APPENDIX A

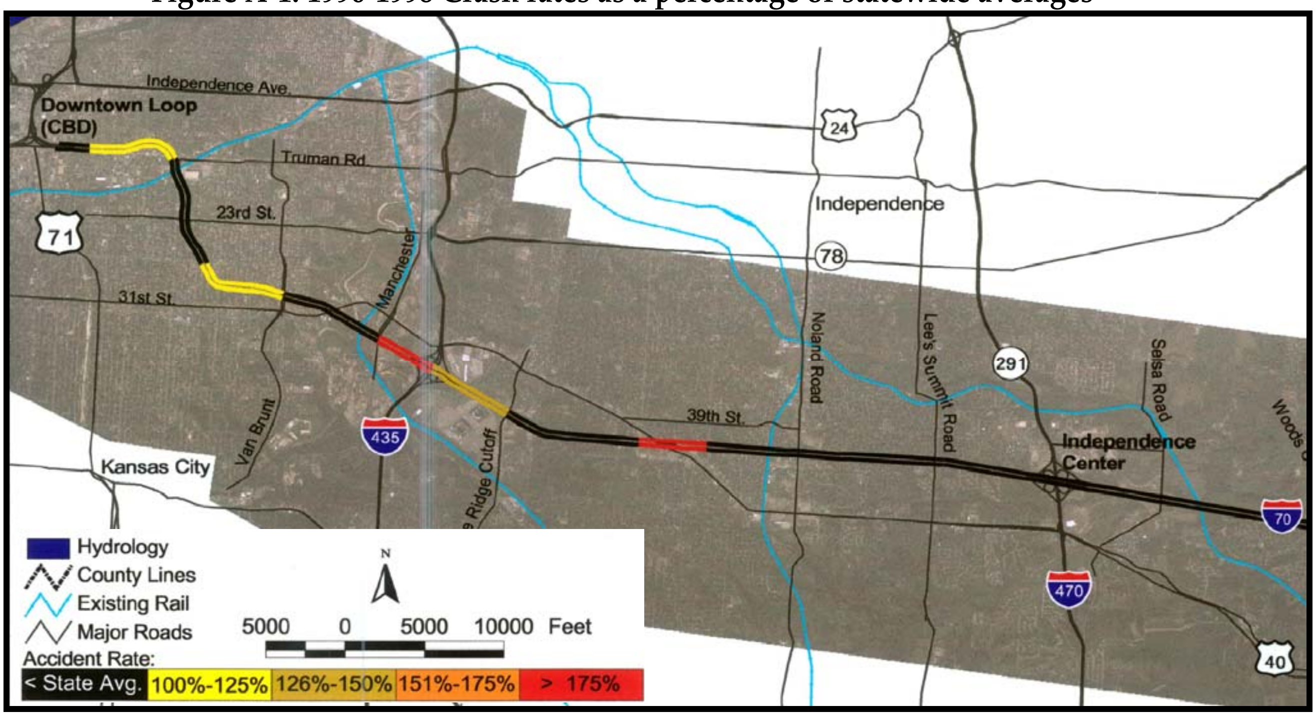
Crash History

I-70 Crash History

Major Investment Study (MIS) Crash Summary

A crash analysis was performed as part of the I-70 Major Investment Study (MIS) for the period 1996-1998 in which the average annual number of crashes and the average crash rate for each segment of I-70 between interchanges was computed. Eight segments were identified to have a crash rate that exceeded the statewide crash rate of 122.77 crashes per hundred million vehicle miles of travel. Approximately 574 crashes were reported in the Study Area during that time period. Approximately 24 percent of the crashes involved personal injury and approximately one percent involved fatalities. The frequency of crashes was more than twice that of the statewide average at I-70 between Manchester Road and I-435 and at I-70 between U.S. 40 and Blue Ridge Boulevard. **Figure A-1** shows the high crash locations explored in the MIS in relation to the statewide average crash rate.

Figure A-1: 1996-1998 Crash rates as a percentage of statewide averages[1]



2003-2007 Crash Analysis

A total of 5,857 crashes were reported within the Study Area I-70 corridor between 2003 and 2007. The locations of the fatal crashes are shown in **Figure A-2**. For the purposes of our

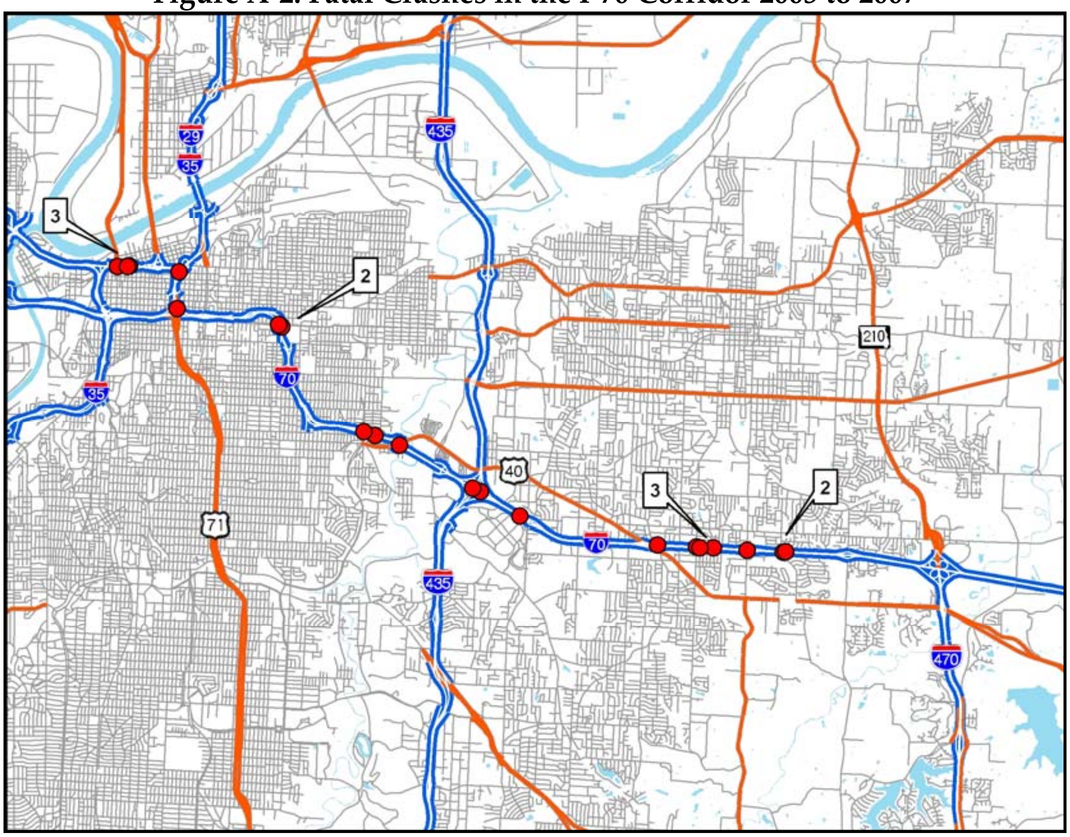
[1] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 5, Page 46, Figure 5.6 (m)

analysis, the study corridor was divided into 14 segments. A summary of the crash rates analysis is shown in **Table A-1**. The crash rates that fall within above 151 percent of the statewide average crash rate are undesirable.

The dominant crash type for the analysis period was rear end (approximately 53 percent) followed by passing and out of control (approximately 18 percent each). Rear end collisions often occur in congested areas as drivers fail to stop for slow moving traffic.

Approximately 78 percent of the crashes in the period of 2003 to 2007 resulted in only property damage and approximately 22 percent resulted in injury. A total of 20 crashes (less than one percent) resulted in fatalities. Injury and fatal crashes were spread throughout the corridor. Approximately 23 percent of all crashes occur in dark conditions and approximately 19 percent occur in icy/snow/wet pavement conditions. Approximately 30 percent occur during the weekday peak period of traffic (7-9 a.m. and 4-6 p.m.), which has the largest effect on delay for motorists. The locations of those fatal crashes are shown in **Figure A-2**.

Figure A-2: Fatal Crashes in the I-70 Corridor 2003 to 2007



The locations with the highest crash rates between 2003 and 2007 are the downtown loop, westbound from the Benton curve to the downtown loop, eastbound from the Jackson curve to I-435 and the I-435 interchange. The locations that were identified in the MIS to have the highest crash rates between 1996 and 1998 were between Manchester Trafficway and Blue Ridge Cut-Off and in the vicinity of the U.S. 40 interchange. The Benton-Jackson curves were also identified to have high crash rates. The part of I-70 where crash rates increased significantly during the period from 2003 to 2007 compared to the period from 1996 to 1998 is the Benton-Jackson curves (approximately 25 percent higher). The crash rates at the Blue Ridge Cut-Off and U.S. 40 East interchanges showed significant reductions. The 1996 to 1998 crash rate was reported as 380.83 crashes per 100 million vehicle miles of travel.

Table A-1: Summary of Crash Analysis for the Period 2003-2007

Analysis Sections		**Length** (miles)	**2003 to 2007 Crash Rate** (Crashes Per 100 Million Vehicle Miles of Travel)		**5 Year Crash Rate versus Statewide Average Crash Rate*** (107.82)	
			Eastbound	**Westbound**	**Eastbound**	**Westbound**
1	Downtown Loop	3.45	340.50		316%	
2	Paseo Interchange	0.86	161.41	227.10	150%	211%
3	Benton Curve	1.20	154.84	211.11	144%	196%
4	23rd Street Interchange	0.67	93.76	61.35	87%	57%
5	Jackson Curve	0.88	234.57	90.07	218%	84%
6	Van Brunt Interchange	0.73	238.13	128.44	221%	119%
7	U.S. 40 West Interchange	0.59	186.80	98.21	173%	91%
8	Manchester Interchange	0.57	211.48	114.95	196%	107%
9	I-435 Interchange	0.96	189.01	213.37	175%	198%
10	Blue Ridge Cut-Off Interchange	1.28	136.12	149.12	126%	138%
11	U.S. 40 East Interchange	1.60	141.61	114.05	131%	106%
12	Noland Road Interchange	1.50	140.11	132.24	130%	123%
13	Lee's Summit Road Interchange	1.35	113.50	106.52	105%	99%
14	I-470 Interchange	1.51	131.95	111.28	122%	103%

* Statewide average crash rate for urban interstates.
Shading indicates sections which exceed the statewide average crash rates by more than 150 percent.

The downtown loop, the I-435 interchange, and an additional four sections eastbound and two sections westbound are defined as undesirable because the crash rate exceeds 150 percent of the statewide average rate of 107.82 crashes per 100 million vehicle miles of travel.

APPENDIX B

Demographic Trends

Demographic Trends

Transportation is generally a derived demand. That is – transportation is usually a means to some other end rather than being an end into itself. That being the case, transportation demand is largely derived from the demographic characteristics of the local and regional environments. It is critically important to understand these characteristics in the study of transportation systems to ensure that the systems are built to best address the local needs. This study used several existing sources of data to put together a composite demographic profile of the Study Area. The sources of data used are shown below:

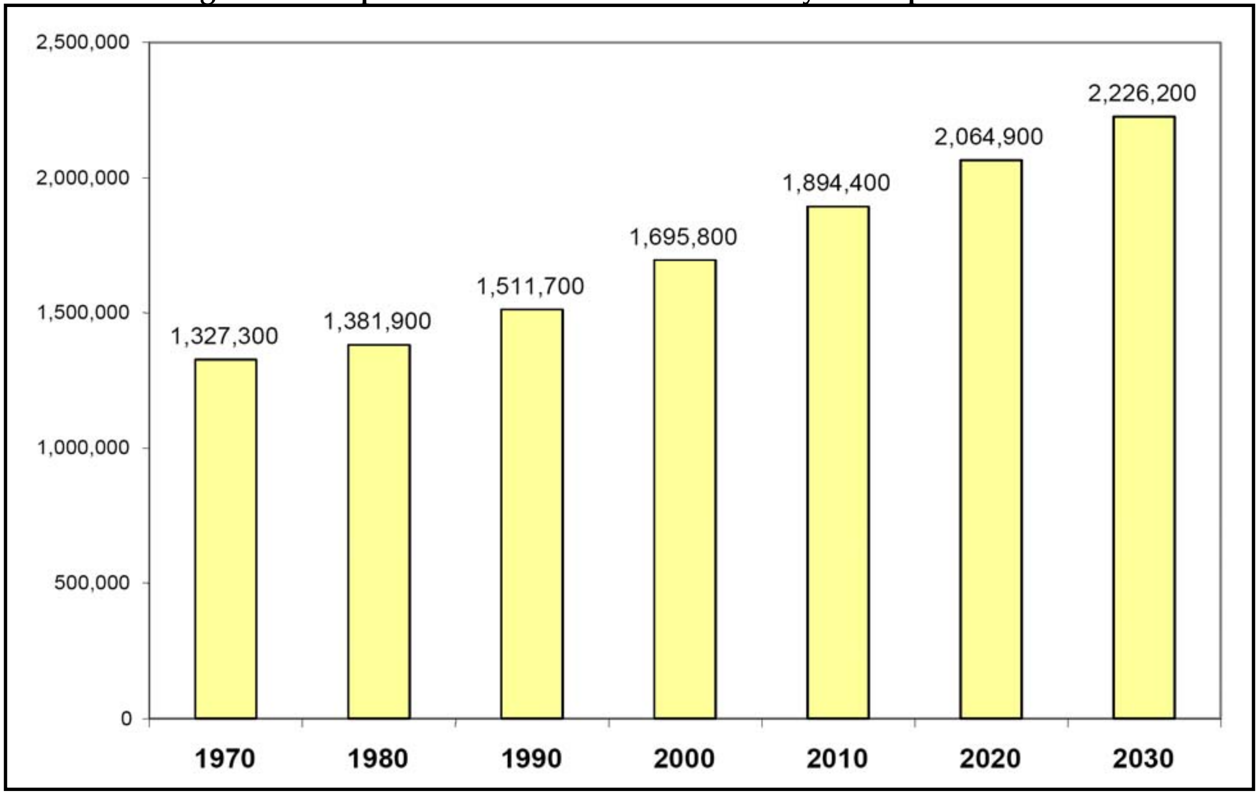
Demographic Data Sources

- I-70 Major Investment Study
  - Historical (1990-2000) population growth in Study Area
  - Projected (2000-2020) population growth in Study Area
  - Major trip generators/attractors
- Mid-America Regional Council 2030 Long Range Transportation Plan
  - Historical population and employment for region and by county
  - Future population and employment for region and by county
  - Historical and future population and employment growth by census tract
  - Travel times
  - Future capacity deficiencies
  - Transit, bike, pedestrian, railroad, truck
- Mid-America Regional Council Emme2 Models
  - Existing and future land use by traffic analysis zone (TAZ)
  - Future link daily and peak hour volumes, level of service, travel times
  - Origin-Destination information
- 2000 Census Transportation Planning Package Data
  - 2000 household and employment data by census tract and TAZ
  - 2000 Home-Work flow information (Origin-Destination, travel time)

Regional Population Trends

Population growth is one of the clearest indicators of economic activity in a corridor or region. Understanding the dynamics of population shifts within regions can help to set priorities for transportation improvements. Kansas City region has experienced a 28 percent growth in population between 1970 and 2000, and according to Mid America Regional Council's forecasts, the region is expected to grow by 31 percent by 2030, which reflects a moderate and steady growth for the region. **Figure B-1** shows the historic and forecasted population trends in the region between 1970 and 2030.

