0.09
Number of Driveways	56.22	86.9	47.25	34.54
Average Number of Roadway Lanes	4.49	2.11	4.84	1.65
Number of Pavement Messages	75.72	80.17	71.06	64.5
% of Transit Stops with 20+ Boardings Per Day	0.4	0.31	0.44	0.24
% of Pavement Segments in Fair/Poor Condition	0.64	0.33	0.79	0.27
N=716	N=152		N=16	

A review of built environment statistics reveals again that most variables occur to a greater percentage within EFA tracts, though to a lesser degree than the demographic variables. Many built environment variables are very similar among EFA and SVI tracts. Some notable differences can be seen in higher instances of safety comments in EFAs (0.75 vs 0.56), a higher percentage of fair/poor pavement segments in EFAs than SVI tracts (79 percent vs. 64 percent), and significantly more trails/paths on average in SVI tracts than EFAs (58.17 vs. 14).

4.7 Built Environment Value Scoring and SVI Overlay

The research team examined a significant amount of built environment data throughout this study. The research team desired to apply a scoring system of several transportation category variables examined during the study. The scoring system would be applied by census tract and would provide additional insight into what census tract areas throughout Utah see a significant amount of impact from traffic effects and existing transportation infrastructure.

4.7.1 BE Scoring Criteria

From statistical analysis, the research team determined which variables were most significant in their impact. These variables were assigned a Built Environment scoring system (referred to as BE scoring), which could then be summed by each census tract area to see which tracts experience the most impact from these variables. Table 4.12 displays the BE scoring system utilized. The tract received one point for each category that matched the criteria below (9 possible points).

Table 4.12. Comparison of BE Scoring Criteria – High SVI and EFAs

Variable	Scoring Criteria
Presence of Redlining	Yes
Number of K-12 Schools	< 1.5
Number of Higher Education Schools	> 0.10
% of Signalized Intersections	> 0.30
Number of Lanes	> 4
Number of Safety Comments	> 0.45
Signal Maintenance	> 2
Pavement Messages	> 70
% of Fair/Poor Pavement Quality	> 0.50

The points for each tract were totaled. Tracts which scored more than a value of four (4) were considered most impacted. In all, 252 of 716 census tracts scored more than a value of four (4) according to the criteria. Results are displayed in Figures 4.36 and 4.37.

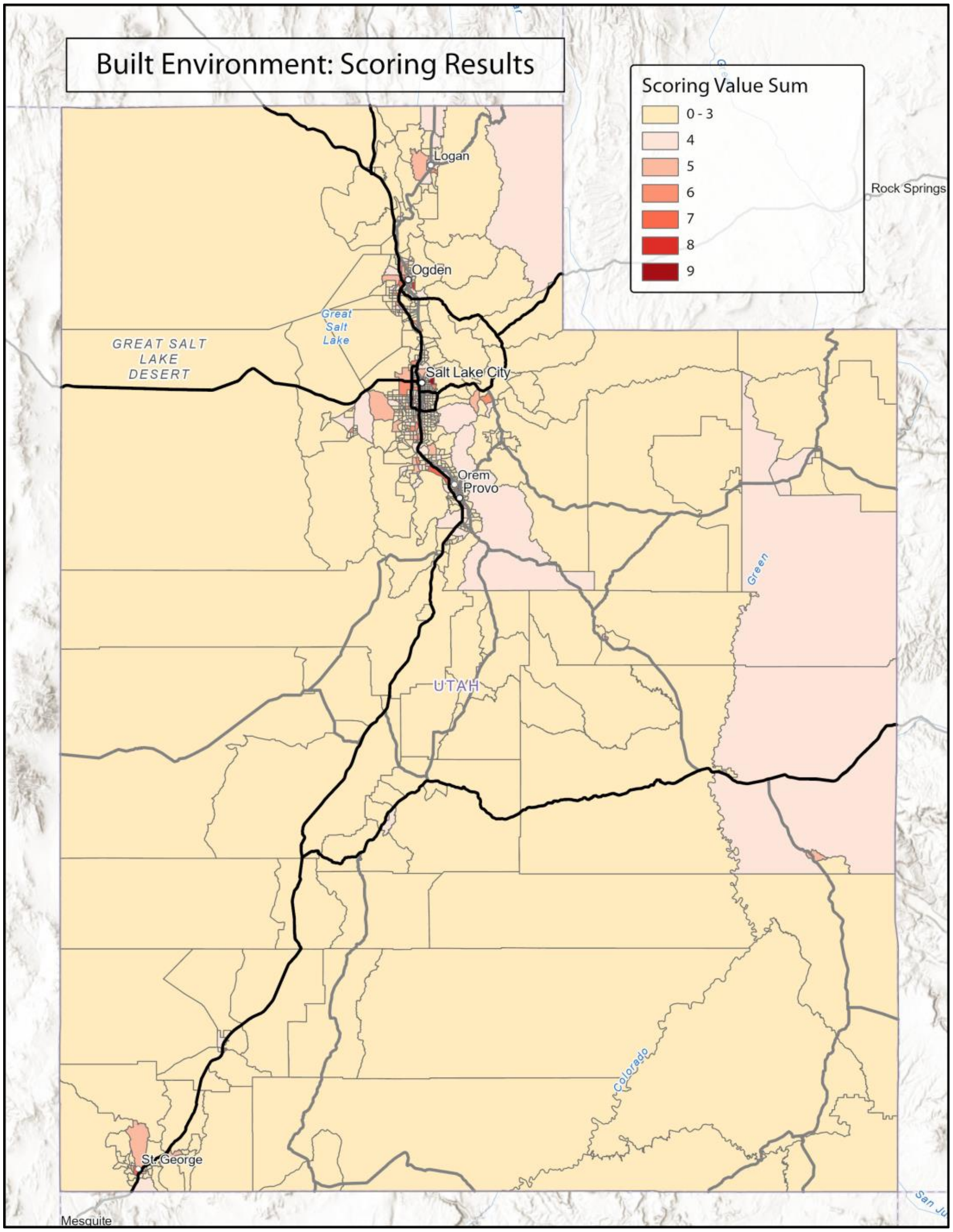

Figure 4.36 BE Scoring City Views

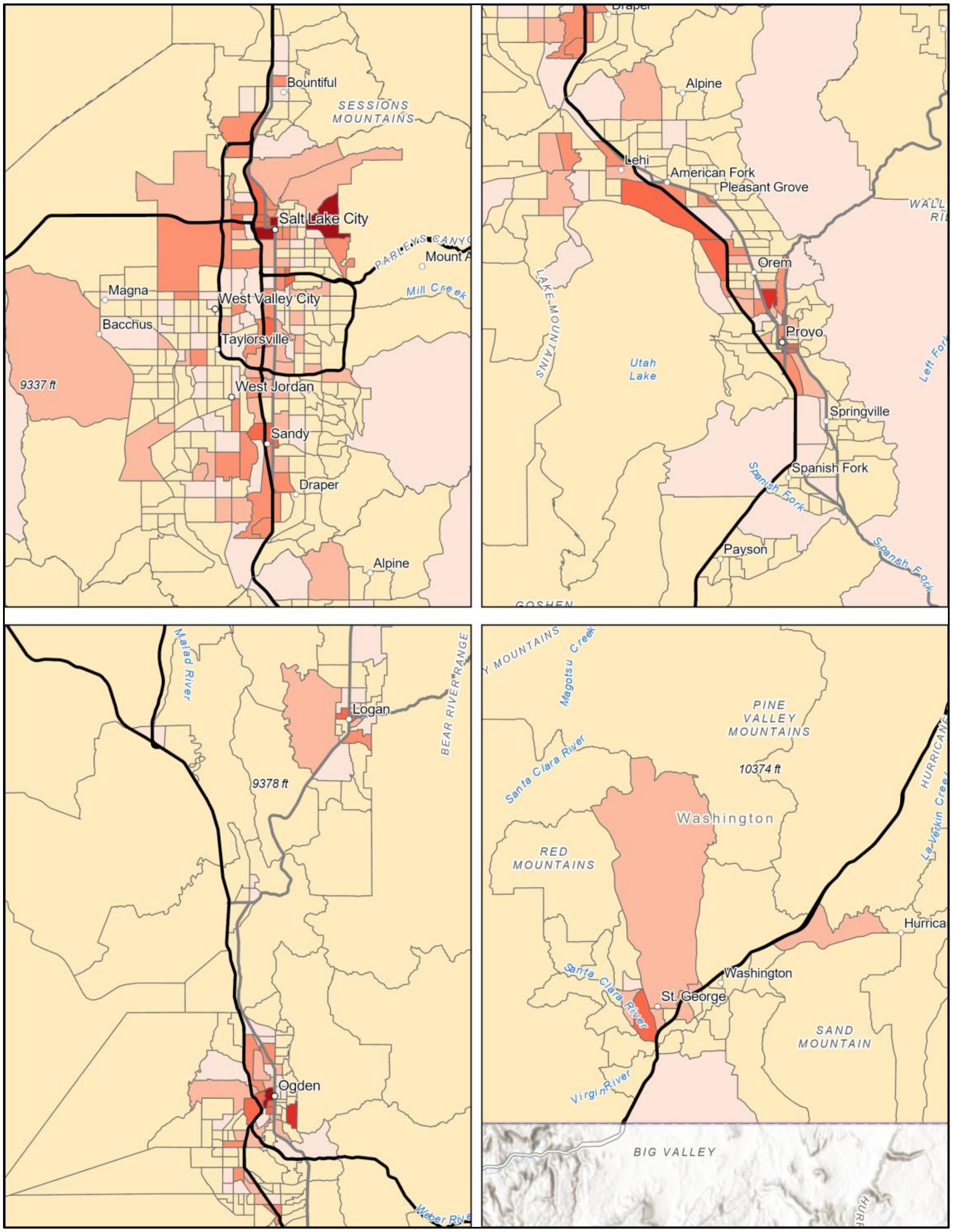

Figure 4.37 Built Environment Scoring City Views

4.7.2 Mapping and Results

As can be seen in the maps, most of the tracts which scored higher than four (4) according to the criteria, are found in urbanized areas. Some exceptions are seen in eastern and northeastern Utah, where several tracts qualified. Many high-scoring tracts are in northern Salt Lake City and along the I-15 corridor through Salt Lake County. The I-15 corridor generally sees many higher-scoring tracts throughout urbanized areas; Utah County, Ogden, and St. George, for example, all see higher-scoring tracts near I-15.

It is generally expected that these areas will see more transportation infrastructure due to the number of roadways in the area. However, more infrastructure may expose residents to more negative traffic impacts. These tracts also report more safety comments as recorded by UDOT, more instances of poor-quality pavement, presence of historical redlining, and other issues. While investment in roadways such as the I-15 corridor can be considered positive, it is also an indication that greater impacts may be found in nearby communities, and proper (and continual) maintenance is required to minimize impacts.

Given that more tracts (252) qualified under the BE scoring criteria than the total tracts which qualified as vulnerable under SVI criteria (152), the research team mapped an overlay between SVI tracts and BE scoring to compare their distribution across the state. The BE scoring and SVI tracts were assigned values based upon their overlapping, which was then visualized in Figures 4.38 and 4.39. This allows for identification of where BE scoring tracts and SVI tracts overlapped and where they did not.

It was determined that 404 tracts in Utah met no criteria, 60 tracts qualify under SVI criteria only, 160 qualify under the BE scoring system only, while 92 qualify under both. As seen on the maps, the main difference is that several rural tracts throughout Utah qualify under SVI criteria, while most BE scoring tracts are found in urbanized areas. There is some discrepancy in urbanized areas; several tracts in western Salt Lake City, for example, qualify under SVI criteria only, while overall many more in the suburban areas of Salt Lake City met the BE scoring criteria (more tracts on the periphery of cities in general met the BE scoring criteria but not SVI criteria). Tracts that met both criteria could be found in urbanized areas for the most part, again heavily centered around the I-15 corridor, while several rural tracts in western Utah also qualified. The discrepancy between SVI and BE scoring tracts is likely due, in part, to the many more demographic variables which impact SVI determination. However, this comparison allows for several tracts to be identified as both significantly vulnerable through SVI criteria and heavily impacted by built environment infrastructure. Appendix A provides the complete list of 92 census tracts which qualify under SVI and BE scoring criteria, can be considered the most impacted by the built environment, and most vulnerable.