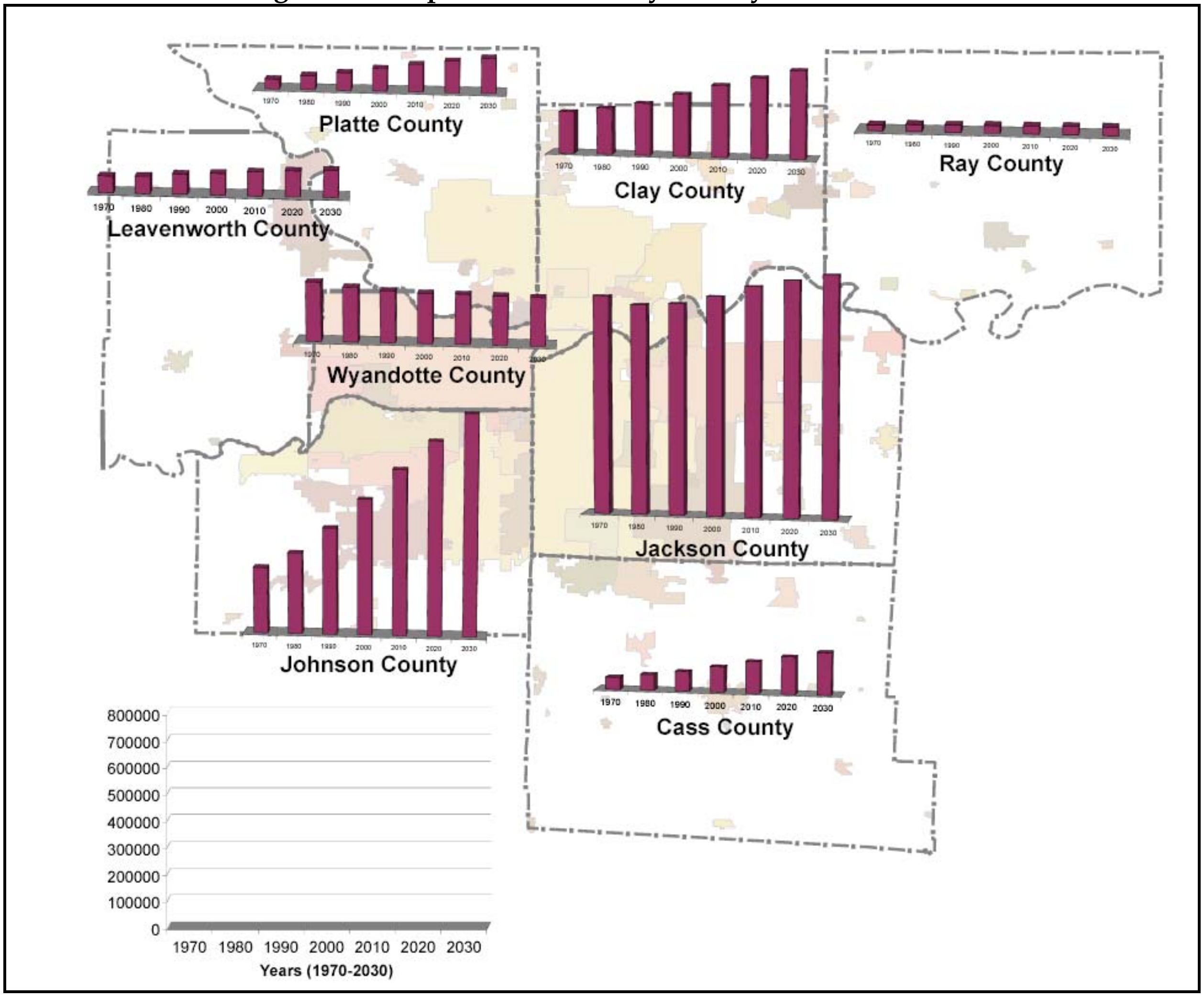
Figure B-1: Population trends of the Kansas City Metropolitan Area[1]



As with most urban areas in the U.S., during the past several decades the Kansas City region's population has spread out over a larger area as the population has grown. One of the areas where much of this growth has occurred is in Johnson County, Kansas. While some of this geographic spreading has occurred to accommodate population growth, much of it has occurred as a result of smaller household sizes and smaller residential household densities. The population trends are shown in **Figures B-2** through **B-5**. The most critical conclusion from this data is that the region is decentralizing; although it is occupying more land, it is also thinning out.

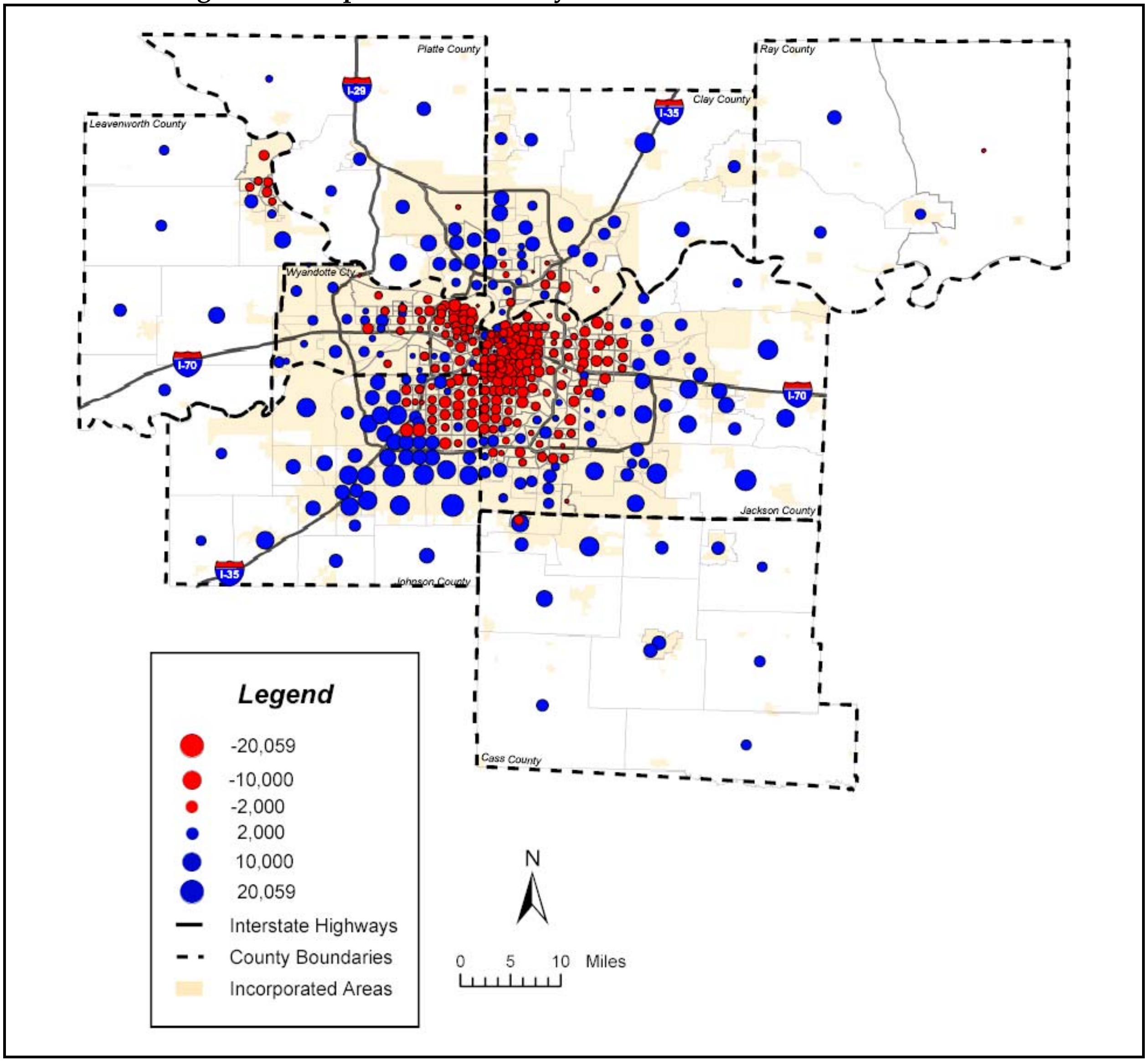
[1] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 6, Figure 2-1

Figure B-2: Population trends by County (1970 to 2000)[2]



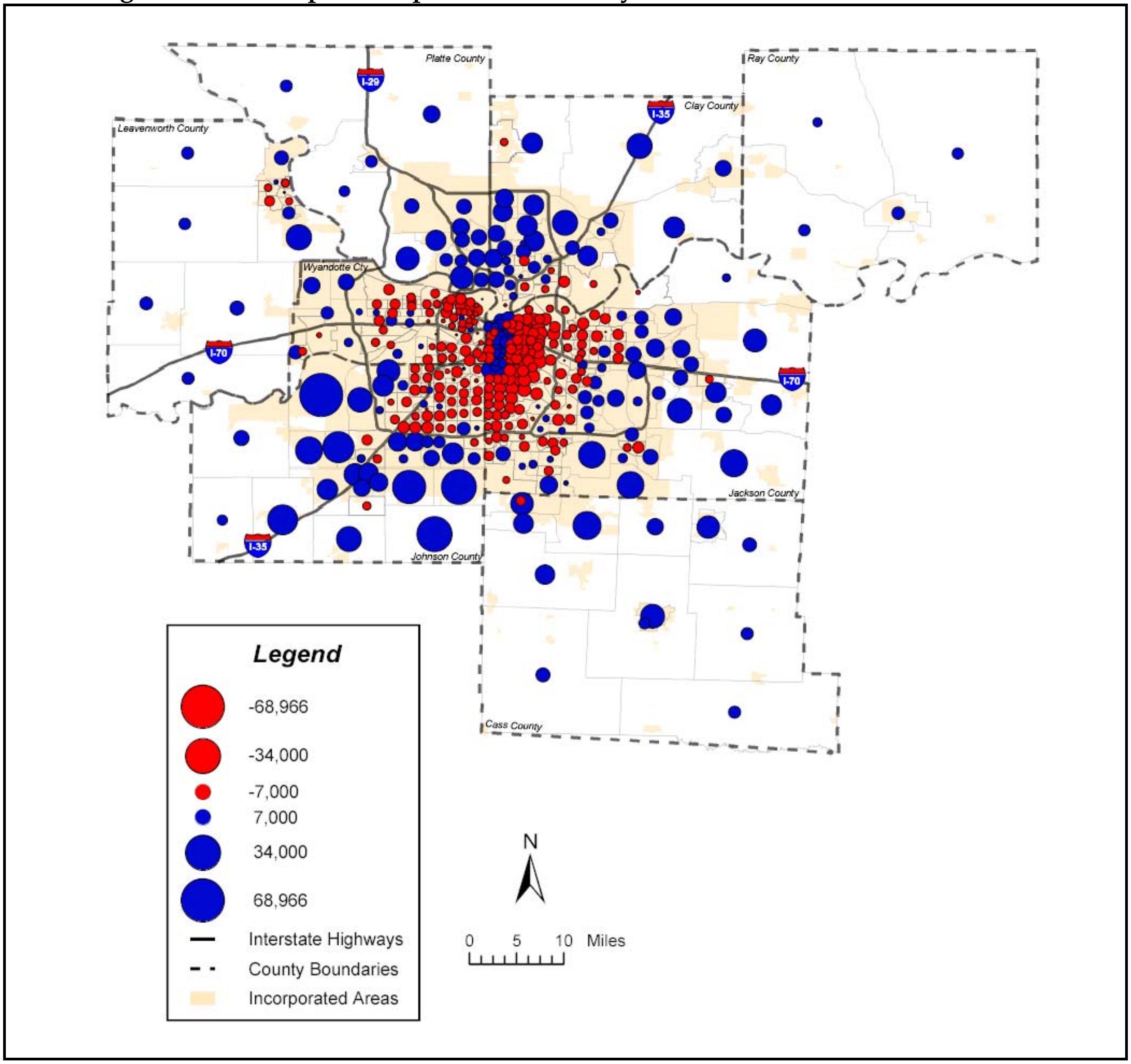
[2] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 7, Figure 2-2

Figure B-3: Population trends by 1990 Census Tract (1970 to 2000)[3]