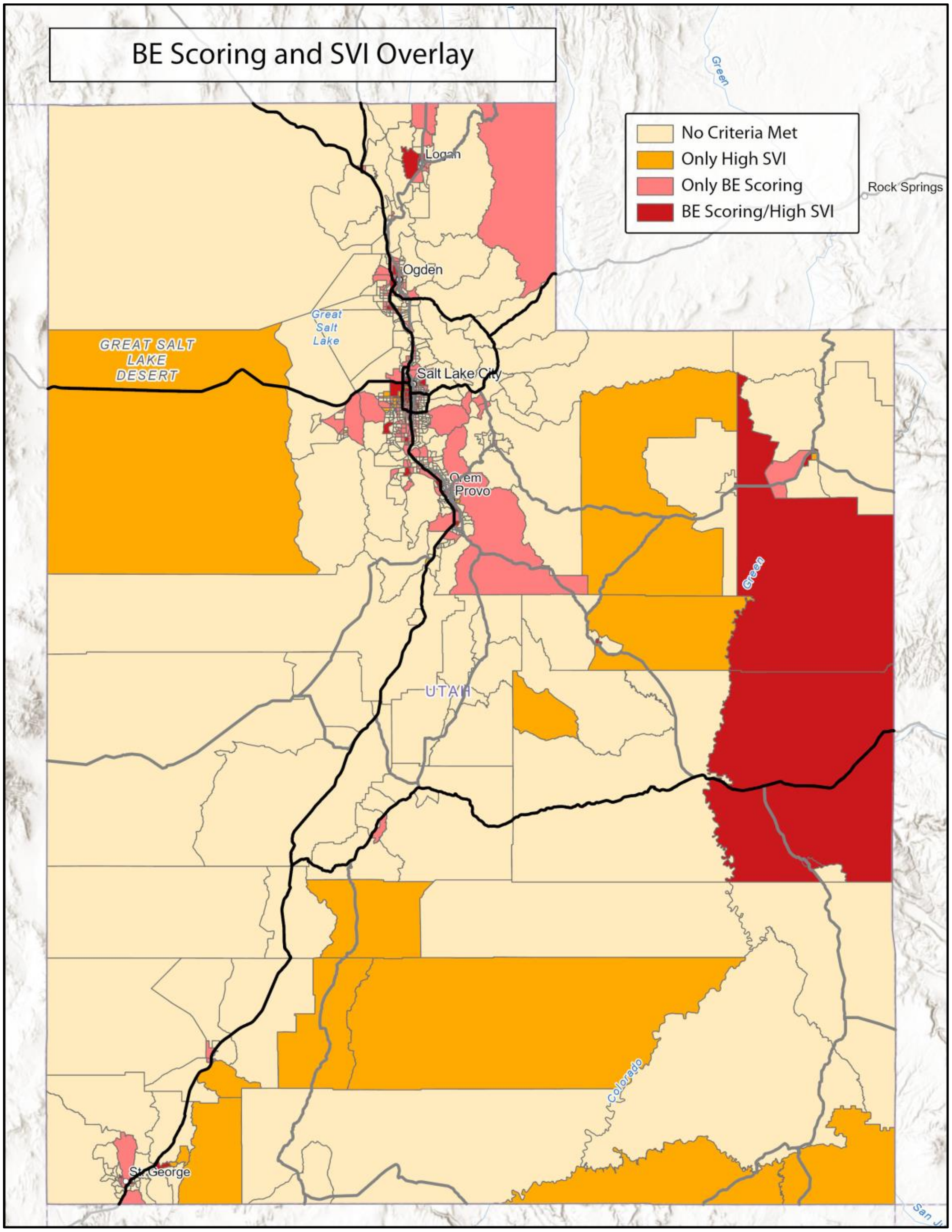

Figure 4.38 BE Scoring and SVI Overlay

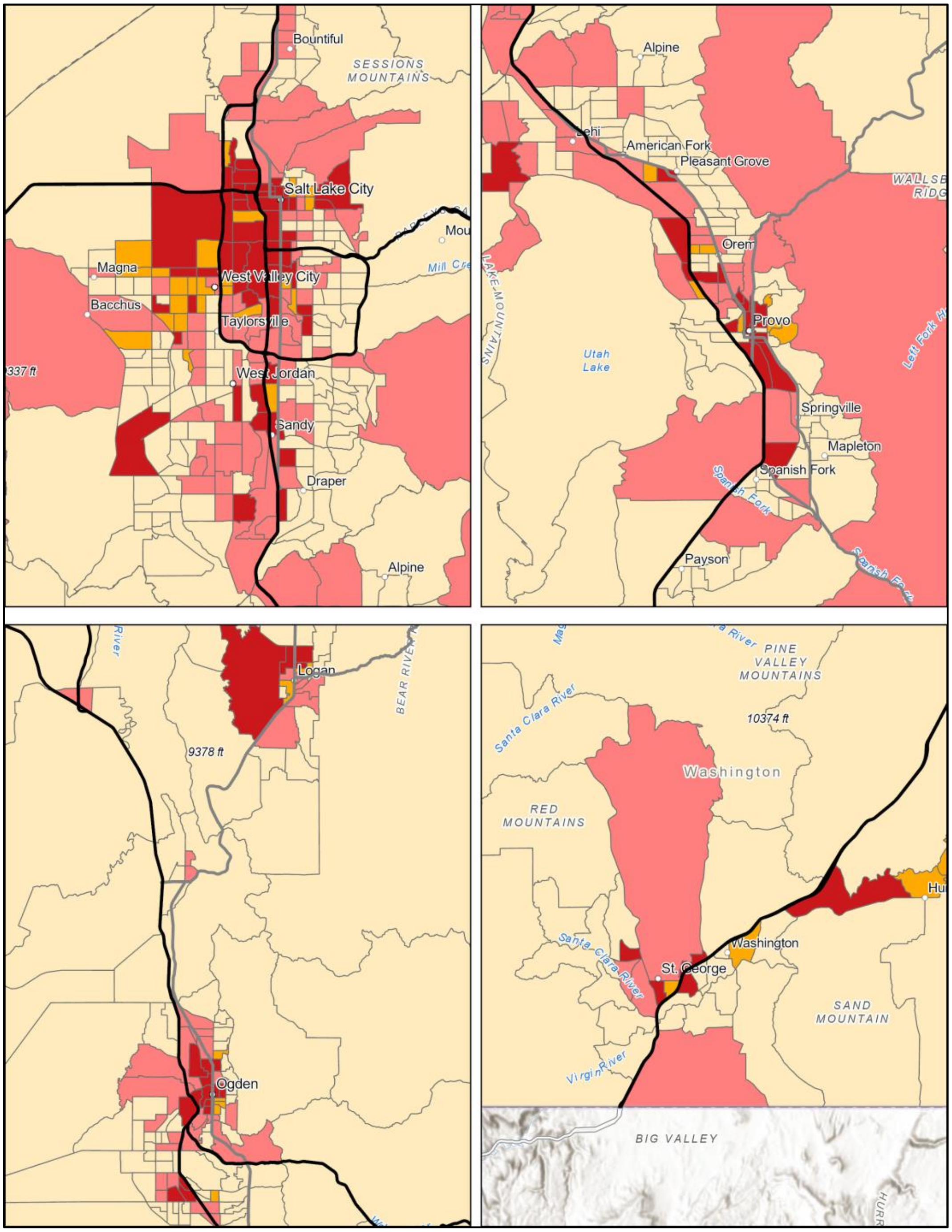

Figure 4.39 BE Scoring and SVI City Views

4.8 Summary

An analysis of transportation characteristics was conducted comparing more vulnerable population areas based on both the WFRC EFAs and the SVI. Summary statistics provide an overview of statewide demographic and built environment variables and allow for comparisons to be made. Using an independent sample *t*-Test, statistical analysis found that there are significant differences between the infrastructure in highly vulnerable tracts and in less vulnerable areas. Highly vulnerable population areas exhibit significant differences in infrastructure quality and investment. ArcGIS Pro was utilized to create maps visualizing data results, organized by EFA and SVI tracts. The research team also assigned a scoring system to census tracts throughout the state based on the occurrence of particular built environment variables. This scoring system was utilized to show which tracts may see the most impact from built environment and infrastructure assets. Overlaying this layer with high-SVI tracts reveals which census tracts may be particularly susceptible to transportation impacts based on their combination of existing vulnerability and built environment characteristics. A discussion of the implications for these differences and recommendations for improvement are described in the following section.

5.0 CONCLUSIONS

5.1 Summary

Statistical methods have been employed to correlate existing transportation conditions with community demographic characteristics using both the EFAs identified by WFRC and those identified as highly vulnerable by the SVI in urban and rural Utah. Spatial statistical analysis then identified areas that have both outdated infrastructure or a lack of infrastructure and are also highly vulnerable socially. Findings were preliminarily outlined in Section 4.5, however, the following sections provide additional detail and insight into the analysis. This section will also provide recommendations for improvement and outline an implementation program for UDOT moving forward.

5.2 Findings

The following sections summarize the findings of the statistical analysis and include a discussion of how each characteristic may impact equity and transportation opportunities.

5.2.1 Redlining

Within this analysis, highly vulnerable census tract areas (SVI) were significantly more likely to have experienced historical redlining than areas that were not identified as highly vulnerable. According to Ellis-Sots, Chapman, and Locke (2023), “race-based zoning policies, such as redlining in the United States during the 1930s, are associated with racial inequity and adverse multigenerational socio-economic levels in income and education, and disparate environmental characteristics.”

Research has suggested that redlined neighborhoods have experienced long-term disinvestment, and historical redlining has also been linked to specific negative health outcomes (Mehdipanah et al., 2023). Human behavior and past social, economic, and political conditions did not just segregate the built environment but may have also left a lasting mark on more current investment.

Most redlining occurred in urban areas, as it took place prior to the suburbanization movement. This trend was consistent in Utah where most tracts that experienced redlining are located in and around Salt Lake City and Ogden. Many of these tracts remain socially vulnerable, as these areas were initially developed during the early 20th century. That period of development was characterized by smaller homes, smaller lots, and proximity to a central business district. Because of these development characteristics, the homes located in these tracts are less expensive and are likely quite old. While some redevelopment has taken place, these historically low-income areas are unlikely to be updated without some level of gentrification. This is because lower-income households may be less able to invest in home improvements, renovations to add square footage, or other projects. Therefore, these areas remain lower income, providing housing for those unable to afford newer and more expensive housing that is typically located further from the downtown area or in the suburbs.

Although recent efforts have been made to reinvest and reinvigorate downtown areas, development trends in Utah have proven over time to favor new developments in greenfield areas located farther from these historic CBDs in suburban or even rural areas. It is not currently uncommon to find new build developments selling single family homes for five times the cost of homes in the vulnerable tracts (Zillow, 2024). Vulnerable households will continue to live where they can afford housing, which creates community clusters of vulnerable households.

Along with the clustering of low income/vulnerable households that occurs near these older downtown housing areas, disparate transportation infrastructure is evident. Construction on I-15 through Utah began in 1958 and was completed in 1978, with widening projects completed between 1997 and 2001 (Utah Rails, 2020). The I-15 corridor has acted as a barrier bisecting the state's two major cities at the time (Salt Lake City and Ogden) and inhibiting transportation from west to east. In recent years, although reinvestment and urban renewal has been prevalent on the east side of I-15 in both Salt Lake City and Ogden, the west side has not seen equal attention. Because these areas do not experience new development, they do not benefit from the infrastructure investment that comes with it. For example, when a new subdivision is constructed in the suburbs it is subject to zoning and city ordinances that require certain characteristics and amenities (e.g., sidewalks, bike lanes, paved shoulders, trails, etc.). Most of the older westside neighborhoods were built before these regulations and requirements were put in place, and without new investment and redevelopment, many of these neighborhood amenities are never installed. Likewise, improvements to roadways (repaving, widening, signal improvements, etc.) are typically tied to other improvement projects or new developments on a segment of the corridor which may be few and far between in older built-out areas.

5.2.2 Presence of Schools

Analysis determined that there are significantly fewer K-12 schools in highly vulnerable neighborhoods. As described in section 5.2.1, many of the high-vulnerability tracts consist of older homes and developments from nearly a century ago. Homes in these areas are typically smaller with smaller lots. Because of the size of the homes, many young families with school-aged children may choose to purchase or rent elsewhere in areas where they can have more square footage or a larger yard/outdoor space. Similarly, many young families may not be able to afford to live in the newer or gentrified areas of the cities, which leads them to move to the suburbs or even rural areas where newer housing can be less expensive. This results in fewer young children living in these areas, a reduced need for K-12 institutions, and the closure of schools that have been in the community for decades. For example, the *Deseret News* recently noted that four K-12 schools in Salt Lake City will close at the end of the 2023-2024 school year because of declining enrollment. The decline is attributed to families electing to home-school, enroll their children in private or charter schools, or moving to suburban or rural communities. (Cortez, 2024).

A separate *t*-Test determined that highly vulnerable tracts are significantly more likely to have higher education institutions located in the tract than other areas. A recent research report found that the richest ZIP codes have less of a concentration of higher education institutions than poorer ZIP codes (Johnson, 2019). In fact, the Smith group found that more than 50 percent of higher education institutions nationwide are located in urban locations (2018). Urban universities face unique challenges. For example, they are “landlocked, surrounded by an urban fabric of existing neighborhoods, cultural centers, commercial shops and businesses” (Smith Group, 2018). In many socially vulnerable, disinvested communities, there is a university or college located either in the middle or immediately adjacent to the community. University staff and students are disproportionately white and Asian, while the people who live in nearby neighborhoods are disproportionately Latino and Black (Oldach, 2021). Another key consideration for tracts containing a higher education institution is that of student demographics. A majority of college and university students are young and underemployed. This equates to a lower-income student population in much of the housing near campus. For example, 79 percent of students at the University of Utah are enrolled full-time, 70 percent receive financial aid, and 84 percent live in off-campus rental housing (Data USA, 2024). Coupled with an older housing stock and large rental market, areas near higher education institutions can struggle from an underinvestment in traditional neighborhood amenities. This pattern can be seen in the urban tracts surrounding Weber State University, the University of Utah, Salt Lake Community College, Brigham Young University, and Utah Technical University.

5.2.3 Signalized Intersections

Next the analysis identified that 35 percent of intersections in high-vulnerability tracts are signalized compared to only 22 percent of intersections in other tracts. A higher percentage of signalized intersections represents a larger presence of higher volume roadways and thoroughfares that would require advanced traffic control. Many of the vulnerable tracts contain major regional arterials and other high-volume roadways that receive significant investment. However, these roadway types can also place an additional burden on the surrounding neighborhoods through higher vehicular volumes and safety concerns for non-motorists and children. According to the FHWA, "traffic signals are often chosen for operational reasons, and may involve tradeoffs between safety and mobility. Signalized intersections represent about one–third of all intersection fatalities, including a large proportion that involve red-light running (FHWA, 2023)." Likewise, traffic signals can impede emergency response vehicles and increase congestion and potential conflicts.

5.2.4 Roadway Characteristics

The analysis determined that highly vulnerable tracts have significantly more average roadway lanes and bike lanes than other tracts. A larger average number of roadway lanes would indicate that the tract contains more major arterials or regionally significant roadways. This would also translate to higher vehicular volumes and Annual Average Daily Traffic (AADT) than roadways with fewer lanes. Neighborhoods near high-volume roadways can experience many negative impacts. Research by Antonczak, et al. (2023), has shown statistically significant associations between higher levels of traffic exposure and greater proportions of people of color and lower household incomes (2023). That same study determined that high-volume roadways are more likely to be located closer to where non-White and lower-income people live, and as traffic volume increases the percentage of the population that is non-White living near high-volume roadways also increases (Antonczak, et al., 2023). Because property values are so closely tied to location characteristics, often homes in neighborhoods located near busy roads are less expensive, attracting lower income and more vulnerable households. Also, proximity to busy roads and consistent exposure to the noise and pollution that accompany vehicles on those roads has been linked to a variety of mental and physical health complications.