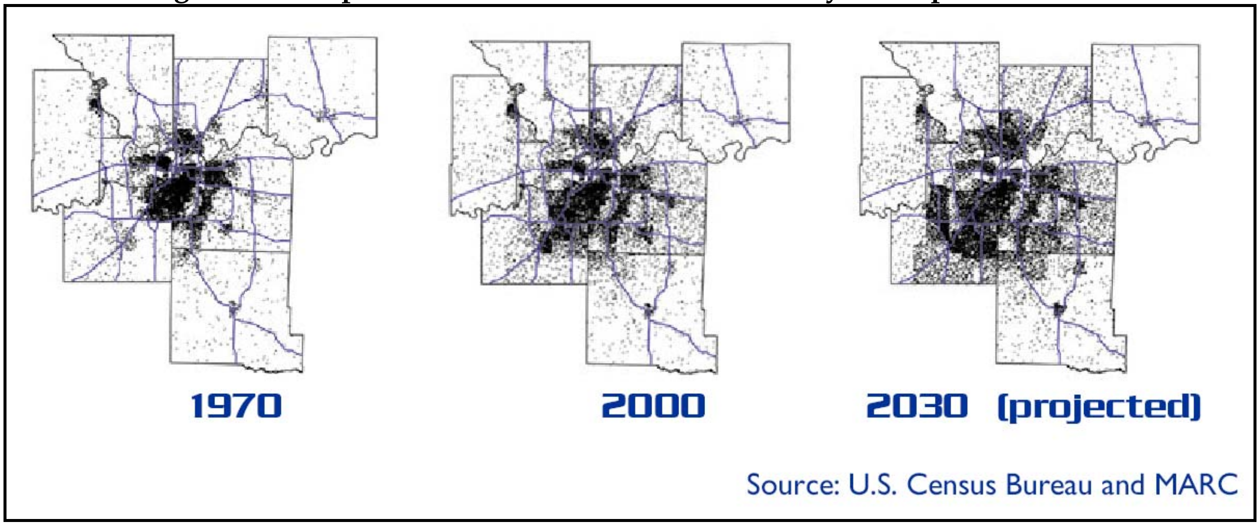
[3] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 8, Figure 2-3

Figure B-4: Anticipated Population trends by 1990 Census Tract (2000 to 2030)[4]



[4] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 9, Figure 2-4

Figure B-5: Population Densities in the Kansas City Metropolitan Area[5]

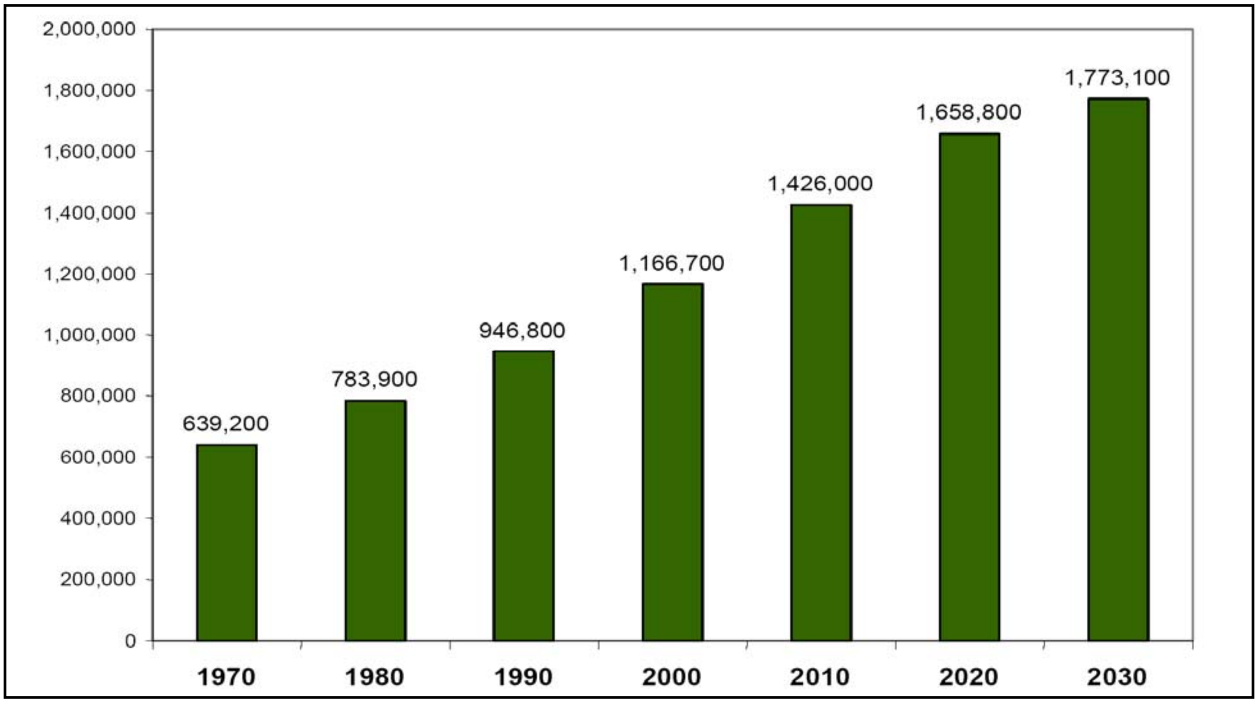


Regional Employment Trends

Also following national trends for urban areas, the Kansas City region has experienced a high employment growth between 1970 and 2000 (82 percent). This trend is expected to continue into the future, with an employment increase of 52 percent anticipated. The Kansas City area is the home to the headquarters of several businesses such as Hallmark Cards, US Sprint, Russell Stover Candies, H & R Block, AMC Theatres, etc. **Figure B-6** shows the employment trend of the region between 1970 and 2030.

[5] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 10, Figure 2-5

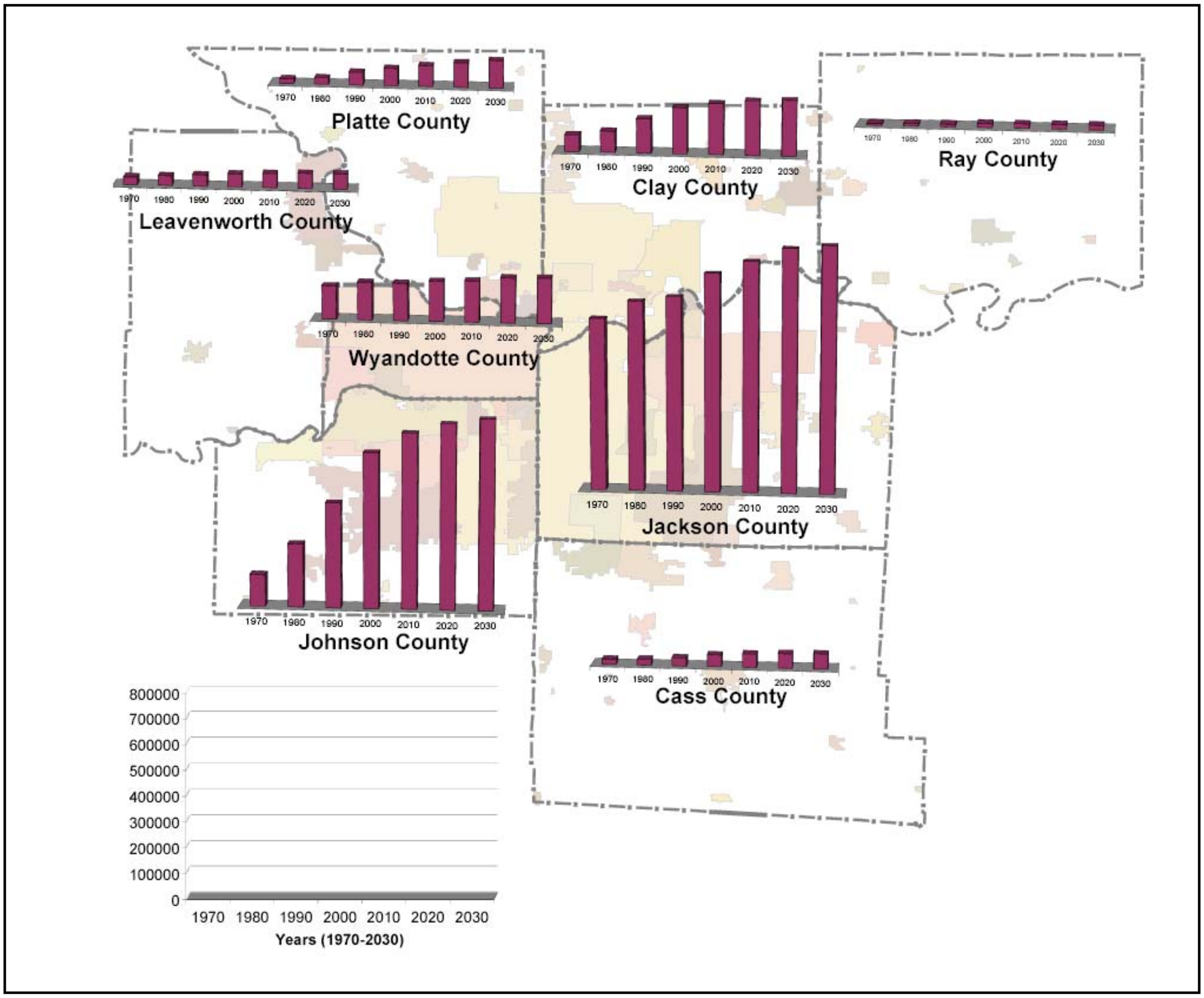
Figure B-6: Employment trends of the Kansas City metropolitan area[6]



As with employment, the greatest employment increase in the region between 1970 and 2000 occurred in Johnson County, Kansas, which is also expected to experience the highest increases in the region between 2000 and 2030. The employment trends by county are shown in **Figures B-7** through **B-9**.

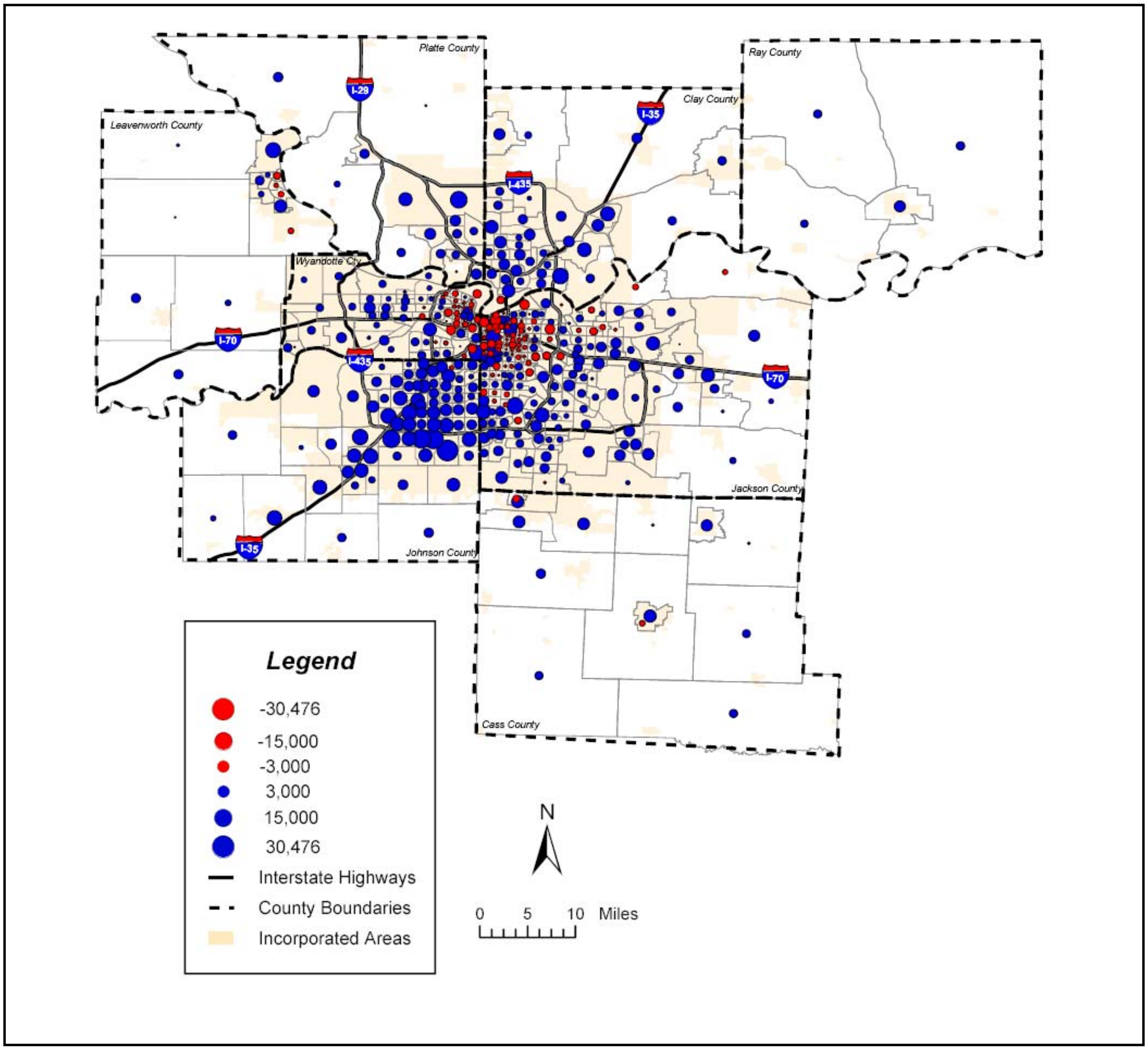
[6] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 11, Figure 2-7

Figure B-7: Employment trends by County[7]