An evaluation of surface conditions determined that the pavement quality of roads in highly vulnerable tracts is significantly lower than in other areas. Two-thirds of roadways in highly vulnerable areas (64 percent) have “fair” or “poor” pavement quality. This is consistent with the findings of the U.S. Government Accountability Office (USGAO, 2022), which determined that highway pavement is less likely to be in good condition in urban areas, localities with higher family poverty rates, and areas with higher percentages of underserved racial and ethnic populations. Pavement quality can also suffer in areas that have been built out for a significant amount of time. In areas and neighborhoods where there has not been significant development and land-use changes have not been made, roadways can remain stagnant with only spot improvements for potholes and cracks rather than corridor-wide improvements such as slurry seal, chip seal, or repaving. Pavement quality can impact safety and traffic flows. When pavement is in disrepair, it can lead to driver distraction, impact vehicle operation, and reduce friction, which can result in crashes. Additionally, when roadways do not receive necessary pavement improvements, they also fail to receive other improvements that are completed contemporaneously with pavement improvements, such as the addition of paved shoulders, bike lanes, etc.

Lastly, the number of pavement messages on the roadway is significantly higher in high-vulnerability tracts versus the number in other tracts in the state. Pavement markings can communicate information to road users informing them of conditions ahead and other important driving-related tasks. Examples of these include “Stop,” “Yield,” “Left or Right Turn Only” as well as other messages or instructions. The reasons for the higher presence of these markings in vulnerable tracts are likely similar to the conditions described in the prior sections. For example, these types of markings are more likely to be seen on roadways with higher traffic volumes where additional direction for drivers would be required. Tracts with a preponderance of small, lower-volume roads therefore would not have as many pavement messages as tracts with a larger number of wide roadways with higher traffic volumes.

5.2.5 Safety Concerns

UDOT provides an avenue for the public to report safety concerns to the department and tracks the comments by location. This study determined that tracts exhibiting higher vulnerability reported significantly more safety comments than tracts in other areas ($p=<0.001$). As lower income and vulnerable households are more likely to rely on active transportation modes and transit, they may experience greater exposure to unsafe conditions, or may simply be more aware of them. For example, someone who walks to work, a store, or to a bus stop is likely to be more cognizant of dangerous crossings or maintenance issues than someone traveling the corridor in a personal vehicle. Similarly, if the conditions described in previous sections have created safety concerns, the people living in these areas would have more to report than residents of areas with new infrastructure.

Overall, the conditions and characteristics described above are all interconnected and cannot be examined in isolation. While these characteristics were identified as significant for vulnerable areas, they may simply be the apparent symptoms of the underlying problem. It is recommended that all characteristics be considered systemically, and that highly vulnerable areas be examined more holistically.

5.2.6 Utah Timeline

A timeline was created for this project which highlights several major events of significance in the history of transportation in Utah and infrastructure equity. These include housing acts, milestones in Utah transportation infrastructure, socio-cultural events, etc. The timeline is divided into three sections and displayed in figures 5.1 through 5.3 below.

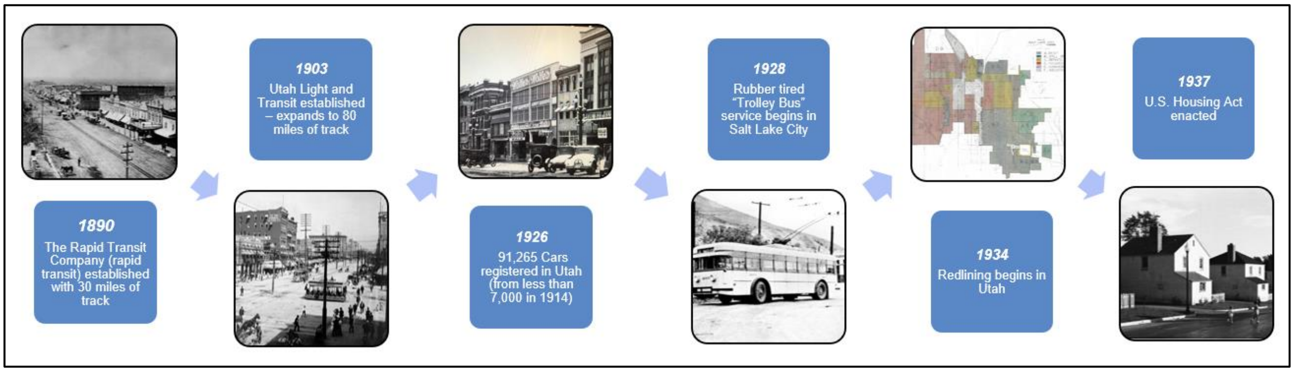

Figure 5.1 Utah Timeline Part I: Early Years

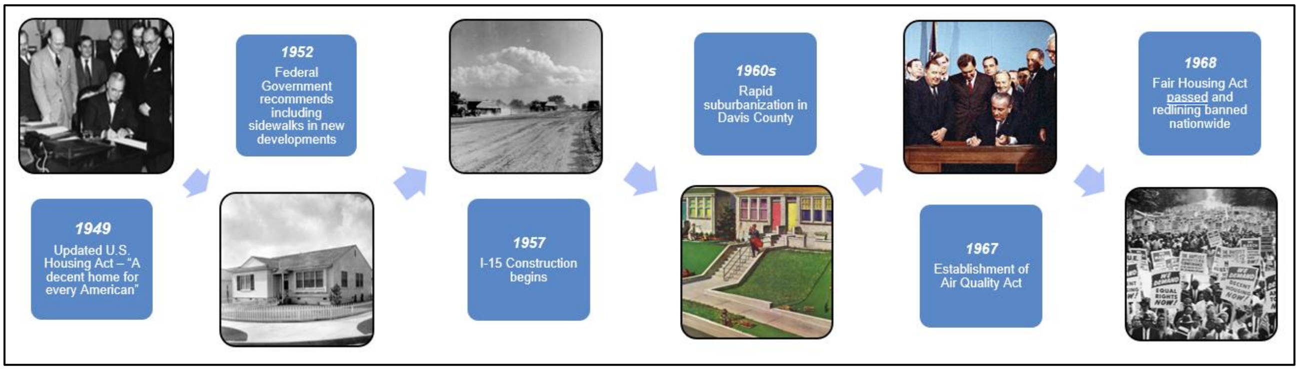

Figure 5.2 Utah Timeline Part II: Postwar Era

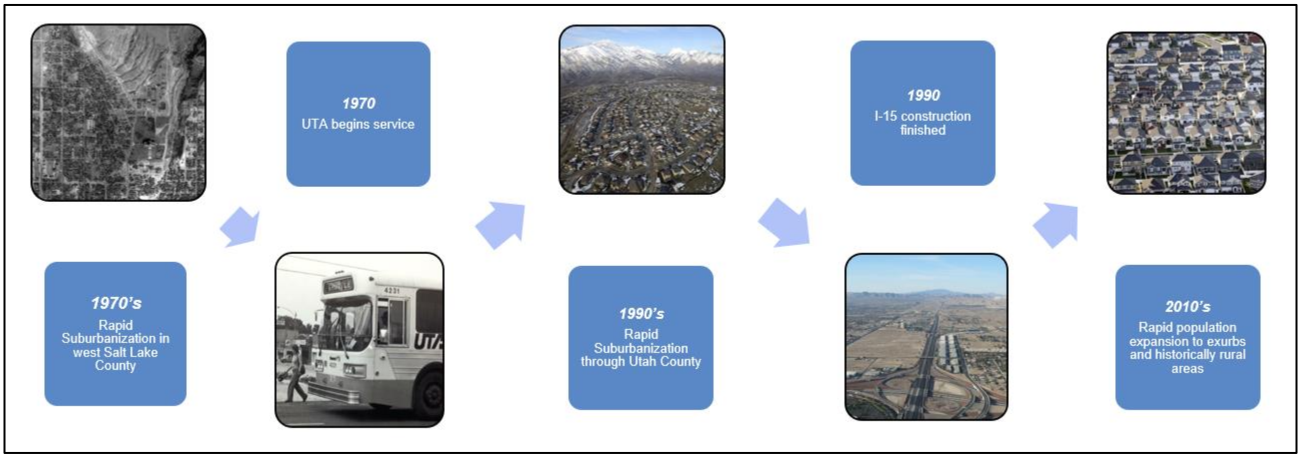

Figure 5.3 Utah Timeline Part III: Modern Era

5.3 Limitations and Challenges

It is acknowledged that some limitations in data and analysis inherent to this study are noted here. Regarding the analysis of transportation infrastructure and its presence in the census tracts, a lack of infrastructure in some areas (e.g., shoulders, pavement messages, or other infrastructure type) may not necessarily indicate historical underinvestment or other equity concerns. Certain areas may not warrant or require certain infrastructure based on what traffic is present. For example, rural areas likely will not have as much transportation infrastructure present, but these areas also have significantly less population and less traffic, therefore experiencing less risk and impact from traffic. As a result, a lack of infrastructure or investment in a particular area must be considered along with the population that is present in that area, and what is warranted.

A data-related limitation in this study is that the various datasets utilized for analysis often were limited to state routes. Residential data on built environment variables was not available. As a result, some analysis in this study does not reflect the impact of infrastructure presence on residential roadways, and some infrastructure was ultimately not included in analysis. For example, sidewalk presence data was not included in this study, as in Utah, there is no central dataset for sidewalks available, and state-route sidewalk data is not always complete and up to date. Another data limitation was present in the pavement quality information; the most recent pavement quality data that could be located is sourced from 2017. More recent data would reflect current conditions with increased accuracy.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

6.1 Recommendations

Based on the analysis conclusions described in Section 5, and input from the Technical Advisory Committee (TAC) and the UDOT Project Champion, the following recommendations have been identified as one source of input, data, and tools that can further support UDOT's Expanding Opportunities for All and All Users mindset.

- Strategize with the Utah Healthy Places Index (Utah HPI) team on what is the best way to incorporate the Social Vulnerability Index (SVI) and Built Environment (BE) Scoring Results into their established system.
- Add SVI scoring to the robust Decision Support Layers for Transportation Infrastructure.
- Download appropriate portions of the Utah HPI and compare/merge the BE and SVI layers with appropriate Utah HPI layers. Analyze these results for possible future uses.
- Strategize with the WFRC team on ways to incorporate the Social Vulnerability Index (SVI) and Built Environment (BE) Scoring Results into their Equity Focus Areas and Access to Opportunities planning areas.
- Seek Federal Funding Opportunities to utilize Appendix A (the most vulnerable tracts) for Expanding Opportunities for All type projects, perhaps as a Demonstration Type Project.

6.2 Implementation Plan

Eileen Barron will work directly with staff from the following divisions within UDOT to identify specific implementation strategies:

- Program Development
- Utah Trail Network
- Traffic and Safety

- Region Leadership
- Others, as identified through the process.

REFERENCES

Antonczak, B., T.M. Thompson, M.W. DePaola, and G. Rowangould. (2023). 2020 Near-roadway population census, traffic exposure and equity in the United States. *Traffic and Research Part D: Transport and Environment. 125*(103965). https://www.sciencedirect.com/science/article/pii/S1361920923003620

ATSDR. (2024). *CDC/ATSDR Social Vulnerability Index*. Agency for Toxic Substances and Disease Registry. https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

Austin Revitalization Authority. (2024). *1968: Fair Housing Act.* Austin Revitalization Authority. Accessed 6/28/24. https://austinrev.org/timeline/fair-housing-act/

Boisjoly, G. and G.T. Yengoh. (2017). Opening the door to social equity: local and participatory approaches to transportation planning in Montreal. *European Transport Research Review. 9*(43). https://etrr.springeropen.com/articles/10.1007/s12544-017-0258-4

Booker, C. (2022). *Fast-growing Utah continues to be a migration magnet.* KUER 90.1. Accessed 6/28/24. https://www.kuer.org/business-economy/2022-12-01/fast-growing-utah-continues-to-be-a-migration-magnet

Brown, A. (2022). From aspiration to operation: ensuring equity in transportation. *Transport Reviews. 42*(4). 409-414. https://doi.org/10.1080/01441647.2022.2064527

Carino, M. M. (2018). *Life in This Iconic Midcentury Suburb Shows How California Dreams Are Shrinking.* KQED. Accessed 6/28/24. https://www.kqed.org/news/11678761/life-in-this-iconic-mid-century-suburb-shows-how-california-dreams-are-shrinking

Cortez, M. (2024). *Salt Lake City has joined urban schools nationwide that are closing due to enrollment losses*. https://www.deseret.com/utah/2024/1/10/24032422/salt-lake-city-has-joined-urban-schools-nationwide-that-are-closing-due-to-enrollment-losses/

Data USA. (2024). *University of Utah*. Deloitte. Accessed 3/28/24. https://datausa.io/profile/university/university-of-utah.