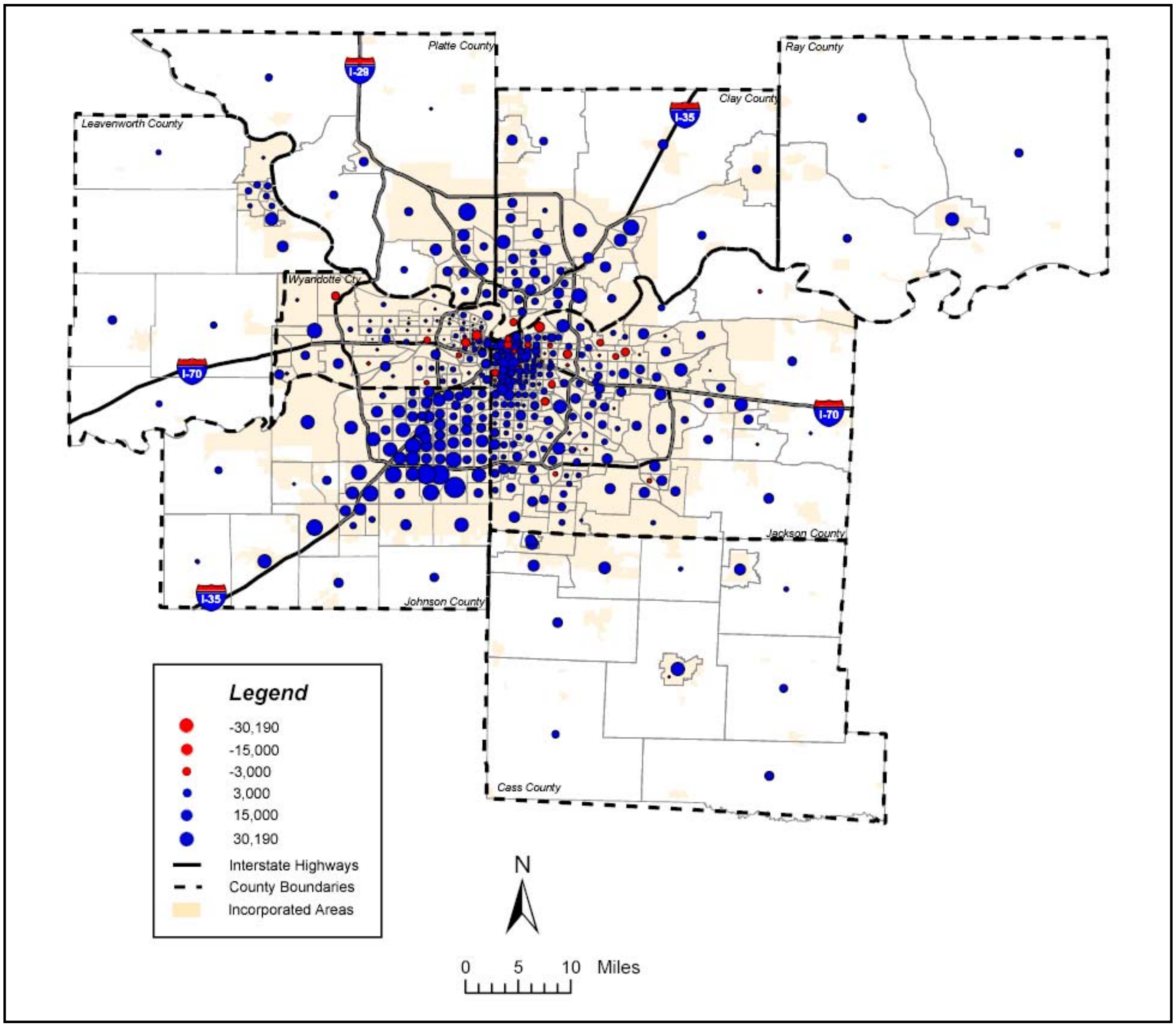
[7] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 12, Figure 2-8

Figure B-8: Employment trends by 1990 Census Tract (1970 to 2000)[8]



[8] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 13, Figure 2-9

Figure B-9: Anticipated Employment trends by 1990 Census Tract (2000 to 2030)[9]



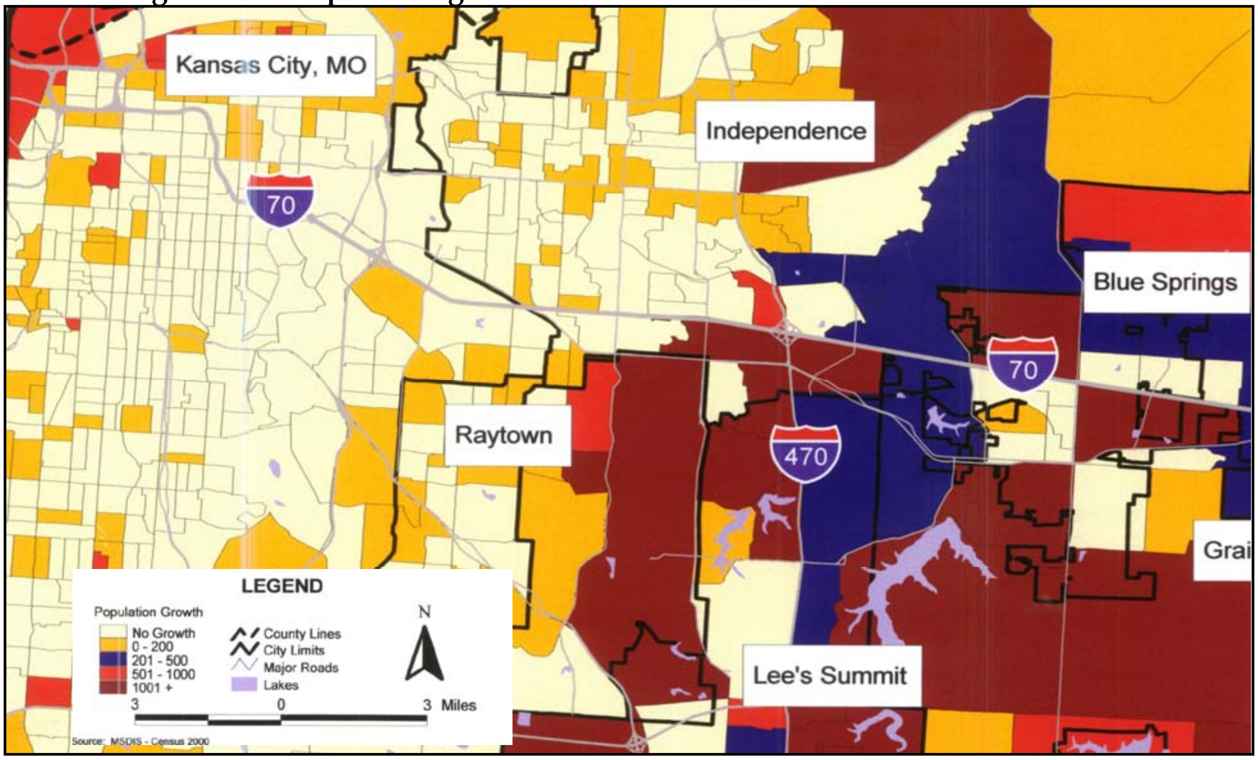
Corridor Population Trends

Within the study corridor I-70 lies in Jackson County between downtown Kansas City and Independence. Jackson County has experienced a slight population decline between 1970 and 1990 but has experienced a 3.5 percent growth in population between 1990 and 2000 and is anticipated to grow by approximately nine percent between 2000 and 2030. Recent population growth in the corridor has been focused in communities on the eastern edge of the Study Area such as Blue Springs and Independence. Employment in Jackson County has grown by 22 percent between 1970 and 2000 and is anticipated to increase by approximately 33 percent between 2000 and 2030. **Figures B-10** and **B-11**, which show the recent and forecasted

[9] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 14, Figure 2-10

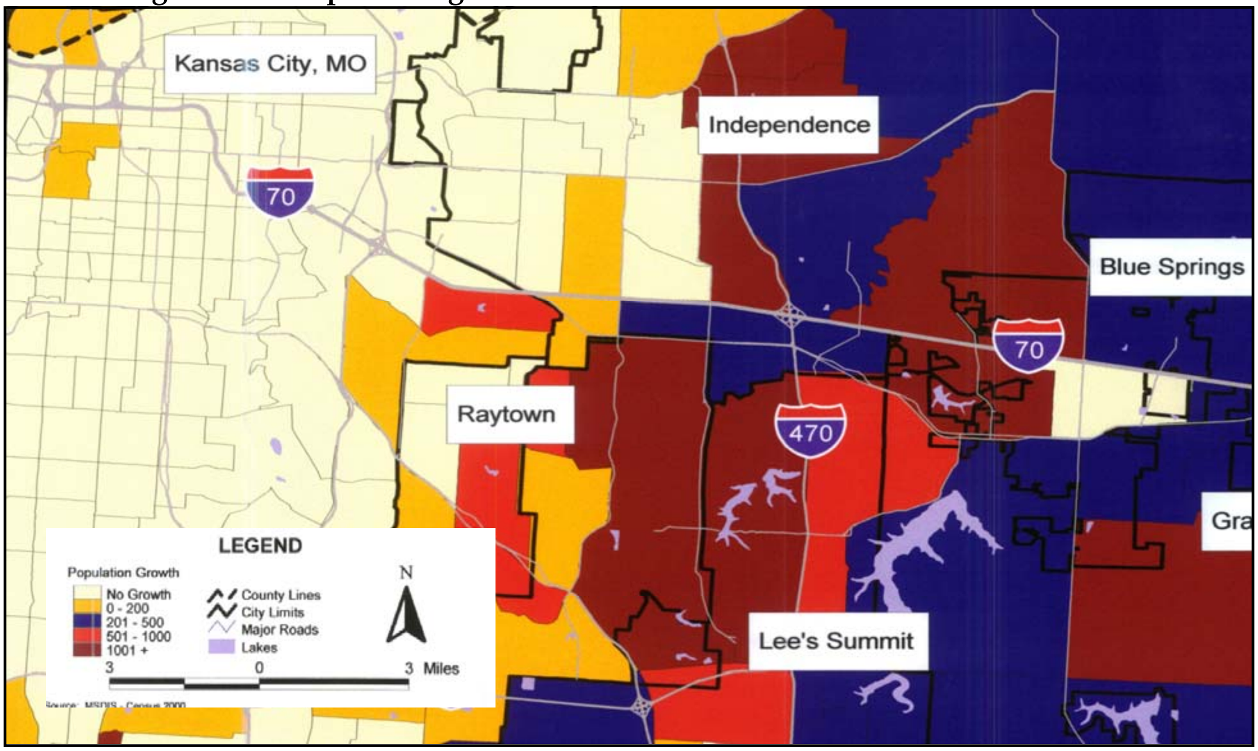
population growth in the Study Area corridor, verify that the people and jobs continue to move eastward along I-70 in the Study Area.

Figure B-10: Population growth in the I-70 corridor between 1990 and 2000[10]



[10] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 3, Page 7, Figure 3.3 (a)

Figure B-11: Population growth in the I-70 corridor between 2000 and 2020[11]



[11] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 3, Page 8, Figure 3.3 (b)

APPENDIX C

Trip Generators and Attractions

Trip Generators and Attractions

The I-70 Major Investment Study (MIS) carried out an extensive inventory of trip generators and attractions along the study corridor. An understanding of these characteristics can help to more fully understand travel needs along the corridor, as well as assist locating critical system components, such as freeway interchanges and transit stops. A description of the findings detailed in the MIS is provided in the following section.

The MIS reported that the residential centers are generally in the middle to outer portions of the Study Area including Independence, Blue Springs, Lee's Summit, and the Country Club Plaza. **Table C-1** identifies the general locations of the major trip origins according to MARC's regional travel demand model.

Table C-1: Trips Generated from Major Trip Origin Centers in the Study Area [1]

General Location	Number of Daily Trips[1]
Work Trips[2]	
Lee's Summit, near US 50	7,484
Blue Springs, US 40 and M-7	5,916
Kansas City, southwest of Raytown	5,863
Blue Springs, north of I-70	5,312
Lee's Summit, near US 50	5,094
Blue Springs, US 40 and M-7	4,684
Independence, US 24 and M-291	4,674
Kansas City, south of Country Club Plaza	4,611
Non-Work Trips[3]	
Kansas City, south of Country Club Plaza	30,940
Lee's Summit, near US 50	29,140
Lee's Summit, near US 50	26,062
Kansas City, Country Club Plaza area	25,631
Kansas City, Country Club Plaza area	24,957

[1] Daily person-trip productions
[2] Includes the home-base work trip purpose
[3] Includes home-based shopping, home-based social/recreational, home-based other, and non-home-based trip purposes.

Source: Cambridge Systematics, Inc.; estimated from MARC travel demand model.

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[1] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 5, Page 32, Table 5.6 (d)

The MIS also reported that the major employment centers are generally located between downtown Kansas City and the Country Club Plaza and near Ward Parkway and Bannister Road whereas the major shopping areas are located near Lee's Summit, Blue Ridge Crossing, and the Country Club Plaza. Other major trip attractors (e.g., entertainment centers) are the Country Club Plaza, the Jackson County Sports Complex near I-435, and near the Independence Shopping Center at I-470. These locations are shown in **Table C-2**.

Table C-2: Trips Attracted to Major Study Area Employment, Shopping, and Entertainment Centers [2]

General Location	Number of Daily Trips[1]
Work Trips[2]	
Kansas City, south, near Bannister Road	13,444
Kansas City Downtown, just south of Downtown Loop	11,252
Kansas City, southwest of Raytown	9,550
Kansas City, southeast of Downtown Loop	9,378
Kansas City, south, near Bannister Road	7,877
Kansas City, Main Street south of 22nd Street	7,361
Kansas City Downtown, just south of Downtown Loop	7,020
Kansas City, I-435 near Riverfront Park	6,881
Kansas City, Country Club Plaza area	6,709
Kansas City, Southwest Trafficway near I-35	6,500
Shopping Trips[3]	
Kansas City, near I-435, southeast of Raytown	12,576
Kansas City, Country Club Plaza area	9,828
Independence, US 40/I-70: major retail center	9,479
Kansas City, Country Club Plaza area	8,979
Lee's Summit, near US 50	8,320
Other Trips[4]	
Kansas City, Country Club Plaza area	45,561
Kansas City, Country Club Plaza area	45,479
Kansas City, south of Country Club Plaza	44,922
Independence, M-291/I-70: major retail center	37,332
Kansas City, south, near Bannister Rd.	35,937
Kansas City Downtown, just south of Downtown Loop	35,604

[1] Daily person-trip attractions
[2] Includes the home-base work trip purpose
[3] Includes the home-based shopping trip purpose
[4] Includes home-based social/recreational, home-based other, and non-home-based trip purposes.
Source: Cambridge Systematics, Inc.; estimated from MARC travel demand model.

[2] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 5, Page 35, Table 5.6 (e)

It should be noted that the data provided above and in the MIS was based on 2000 census data, as is MARC's current validated existing conditions regional travel demand model. However, the study corridor has obviously changed since the 2000 census. The I-470 and I-70 interchange has experienced an increase in regional retail opportunities with the Eastland Business Park and the Bass Pro Shop. The Blue Ridge Mall redevelopment has Blue Ridge Crossing which includes Walmart Super Center, Lowe's, and additional pad site retail. The Bannister Mall has since closed. The Sprint Center has also opened since 2000.

Furthermore, it needs to be mentioned that the Jackson County Sports Complex is in the Study Area (in the southeast quadrant of the I-70/I-435 interchange) and is a major trip attractor during special events. The Sports Complex includes Arrowhead Stadium (Kansas City Chiefs) and Kauffman Stadium (Kansas City Royals). The roadways that serve these stadiums must take the stadiums into account while improvement strategies are being developed.

APPENDIX D

Traffic Data and Level of Service Analysis

I-70 Traffic Data and Level of Service Analysis

Traffic volumes are the manifestation of a corridor's demographic and transportation system characteristics. As such, this data is a critical component in understanding how a transportation system reacts to the travel demands placed onto it. Moreover, traffic volumes are one of the most critical factors in determining a system's operations, that is how safely and efficiently they function. Therefore, a comprehensive collection of traffic volume data is vital to the description of corridor operations and the development and evaluation of corridor strategies. Fortunately for this study, a wealth of traffic volume data is available along I-70 as is discussed below.

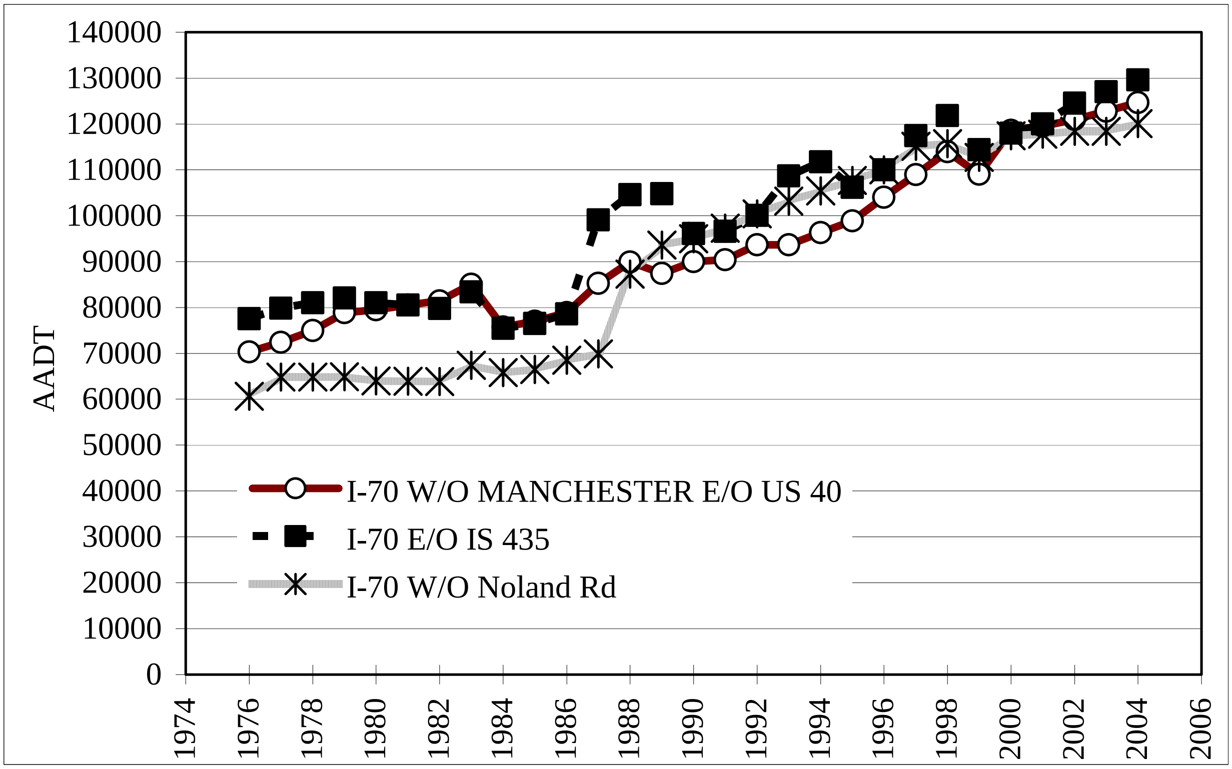
Traffic Volume Data Sources

- MoDOT Counts (2005)
  - 2005 AM (6-8 a.m.) and PM (4-6 p.m.) peak period ramp volumes for interchanges of I-70 with Manchester Trafficway, Blue-Ridge Cut-Off, and Noland Road
  - 2005 hourly and daily volumes from January to June for several I-70 corridor locations
- MoDOT Historical Counts
  - 1973-2002 Average Annual Daily Traffic (AADT) on I-70 East of Paseo, west of Van Brunt, west of Manchester and east of U.S. 40, east of I-435, west of Noland Road, east of Selsa Road, west of MO-7,
    and east of MO-7 (data for some years were not available for some locations)
  - Maximum hourly volumes for 1997-2003 for I-70 west of Noland Road
  - Daily volumes for 2003 for I-70 west of Noland Road
- Crawford, Bunte, Brammeier (CBB) Counts (2005)
  - AM (6-10 a.m.) and PM (3-7 p.m.) peak period ramp volumes at the interchanges of I-70 with I-435 and I-470
- Major Investment Study Data (2000)
  - 2000 I-70 mainline and ramp daily and AM/PM peak hour volumes
  - Truck percentage on mainline I-70 for daily and AM/PM peak periods

Historical AADT Growth

MoDOT District 4 provided historic automatic machine counts (AADT) for several locations along I-70 in the Study Area for the years 1973 to 2002. Volumes that were unavailable at some locations for certain years were estimated through interpolation. These historic volumes are important in that they provide us with insights into how traffic volumes have grown on a facility over time, and more importantly whether current growth on a given facility is on-going or stagnant. The historic volumes along with the existing 2005 volumes are shown in **Figure D-1**. It can be seen that the traffic volumes along I-70 have been consistently increasing over the past 30 years.

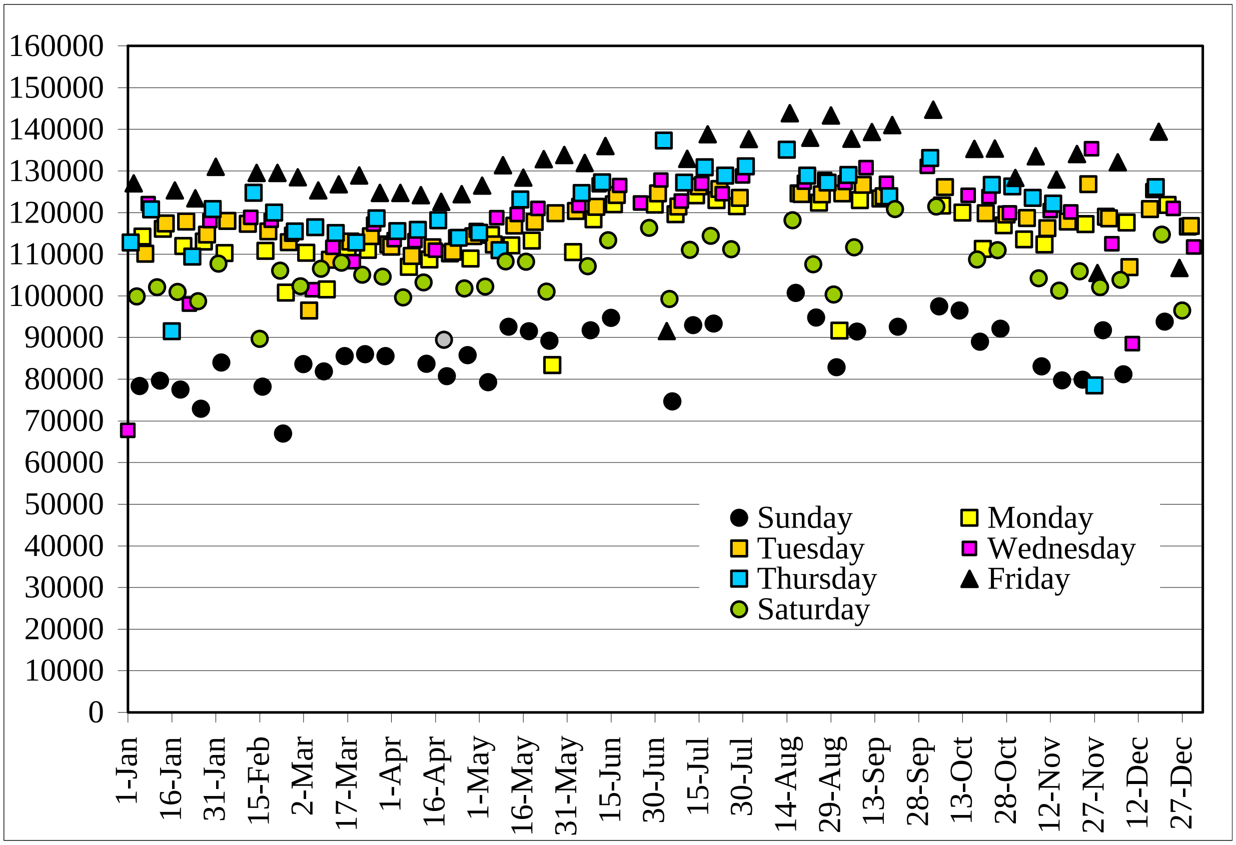
Figure D-1: Historical Daily Traffic Volumes on I-70



Daily Volume Variation

MoDOT District 4 also provided automatic machine counts (daily volumes) for I-70 West of Noland Road from January to December 2003. These are shown in **Figure D-2**. An inspection of this chart shows that daily volumes were relatively consistent throughout the year (between seasons) and that in general the highest traffic volumes occur on Fridays.

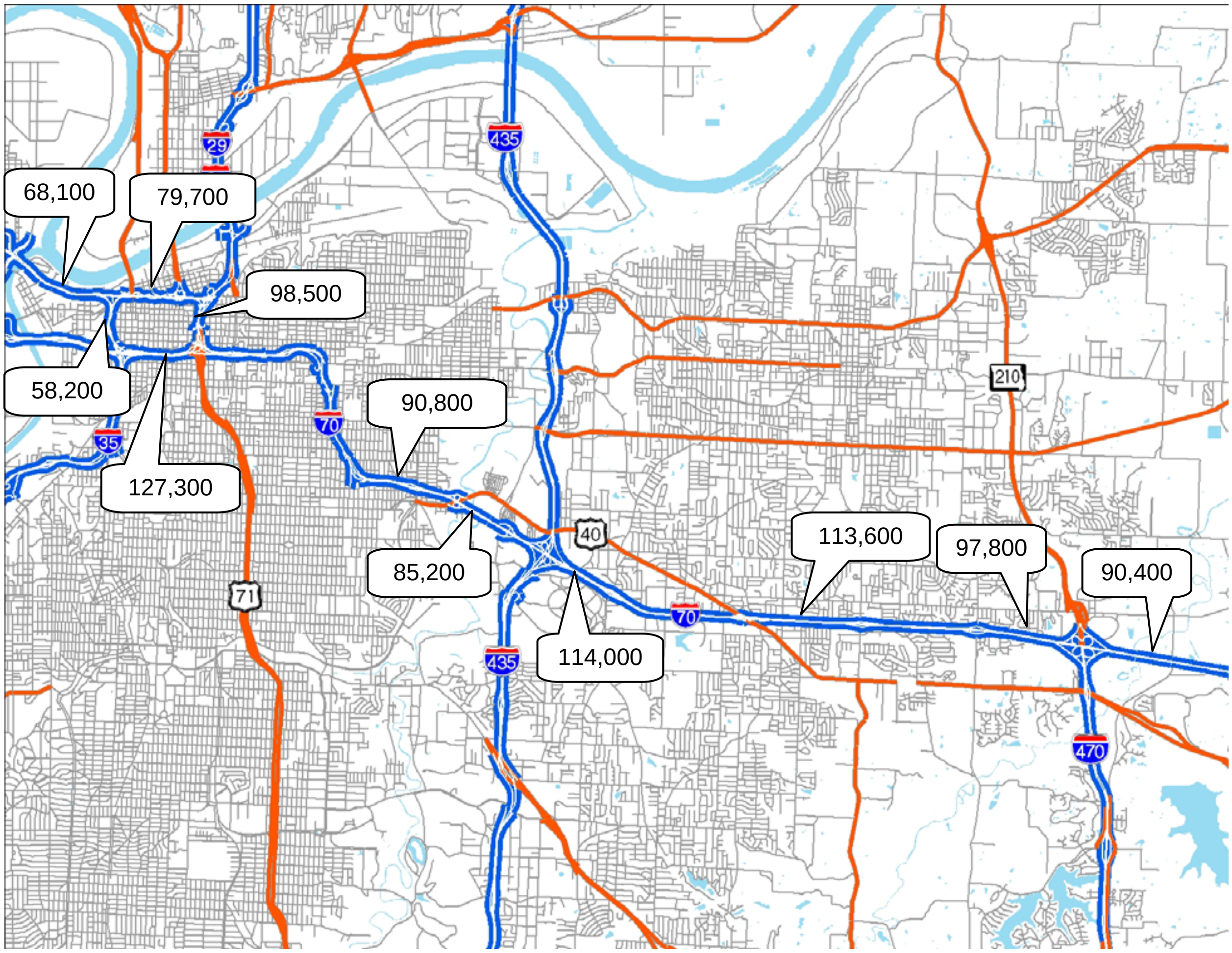
Figure D-2: 2003 Daily Volumes on I-70 West of Noland Road



Base Daily Counts

The Study Team consolidated several independent traffic counts in the development of a "base" set of 2005 existing traffic counts as discussed in the *Traffic Volume Data Sources* section. The consolidated traffic counts are shown in **Figure D-3**.