DHHS. (2024). Utah Healthy Places Index. Accessed 6/5/24. https://dhhs.utah.gov/utahhpi/

Doran, A., El-Geneidy, A. and K. Manaugh. (2021). The pursuit of cycling equity: A review of Canadian transport plans. *Journal of Transport Geography*. 90. https://doi.org/10.1016/j.jtrangeo.2020.102927

Ellis-Soto, D., M. Chapman, and D.H. Locke. (2023). Historical redlining is associated with increasing geographical disparities in bird biodiversity sampling in the United States. *Nature Human Behavior 7*, 1869–1877

FHWA. (2023). *About Intersection Safety*. FHWA Safety Programs. Accessed 3/28/24. https://highways.dot.gov/safety/intersection-safety/about

Gurr, A. H. (2023). *Utah's growth rate is slowing, yet exurb counties continue to grow*. KSL NewsRadio 102.7 FM. Accessed 6/28/24. https://kslnewsradio.com/1996827/utahs-growth-rate-is-slowing-yet-exurb-counties-continue-to-grow/

Historia Sanitaria. (No Date). *1937 – National Housing Act passed in the United States.* Historia Sanitaria. Accessed 6/28/24. https://www.wiki.sanitarc.si/1937-national-housing-act-passed-in-the-united-states/

Historic Trolley Square. (No Date). *Trolley Square History Museum.* Historic Trolley Square. Accessed 6/28/24. https://www.trolleysquare.com/history

Johnson, E. (2019). *Education Deserts*. Inside Higher Education. 12/12/19. https://www.insidehighered.com/news/2019/12/20/access-higher-education-tilts-heavily-toward-urban-areas

Keen, D., Kyritsis, J., Meiser, E. and M. Rosales. (2021). Resource Guide for Improving Diversity and Inclusion Programs for the Public Transportation Industry. The National Academies of Sciences Engineering Medicine, Transportation Research Board. *TCRP Research Report 228*. https://doi.org/10.17226/26230

Litman, T. (2023). *Evaluating Transportation Equity.* Victoria Transport Policy Institute. https://www.vtpi.org/equity.pdf

Liu, H., M. Rahman, and A. Karner. (2023). Bus network redesigns and public transit equity analysis: Evaluating system-wide changes in Richmond, Virginia. Travel Behavior and Society. *31*(p 151-165) https://doi.org/10.1016/j.tbs.2022.12.002

Manaugh, K., M.G. Badami, and A.M. El-Geneidy. Integrating social equity into urban transportation planning: A critical Evaluation of equity objectives and measures in transportation plans in North America. *Transport Policy. 37*. 167-176. http://dx.doi.org/10.1016/j.tranpol.2014.09.013

Mehdipanah, R., K.R. McVay, and A.J. Schulz, (2023). Historic Redlining Practices and Contemporary Determinants of Health in the Detroit Metropolitan Area. *American Journal of Public Health. 113*, S49_S57.

Oldach, L. (2021). *Can urban universities be better neighbors*? ASBMB Today. Accessed 3/28/24. https://www.asbmb.org/asbmb-today/policy/021021/can-urban-universities-be-better-neighbors

Pereira, R. H. M., Schwanen, T. and D. Banister. (2016). Distributive justice and equity in transportation. *Transport Reviews. 37*(2). https://doi.org/10.1080/01441647.2016.1257660

Richmond University. (No Date). *Mapping Inequality: Redlining in New Deal America.* Richmond University. Accessed 6/28/24. https://dsl.richmond.edu/panorama/redlining/map/UT/SaltLakeCity/areas#loc=12/40.7449/-111.8499

Rista, F. N., Momin, K. A. and A. M. Sadri. (2022). Identifying Diversity, Equity, Inclusion, and Accessibility (DEIA) Indicators for Transportation Systems using Social Media Data: The Case of New York City during Covid-19 Pandemic. *Social and Information Networks* (cs.SI). https://doi.org/10.48550/arXiv.2210.14962

Sanguinetti, A., and E. Alston-Stepnitz. (2023). Using emerging mobility data to advocate equitable micromobility infrastructure in underserved communities. *Transportation Research Part D.* 117. https://doi.org/10.1016/j.trd.2023.103613

Saturday Evening Post. (2022). *The 1960s Suburban Lawn Boom.* The Saturday Evening Post. Accessed 6/28/24. https://www.saturdayeveningpost.com/2022/03/the-1960s-suburban-lawn-boom/

Smith Group. (2018). *Planning for Urban Universities and Colleges*. Accessed 3/28/24 https://www.smithgroup.com/perspectives/2018/planning-for-urban-universities-and-colleges

Standt, L., Combs, T., and J. Cohn. (2016*). Pursuing Equity in Pedestrian and Bicycle Planning*. Pedestrian and Bicycle Information Center. https://www.pedbikeinfo.org/cms/downloads/PBIC_WhitePaper_Equity.pdf

UDOT. (2022). UDOT Strategic Direction. https://udot.utah.gov/strategic-direction/

UDOT. (2024). Utah Department of Transportation- About Us. Accessed 6/5/24: https://www.udot.utah.gov/connect/about-us/

USDOT. (No Date). *Equity*. U.S. Department of Transportation. https://www.transportation.gov/priorities/equity

USGAO. (2022). *National Highways: Analysis of Available Data Could Better Ensure Equitable Pavement Condition*. Accessed 3/28/24. https://www.gao.gov/products/gao-22-104578

UGS. (No Date). *Aerial Imagery Collection.* Utah Geological Survey. Accessed 6/28/24. https://geology.utah.gov/portfolio-item/aerial-imagery-collection/

USDA. (No Date). *Harry S. Truman Signing the Housing Act of 1949.* USDA. Accessed 6/28/24. https://commons.wikimedia.org/wiki/File:Harry_S._Truman_signing_the_Housing_Act_of_1949.jpg

UTA. (No Date). *History.* Utah Transit Authority. Accessed 6/28/24. https://www.rideuta.com/-/media/Files/About-UTA/Fact-Sheets/2017/History_FactSheet_April2017

Utah Rails. (2020). *Interstate 15 in Utah*. Accessed 3/28/24 https://utahrails.net/highways-interstate-15.php

Utah State University. (2024*). (In) The Road of Progress: The West Side and I-15: Construction of Interstate.* Utah State University: University Libraries. Accessed 6/28/24. http://exhibits.usu.edu/exhibits/show/intheroadofprogress-west-side/section-iv/construction-of-interstate

Utah Stories. (2017). *This is State Street downtown Salt Lake City in 1926.* [Image Attached] [Status Update]. Facebook. Accessed 6/28/24. https://www.facebook.com/utahstories/photos/a.335172093250153/1261149333985753/?type=3

WFRC. (No Date). *Equity Planning.* Wasatch Front Regional Council. https://wfrc.org/public-involvement/equity-planning/

Zillow. (2024). *Zillow Real Estate Estimates for Utah*. Accessed: 3/28/24. https://www.zillow.com/homes/utah_rb/

APPENDIX A: SVI/BE Scoring Census Tracts

The table below includes a full list of the census tracts which meet both the BE scoring criteria and SVI criteria as described in Section 4.7. These tracts can be considered to experience the most impact from BE factors and are most vulnerable regarding socio-demographic concerns.

Table A.1. High SVI and BE Scoring Utah Census Tracts

County ID	County	FIPS	Location
49005	Cache	49005000302	Census Tract 3.02, Cache County, Utah
49005	Cache	49005000401	Census Tract 4.01, Cache County, Utah
49005	Cache	49005000502	Census Tract 5.02, Cache County, Utah
49005	Cache	49005000602	Census Tract 6.02, Cache County, Utah
49007	Carbon	49007000300	Census Tract 3, Carbon County, Utah
49011	Davis	49011125600	Census Tract 1256, Davis County, Utah
49011	Davis	49011125701	Census Tract 1257.01, Davis County, Utah
49011	Davis	49011125702	Census Tract 1257.02, Davis County, Utah
49013	Duchesne	49013940501	Census Tract 9405.01, Duchesne County, Utah
49019	Grand	49019000200	Census Tract 2, Grand County, Utah
49019	Grand	49019000302	Census Tract 3.02, Grand County, Utah
49035	Salt Lake	49035100306	Census Tract 1003.06, Salt Lake County, Utah
49035	Salt Lake	49035100308	Census Tract 1003.08, Salt Lake County, Utah
49035	Salt Lake	49035100500	Census Tract 1005, Salt Lake County, Utah
49035	Salt Lake	49035100600	Census Tract 1006, Salt Lake County, Utah
49035	Salt Lake	49035100800	Census Tract 1008, Salt Lake County, Utah
49035	Salt Lake	49035101401	Census Tract 1014.01, Salt Lake County, Utah
49035	Salt Lake	49035101402	Census Tract 1014.02, Salt Lake County, Utah
49035	Salt Lake	49035102000	Census Tract 1020, Salt Lake County, Utah
49035	Salt Lake	49035102100	Census Tract 1021, Salt Lake County, Utah
49035	Salt Lake	49035102300	Census Tract 1023, Salt Lake County, Utah
49035	Salt Lake	49035102501	Census Tract 1025.01, Salt Lake County, Utah
49035	Salt Lake	49035102502	Census Tract 1025.02, Salt Lake County, Utah
49035	Salt Lake	49035102600	Census Tract 1026, Salt Lake County, Utah
49035	Salt Lake	49035102701	Census Tract 1027.01, Salt Lake County, Utah
49035	Salt Lake	49035102702	Census Tract 1027.02, Salt Lake County, Utah
49035	Salt Lake	49035102802	Census Tract 1028.02, Salt Lake County, Utah
49035	Salt Lake	49035102900	Census Tract 1029, Salt Lake County, Utah
49035	Salt Lake	49035103200	Census Tract 1032, Salt Lake County, Utah
49035	Salt Lake	49035111105	Census Tract 1111.05, Salt Lake County, Utah
49035	Salt Lake	49035111400	Census Tract 1114, Salt Lake County, Utah
49035	Salt Lake	49035111500	Census Tract 1115, Salt Lake County, Utah

49035	Salt Lake	49035111601	Census Tract 1116.01, Salt Lake County, Utah
49035	Salt Lake	49035111602	Census Tract 1116.02, Salt Lake County, Utah
49035	Salt Lake	49035111702	Census Tract 1117.02, Salt Lake County, Utah
49035	Salt Lake	49035111904	Census Tract 1119.04, Salt Lake County, Utah
49035	Salt Lake	49035112101	Census Tract 1121.01, Salt Lake County, Utah
49035	Salt Lake	49035112404	Census Tract 1124.04, Salt Lake County, Utah
49035	Salt Lake	49035112406	Census Tract 1124.06, Salt Lake County, Utah
49035	Salt Lake	49035112621	Census Tract 1126.21, Salt Lake County, Utah
49035	Salt Lake	49035112822	Census Tract 1128.22, Salt Lake County, Utah
49035	Salt Lake	49035112829	Census Tract 1128.29, Salt Lake County, Utah
49035	Salt Lake	49035112918	Census Tract 1129.18, Salt Lake County, Utah
49035	Salt Lake	49035113308	Census Tract 1133.08, Salt Lake County, Utah
49035	Salt Lake	49035113311	Census Tract 1133.11, Salt Lake County, Utah
49035	Salt Lake	49035113312	Census Tract 1133.12, Salt Lake County, Utah
49035	Salt Lake	49035113406	Census Tract 1134.06, Salt Lake County, Utah
49035	Salt Lake	49035113509	Census Tract 1135.09, Salt Lake County, Utah
49035	Salt Lake	49035113512	Census Tract 1135.12, Salt Lake County, Utah
49035	Salt Lake	49035113536	Census Tract 1135.36, Salt Lake County, Utah
49035	Salt Lake	49035113539	Census Tract 1135.39, Salt Lake County, Utah
49035	Salt Lake	49035113702	Census Tract 1137.02, Salt Lake County, Utah
49035	Salt Lake	49035114000	Census Tract 1140, Salt Lake County, Utah
49035	Salt Lake	49035114500	Census Tract 1145, Salt Lake County, Utah
49035	Salt Lake	49035114602	Census Tract 1146.02, Salt Lake County, Utah
49035	Salt Lake	49035115211	Census Tract 1152.11, Salt Lake County, Utah
49047	Uintah	49047940201	Census Tract 9402.01, Uintah County, Utah
49047	Uintah	49047968401	Census Tract 9684.01, Uintah County, Utah
49047	Uintah	49047968403	Census Tract 9684.03, Uintah County, Utah
49049	Utah	49049000511	Census Tract 5.11, Utah County, Utah
49049	Utah	49049001103	Census Tract 11.03, Utah County, Utah
49049	Utah	49049001108	Census Tract 11.08, Utah County, Utah
49049	Utah	49049001403	Census Tract 14.03, Utah County, Utah
49049	Utah	49049001404	Census Tract 14.04, Utah County, Utah
49049	Utah	49049001601	Census Tract 16.01, Utah County, Utah
49049	Utah	49049001602	Census Tract 16.02, Utah County, Utah
49049	Utah	49049001801	Census Tract 18.01, Utah County, Utah
49049	Utah	49049001802	Census Tract 18.02, Utah County, Utah
49049	Utah	49049001900	Census Tract 19, Utah County, Utah
49049	Utah	49049002002	Census Tract 20.02, Utah County, Utah
49049	Utah	49049002209	Census Tract 22.09, Utah County, Utah
49049	Utah	49049002210	Census Tract 22.10, Utah County, Utah
49049	Utah	49049002400	Census Tract 24, Utah County, Utah

49049	Utah	49049002500	Census Tract 25, Utah County, Utah
49049	Utah	49049010125	Census Tract 101.25, Utah County, Utah
49049	Utah	49049010306	Census Tract 103.06, Utah County, Utah
49049	Utah	49049980300	Census Tract 9803, Utah County, Utah
49049	Utah	49049980500	Census Tract 9805, Utah County, Utah
49053	Washington	49053270701	Census Tract 2707.01, Washington County, Utah
49053	Washington	49053270904	Census Tract 2709.04, Washington County, Utah
49053	Washington	49053271200	Census Tract 2712, Washington County, Utah
49053	Washington	49053271400	Census Tract 2714, Washington County, Utah
49057	Weber	49057200202	Census Tract 2002.02, Weber County, Utah
49057	Weber	49057200301	Census Tract 2003.01, Weber County, Utah
49057	Weber	49057200302	Census Tract 2003.02, Weber County, Utah
49057	Weber	49057200400	Census Tract 2004, Weber County, Utah
49057	Weber	49057200800	Census Tract 2008, Weber County, Utah
49057	Weber	49057200900	Census Tract 2009, Weber County, Utah
49057	Weber	49057201100	Census Tract 2011, Weber County, Utah
49057	Weber	49057201200	Census Tract 2012, Weber County, Utah
49057	Weber	49057201800	Census Tract 2018, Weber County, Utah
49057	Weber	49057201900	Census Tract 2019, Weber County, Utah