Figure D-3: 2005 Traffic Volumes

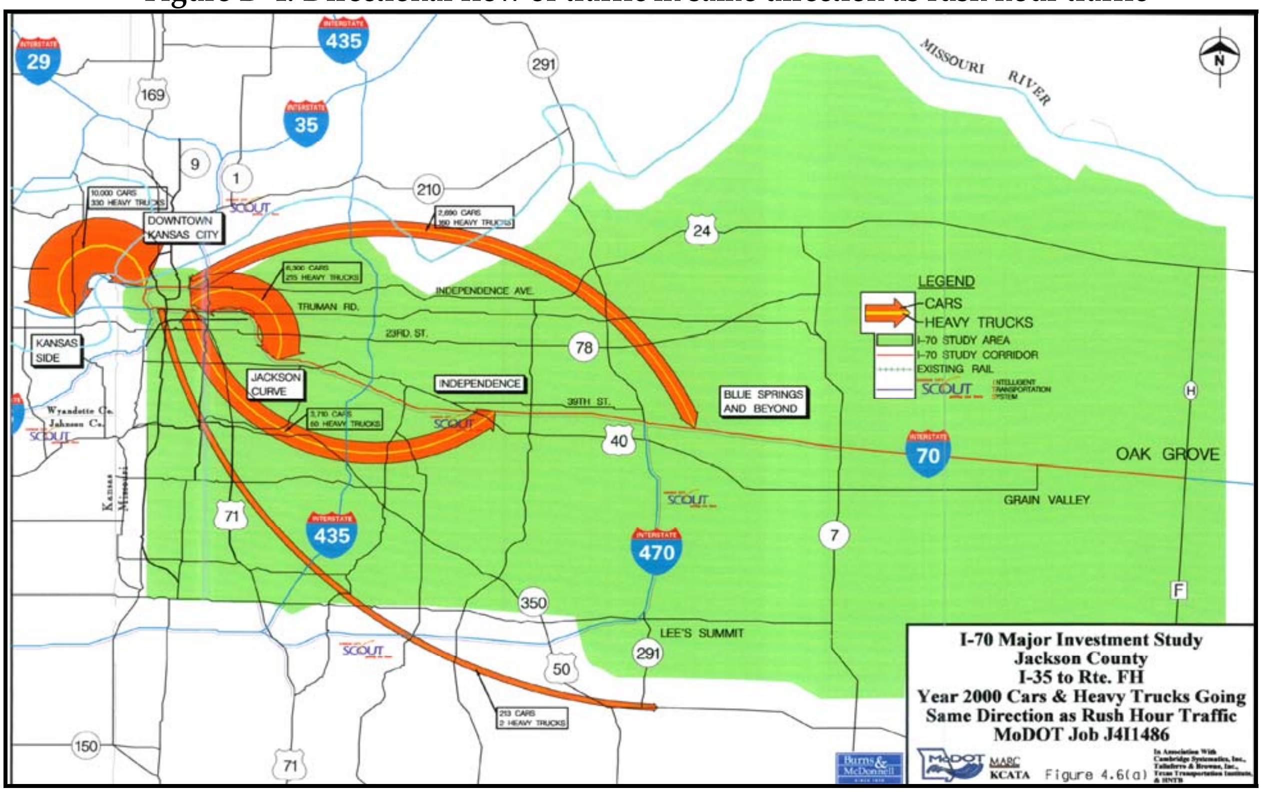


Directional Flow of Traffic

Commuter traffic in the study corridor is highly directional with most traffic destined towards the Kansas City Central Business District (CBD) during the morning and away from the CBD during the afternoon peak periods. The highly directional nature of the commuter traffic is important in its impact on freeway operations. As described in the *Freeway Operations* section, this characteristic is largely the cause for congestion and capacity failures in the system during the peak periods.

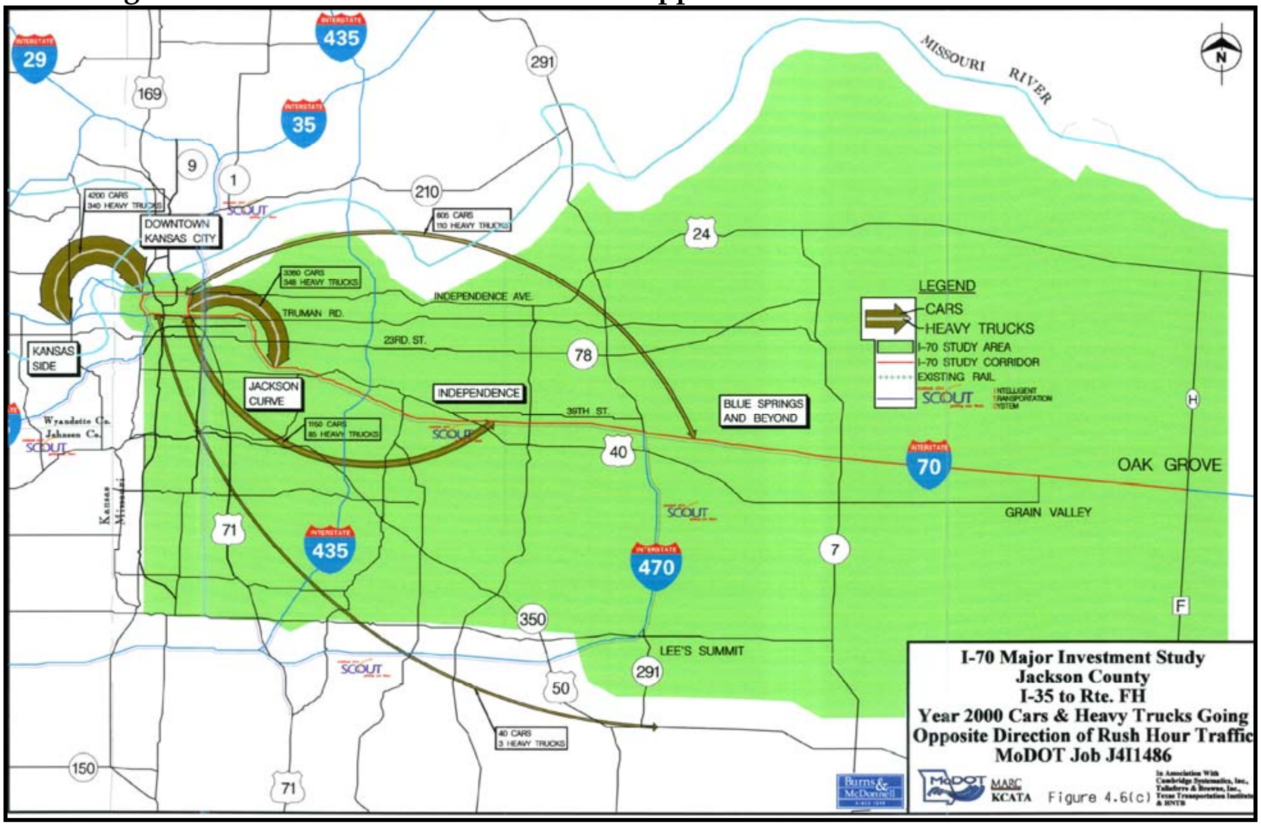
As reported in the I-70 Major Investment Study (MIS), **Figure D-4** shows the inbound AM and outbound PM peak rush hour traffic whereas **Figure D-5** shows the outbound AM and inbound PM peak traffic in the opposite direction as rush hour traffic. The orange band depicts car volumes and the yellow band depicts truck volumes.

Figure D-4: Directional flow of traffic in same direction as rush hour traffic[1]



[1] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 4, Page 8, Figure 4.6 (a)

Figure D-5: Directional flow of traffic in opposite direction as rush hour traffic[2]



Trucks

Trucks are a major component of the traffic stream in the I-70 corridor. The daily truck percentage is approximately 11 percent, which is consistent with that of interstate corridors in urban areas. Truck percentages during the peak periods are higher towards the eastern parts of the Study Area due to the increase in commuter traffic towards downtown. **Table D-1** shows the truck percentages for the daily, AM peak and PM peak hour conditions.

Table D-1: Truck Percentages on I-70

		AM	PM	Daily
Eastbound I-70	Downtown Loop to I-435	9%	4%	11%
	I-435 to I-470	10%	4%	11%
Westbound I-70	I-470 to I-435	4%	9%	11%
	I-435 to Downtown Loop	3%	8%	11%

[2] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 4, Page 10, Figure 4.6 (c)

Trucks impact the freeway operations in two significant ways. First, truck operations impact mainline traffic flow. While the percentage of trucks on mainline I-70 is relatively low in the peak direction during the peak periods, (approximately 3-4 percent of the overall traffic flow) it has been observed that the mixture of slow traffic and grades on the corridor often causes trucks to accelerate slowly, impeding traffic flow. Secondly, the major truck generators throughout the corridor have a significant impact on the operations of some of the corridor's interchanges.

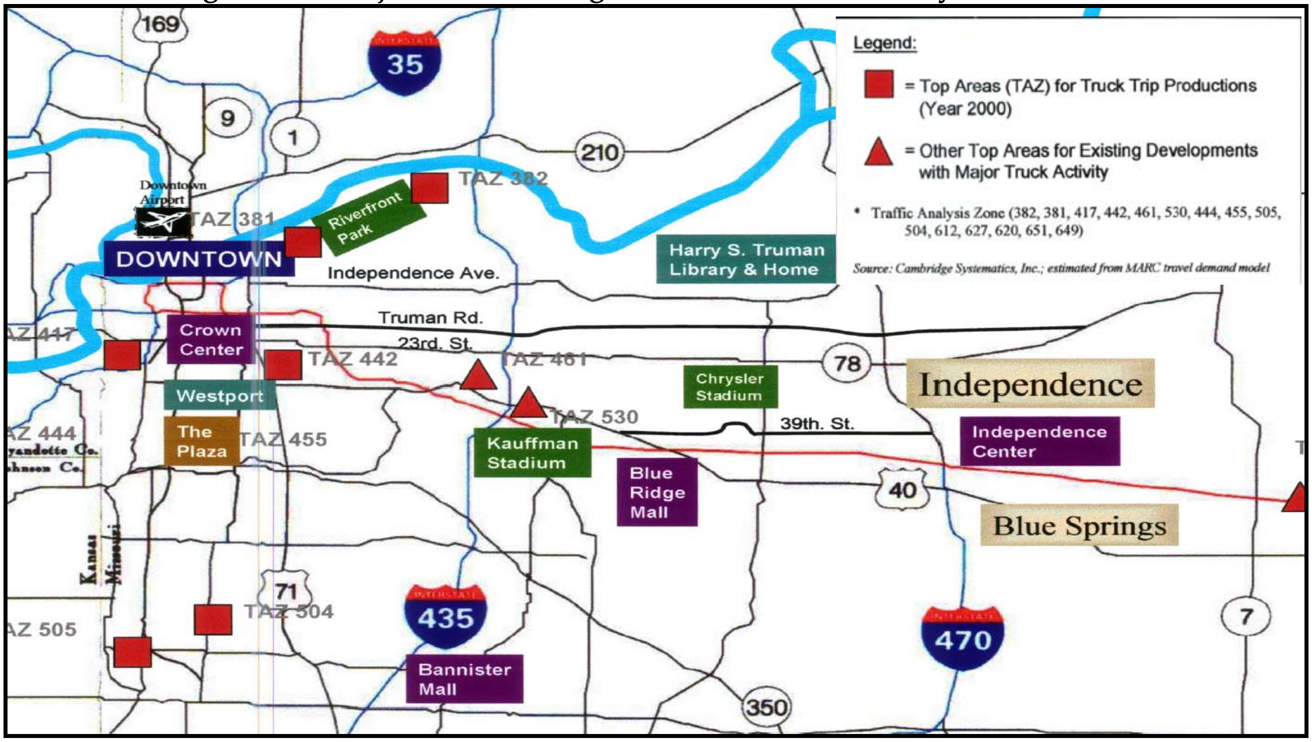
As identified in the MIS, the current major truck traffic generators are located mostly outside the downtown loop and two additional locations are located near Bannister Road, which are in the western part of the Study Area. These locations are listed in **Table D-2**.

Table D-2: Major truck traffic generators in the Study Area-Year 2000

General Location	Number of Daily Trips*
Kansas City, Front Street west of I-435	2,177
Kansas City, Bannister Road Federal Complex	1,728
Kansas City, Midtown Area	1,446
Kansas City, Front Street east I-29/35	1,272
Kansas City, Crown Center	1,243
*Daily vehicle-trips by light-duty and heavy-duty trucks	

As described in the MIS, the largest generators of truck traffic in the study are the Kohl's distribution center at Adams Dairy Parkway, the Lake Ammunition Plant, the Lipton Tea factory on Noland Road, and a major retail center at I-470 and I-70. **Figure D-6** shows the major truck generators in the study area.

Figure D-6: Major truck traffic generators in the I-70 study corridor[3]



Freeway Operations

Freeway operations are impacted by many variables such as roadway geometrics, traffic volumes, driver aggressiveness, weather and lighting conditions, incidents, downstream bottlenecks, and vehicle compositions. As such, freeway operations are the amalgamation of all of a freeway corridor's characteristics discussed in the previous sections. In essence, freeway operations are the driver's daily experience on a particular freeway facility. This section explores the existing freeway operations on the I-70 corridor.

Regional Freeway Operations

The Kansas City region enjoys an extensive freeway system. As put in MARC's 2030 Long Range Transportation Plan:

> Kansas City's system of roadways is among the most extensive in the nation. Recently, new statistics made available from the Federal Highway Administration confirm that Kansas City continues to possess the most freeway miles per person of all urbanized areas with populations greater than 500,000. The Kansas City Metropolitan Area also has the fourth highest total roadway miles per person, the

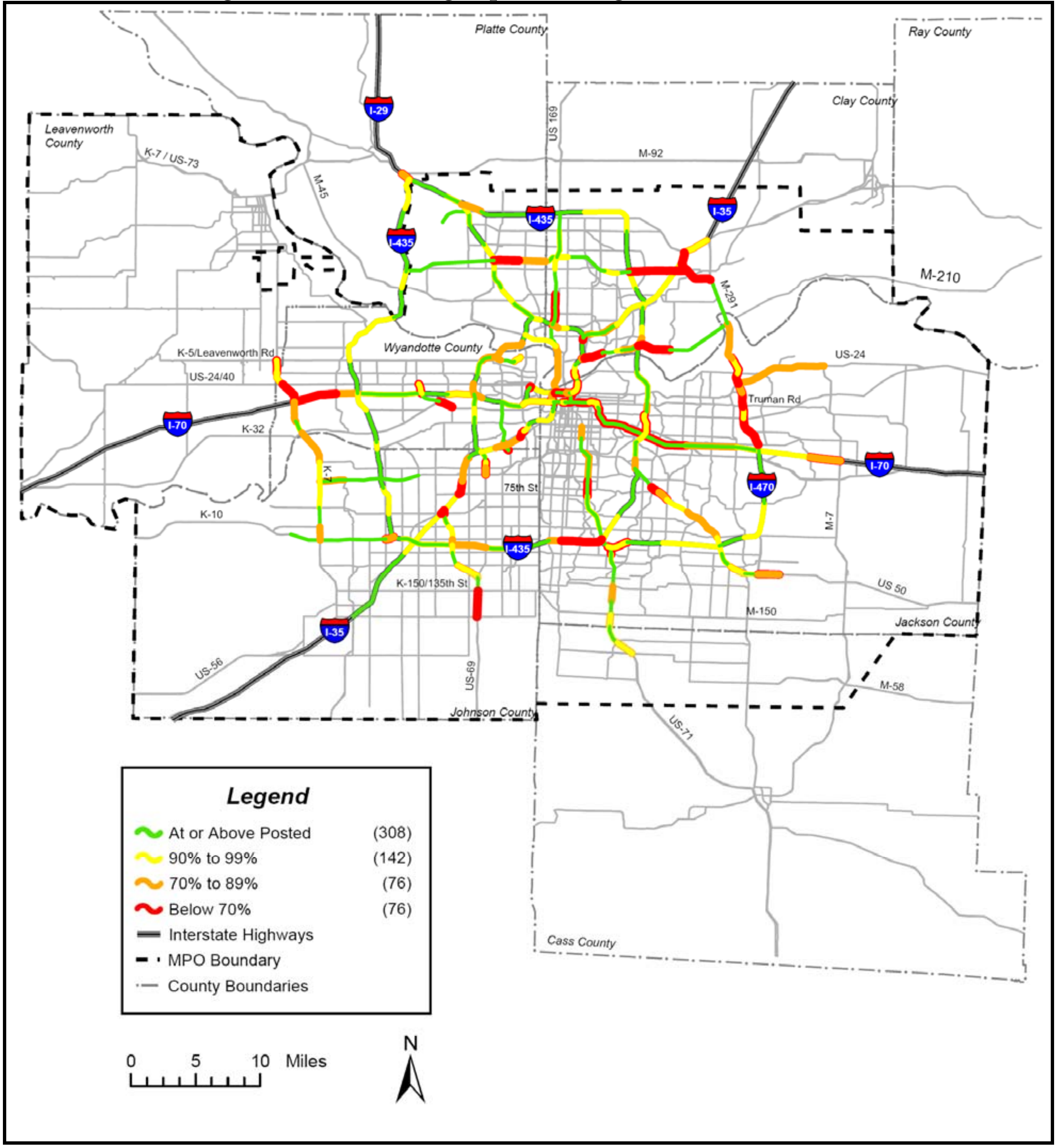
[3] I-70 MIS Jackson County, Technical Memorandum 1, "Problem Definition and Initial Statement of Purpose and Need", Section 5, Page 40, Figure 5.6 (k)

second highest estimated freeway lane miles per person, and the tenth most daily vehicle miles traveled (DVMT) per person.[4]

Because of this extensive freeway system, Kansas City drivers fare much better than other comparable urban areas in relation to freeway congestion. However, there are still facilities that operate at congested levels and would benefit from increased capacity. In fact, **Figure D-7** shows that I-70 is one of the congested corridors in the Kansas City region. Moreover, **Figure D-8** shows that this congestion has continually worsened over time to the point that corridor travel times to the CBD during peak periods now are near what they were before I-70 was constructed.

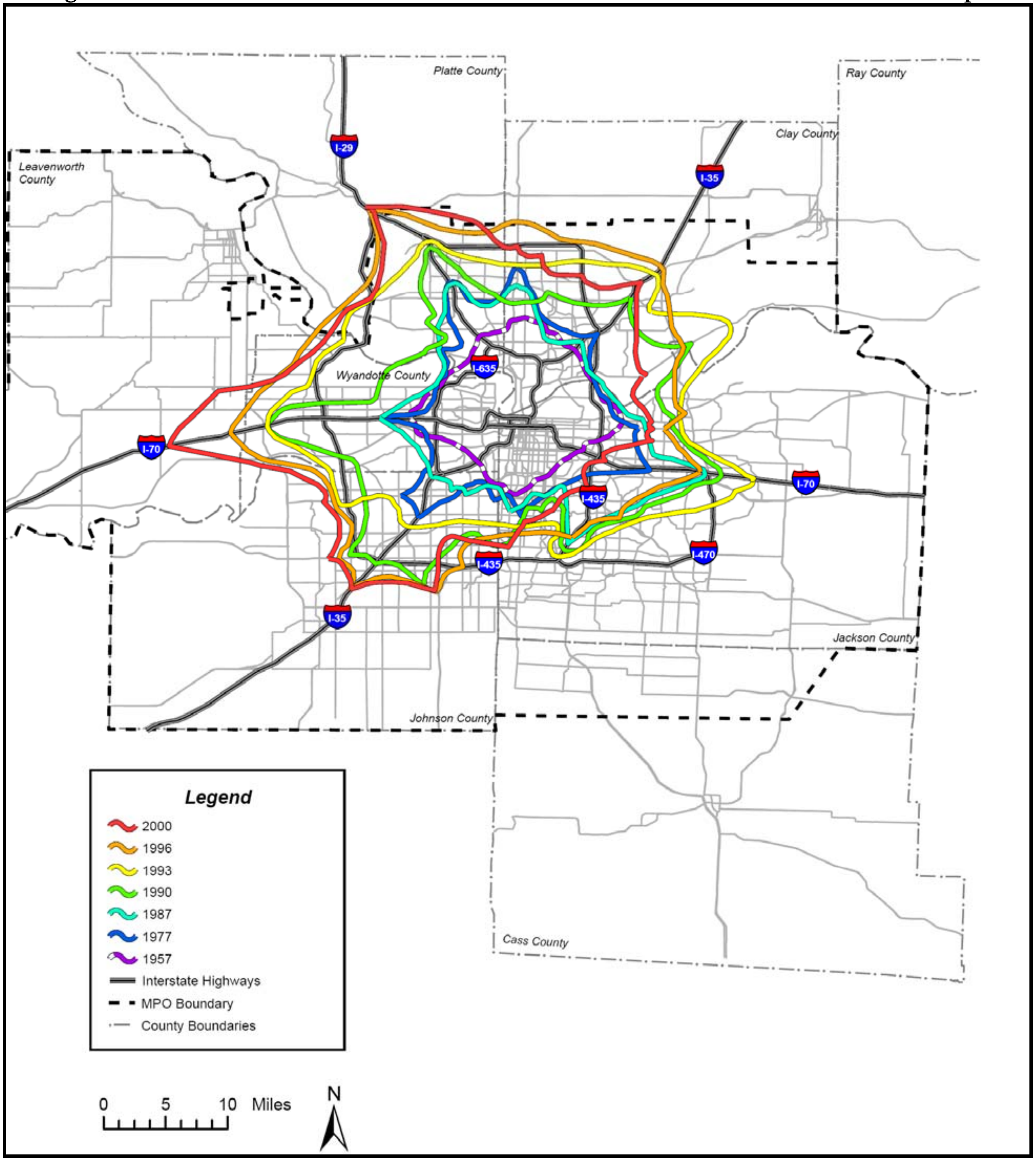
[4] "Transportation Outlook 2030", Mid American Regional Council (MARC) Long Range Plan, Page 15

Figure D-7: PM Average Speed on Higher Level Facilities[5]



5 "Transportation Outlook", MARC Long Range Plan, Page 22, Figure 2-19

Figure D-8: Historical 20-minute PM Travel Time Intervals from the Downtown Loop[6]



Corridor HCM Analysis

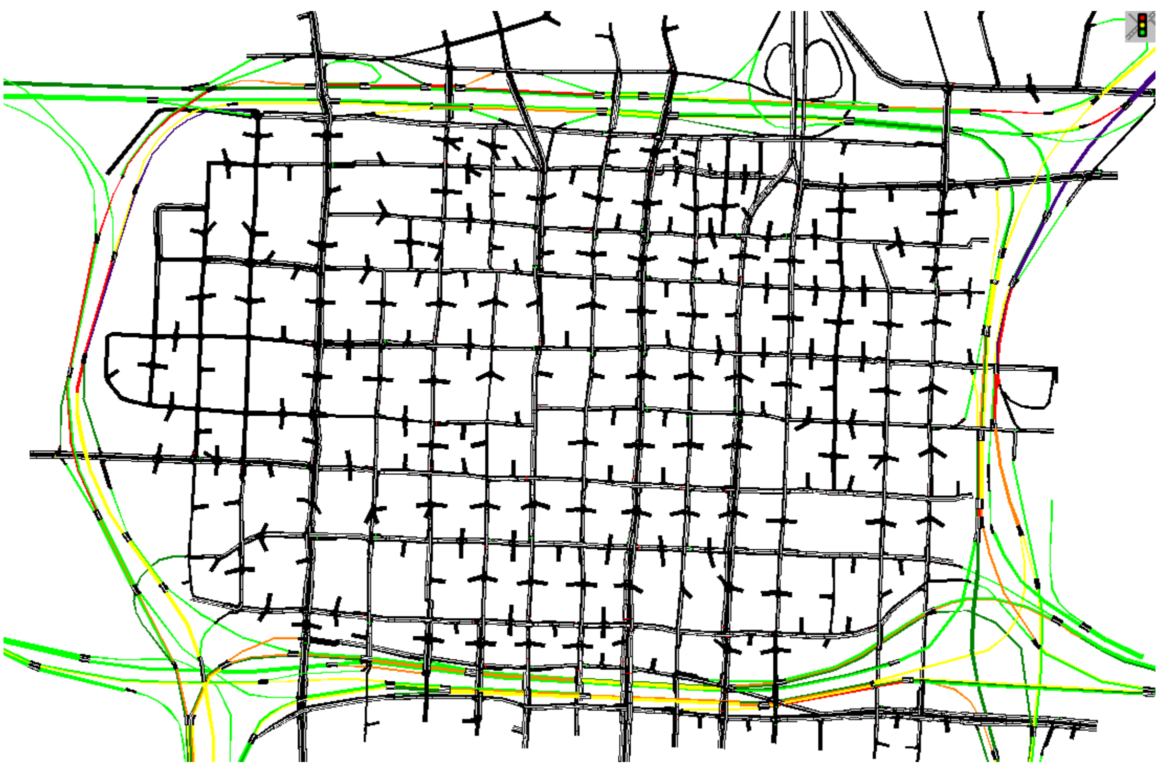
The downtown loop level of service analysis was based from the VISSIM model analysis completed for the Downtown Loop Study. VISSIM can be useful in obtaining freeway density

[6] "Transportation Outlook", MARC Long Range Plan, Page 24, Figure 2-21

and speed data. There is a subtle difference between freeway density in VISSIM and freeway density as defined by the Highway Capacity Manual (HCM). Therefore, level of service (LOS) as defined in the HCM does not exactly match the level of service reported by VISSIM by applying HCM thresholds to VISSIM freeway density output. Still, the two are very similar and can give a reasonable idea of the operations of the freeways. Figure 17 applies the density thresholds from the HCM to the densities reported on the VISSIM freeway network by lane for the existing model. Green represents LOS C or better, yellow represents LOS D, orange represents LOS E, and red represents LOS F. There is also some dark blue that represents stopped vehicles.

Most of the existing problem areas are found in the corners of the loop. In the northeast corner, vehicles traveling to northbound I-29/I-35 are stop-and-go and back up to the north and east sides of the loop. In the northwest corner, vehicles exiting from the northbound side of the west loop to Broadway back up onto the mainline. Also in the northwest corner, vehicles following southbound I-35 around the north and west sides of the loop are delayed due to lane continuity and capacity issues from the southwest corner of the loop all the way back to the middle of the north loop in the westbound direction. The south loop operates at or near capacity in the eastbound direction and is volatile and sensitive to any small disruptions in traffic flow.

Figure D-9 - Freeway Level of Service



The Highway Capacity Software (HCS) was the primary tool used in the analysis of the I-70 operations. The HCS analysis procedures are based upon the methodologies outlined in the

"Highway Capacity Manual" (HCM), last updated in 2000 by the Transportation Research Board. The HCM 2000, which is used universally by highway and traffic engineers to measure roadway capacity, establishes criteria for six Levels of Service (LOS): Level A ("Free Flow") to Level F ("Breakdown Conditions").

Several Measures of Effectiveness (MOE) were used in this evaluation including: LOS, volume to capacity ratios (v/c), density, and travel speed. Although speed is a major indicator of service quality to drivers, freedom to maneuver within the traffic stream and proximity to other vehicles, as measured by the density of the traffic stream, are equally noticeable concerns. Density increases as flow increases up to capacity, resulting in a measure of effectiveness that is sensitive to a broad range of flows. For these reasons, density is the parameter used to define LOS for the freeway and ramp sections, as shown in **Table D-3**.

Table D-3: Freeway Level of Service Criteria

Level of Service	**Freeway Weaving Segment Density** (pc/mi/ln)	**Basic Freeway Segment Density (**pc/mi/ln**)**
A	0 – 10	0 – 11
B	> 10 – 20	> 11 – 18
C	> 20 – 28	> 18 – 26
D	> 28 – 35	> 26 – 35
E	> 35 – 43	> 35 – 45
F	> 43.0	> 45.0
(pc/mi/ln) - passenger car equivalent per mile per lane		

Basic Freeway Segments - HCS analysis was performed for all the freeway segments along I-70 in the Study Area for the AM and PM peak hours. **Tables D-4** and **D-5** summarize the LOS analysis. These tables show both the calculated LOS based on HCM methodologies using traffic volumes on I-70 as well as the LOS that were reported in the MIS, which was calculated using measured travel speeds. It should be noted that there are dramatic differences in the results that are reported largely because HCM Methodologies do not account for congestion caused by downstream bottlenecks, and therefore the LOS calculated by the HCM may represent operations that are better than actually occurs in the field. The methodologies that use field measured travel speeds do account for downstream bottlenecks and are more realistic under cases of major congestion.

However, these differences can also provide insights into some of the core capacity deficiencies in the corridor. Specifically, the 2005 "FTEIS" analysis of basic freeway segments shows operations generally in the range of LOS D/E, near the capacity of the freeway. However, the 2000 "MIS" analysis shows large portions of the freeway that are significantly over capacity. This pattern is indicative of corridors that have significant "choke points" that cause spill-back queues into freeway segments that might otherwise provide acceptable operations.

Table D-4: Summary of HCS Basic Freeway Segments (Peak Traffic Direction)

	2005 FTEIS (LOS Based on HCM Calculations)[7]		2000 MIS (LOS Based on travel speeds)		
	Density pc/mi/ln	LOS	Density pc/mi/ln	LOS	Travel Speed*
AM Peak Period in the Westbound Direction					
Between Brooklyn and Prospect	**N/A**	**F**	**56**	**F**	17.3
Between Benton and 18th St.	**43.4**	**E**	**60**	**F**	29.3
Between 23rd St. and 27th St.	**36.6**	**E**	**60**	**F**	33.3
Between 27th St. and Jackson	34.3	**D**	**64**	**F**	32.9
Between Jackson and Van Brunt	**37.1**	**E**	**55**	**F**	35
Between Van Brunt and U.S. 40	**40.5**	**E**	**73**	**F**	35.7
Between U.S. 40 and Manchester	32.7	**D**	**52**	**F**	60.4
Between I-435 and Blue Ridge Cut Off	**24.9**	**C**	**41**	**E**	58.1
Between Blue Ridge Cut Off and U.S. 40	32.9	**D**	**41**	**E**	49
Between U.S. 40 and Noland Road	32.6	**D**	**41**	**E**	47.6
Between Noland Road and Lee's Summit	30.1	**D**	**43**	**E**	46.3
Between Lee's Summit and I-470	27.8	**D**	**38**	**E**	59.8
PM Peak Period in the Eastbound Direction					
Between Brooklyn and Prospect	**43.1**	**E**	**42**	**E**	34.6
Between Prospect and Benton	**36.9**	**E**	**40**	**E**	40.8
Between Benton and 18th St.	33.1	D	**47**	**F**	40.8
Between 23rd St. and 27th St.	31.2	D	**40**	**E**	41.3
Between 27th St. and Jackson	29.8	D	**67**	**F**	35.4
Between Jackson and Van Brunt	28.8	D	**70**	**F**	29.6
Between Van Brunt and U.S. 40	29	D	**66**	**F**	21.1
Between U.S. 40 and Manchester	24.8	C	**63**	**F**	23.8
Between I-435 and Blue Ridge Cut Off	**38.2**	**E**	**52**	**F**	29.4
Between Blue Ridge Cut Off and U.S. 40	**36.9**	**E**	**43**	**E**	39
Between U.S. 40 and Noland Road	**39**	**E**	**37**	**E**	52.2
Between Noland Road and Lee's Summit	**35.9**	**E**	30	D	60.7
Between Lee's Summit and I-470	31.9	D	28	D	60.8

*Travel Speeds reported from MIS
(pc/mi/ln) - passenger car equivalent per mile per lane

[7] HCM Methodologies do not account for congestion caused by downstream bottlenecks. Therefore, LOS displayed may represent better operations than actually occurs in the field.

Table D-5: Summary of HCS Basic Freeway Segments (off-Peak Traffic Direction)

	2005 FTEIS (LOS Based on HCM Calculations)		2000 MIS	
	Density pc/mi/ln	LOS	Density pc/mi/ln	LOS
AM Peak Period in the Eastbound Direction				
Between Brooklyn and Prospect	17.9	B	18	B
Between Benton and 18th St.	14.7	B	17	B
Between 23rd St. and 27th St.	15.3	B	16	B
Between 27th St. and Jackson	14.6	B	15	B
Between Jackson and Van Brunt	14.9	B	11	A
Between Van Brunt and U.S. 40	14.5	B	15	B
Between U.S. 40 and Manchester	15	B	13	B
Between I-435 and Blue Ridge Cut Off	13.1	B	13	B
Between Blue Ridge Cut Off and U.S. 40	16.3	B	12	B
Between U.S. 40 and Noland Road	15.4	B	13	B
Between Noland Road and Lee's Summit	14.1	B	12	B
Between Lee's Summit and I-470	14.1	B	11	A
PM Peak Period in the Westbound Direction				
Between Brooklyn and Prospect	24.1	C	17	B
Between Prospect and Benton	23.1	C	15	B
Between Benton and 18th St.	19.4	C	20	C
Between 23rd St. and 27th St.	18.8	C	16	B
Between 27th St. and Jackson	17.4	B	17	B
Between Jackson and Van Brunt	18.5	C	16	B
Between Van Brunt and U.S. 40	18.3	C	17	B
Between U.S. 40 and Manchester	18.1	C	12	B
Between I-435 and Blue Ridge Cut Off	14.3	B	15	B
Between Blue Ridge Cut Off and U.S. 40	18.3	C	15	B
Between U.S. 40 and Noland Road	18.7	C	17	B
Between Noland Road and Lee's Summit	18	C	15	B
Between Lee's Summit and I-470	18	C	15	B
(pc/mi/ln) - passenger car equivalent per mile per lane				

<u>*Merge/Diverge Areas*</u> - HCS analysis was performed on all merge and diverge areas along I-70 in the Study Area for the AM and PM peak hours. **Tables D-6** to **D-9** shows that although the ramps generally operate at acceptable LOS, there are isolated capacity failures at some of the ramps during select time periods. These failures are typical of corridor "chokepoints" that can spill-back and compromise mainline operations.

Table D-6: Summary of HCS analysis for merge and diverge areas along I-70 (AM Peak Hour)

LOCATION	MOVEMENT	2005 FTEIS		2000 MIS	
		DENSITY (pc/mi/ln)	LOS	DENSITY (pc/mi/ln)	LOS
I-70 / I-470	WB/NB DIVERGE	25.5	C	29	D
	SB/WB MERGE	29.6	D	30.9	D
	EB/SB DIVERGE	17.9	B	15.9	B
	NB/EB MERGE	15.5	B	14.4	B
I-70 / LEE'S SUMMIT	EB DIVERGE	19.5	B	17.7	B
	EB MERGE	17.9	B	16.3	B
	WB DIVERGE	32.2	D	33.1	D
	WB MERGE	32.2	D	34.2	D
I-70 / NOLAND	EB DIVERGE	21.6	C	20	C
	EB MERGE	18.2	B	16.5	B
	WB DIVERGE	33.8	D	34.6	D
	WB MERGE	32	D	34.3	D
I-70 / BLUE RIDGE BLVD.	EB MERGE	18.7	B	17.3	A
I-70 / U.S. 40 EAST	EB DIVERGE	1.1	A	13.3	B
	EB MERGE	19.2	B	17.8	B
	WB DIVERGE	**35.2**	**E**	**35**	**E**
	WB MERGE	33.9	D	34.9	D
I-70 / STERLING	EB DIVERGE	18.1	B	16.6	B
I-70 / BLUE RIDGE CUTOFF	EB DIVERGE	13.6	B	12.4	B
	EB MERGE	18.1	B	15.7	B
	WB DIVERGE	33.2	D	33	D
	WB MERGE	26	C	25.6	C
I-70 / I-435	WB/NB DIVERGE	N/A	A	N/A	A
	WB/SB DIVERGE	**39.7**	**F**	**37.1**	**F**
	NB/SB/EB MERGE	14.1	B	12.7	B

(pc/mi/ln) - passenger car equivalent per mile per lane

Table D-7: Summary of HCS analysis for merge and diverge areas along I-70 (AM Peak Hour)

LOCATION	MOVEMENT	2005 FTEIS		2000 MIS	
		DENSITY (pc/mi/ln)	LOS	DENSITY (pc/mi/ln)	LOS
I-70 / MANCHESTER	EB DIVERGE	19.9	B	20.8	C
	WB MERGE	31.2	D	30.7	D
I-70 / U.S. 40 WEST	EB DIVERGE	17.3	B	18	B
	EB MERGE	17.9	B	18.7	B
	WB DIVERGE	32.1	D	31.1	D
	WB MERGE	**35.2**	**E**	**37.3**	**E**
I-70 / VAN BRUNT	EB DIVERGE	19	B	21.4	C
	EB MERGE	15.3	B	19.7	B
	WB DIVERGE	**38.3**	**E**	**37.4**	**E**
	WB MERGE	31.3	D	32.2	D
I-70 / JACKSON	WB DIVERGE	32.3	D	31.4	D
	EB MERGE	18	B	18	B
I-70 / 31ST	EB DIVERGE	17.5	B	18.2	B
I-70 / 27TH	EB DIVERGE	18.3	B	19	B
	WB MERGE	**35.1**	**E**	34	D
I-70 / 23RD	EB DIVERGE	18.4	B	19.1	B
	EB MERGE	16.9	B	17.5	B
	WB DIVERGE	34.3	D	33.4	D
	WB MERGE	**36.8**	**F**	**37.9**	**E**
I-70 / 18TH	EB DIVERGE	18.6	B	19.3	B
	EB MERGE	19.1	B	19.7	B
	WB DIVERGE	**37.7**	**F**	**36.9**	**F**
	WB MERGE	**35.4**	**F**	**35.5**	**F**
I-70 / BENTON	WB MERGE	19.1	B	19	B
	EB DIVERGE	22.1	C	22.8	C
I-70 / PROSPECT	EB DIVERGE	9.9	A	10.5	B
	EB MERGE	17.1	B	17.7	B
	WB DIVERGE	**36.5**	**E**	**35.6**	**E**
	WB MERGE	21.9	C	21.4	C
I-70 / BROOKLYN	EB DIVERGE	19.2	B	19.8	B
	WB MERGE	26.4	C	25.8	C
I-70 / PASEO	EB DIVERGE	21.5	C	22.2	C
	EB MERGE	18.1	B	18.9	B
	WB DIVERGE	34.1	D	33.4	D
	WB MERGE	22.7	C	23.3	C

(pc/mi/ln) - passenger car equivalent per mile per lane

Table D-8: Summary of HCS analysis for merge and diverge areas along I-70 (PM Peak Hour)

LOCATION	MOVEMENT	2005 FTEIS		2000 MIS	
		DENSITY (pc/mi/ln)	LOS	DENSITY (pc/mi/ln)	LOS
I-70 / I-470	WB/NB DIVERGE	17.4	B	17.2	B
	SB/WB MERGE	21.1	C	19.8	B
	EB/SB DIVERGE	34	D	33.8	D
	NB/EB MERGE	29.3	D	29.9	D
I-70 / LEE'S SUMMIT	EB DIVERGE	**37.1**	**E**	**36.9**	**E**
	EB MERGE	32.5	D	33.4	D
	WB DIVERGE	23.8	C	22.4	C
	WB MERGE	22.1	C	20.8	C
I-70 / NOLAND	EB DIVERGE	**38.5**	**E**	**37.7**	**E**
	EB MERGE	**35.5**	**E**	**36.4**	**E**
	WB DIVERGE	24.2	C	22.8	C
	WB MERGE	23.6	C	22.3	C
I-70 / BLUE RIDGE BLVD.	EB MERGE	**37.2**	**E**	**36.6**	**E**
I-70 / U.S. 40 EAST	EB DIVERGE	14.6	B	29	D
	EB MERGE	34.8	D	34.4	D
	WB DIVERGE	24.9	C	23.6	C
	WB MERGE	21.4	C	21.8	C
I-70 / STERLING	EB DIVERGE	33.1	D	32.6	D
I-70 / BLUE RIDGE CUTOFF	EB DIVERGE	26.6	C	25.9	C
	EB MERGE	33	D	19.4	B
	WB DIVERGE	22	C	20.7	C
	WB MERGE	10.9	B	9.8	A
I-70 / I-435	WB/NB DIVERGE	N/A	A	N/A	A
	WB/SB DIVERGE	18.5	B	15	B
	NB/SB/EB MERGE	**31.7**	**F**	**31.8**	**F**
(pc/mi/ln) - passenger car equivalent per mile per lane					

Table D-9: Summary of HCS analysis for merge and diverge areas along I-70 (PM Peak Hour)

LOCATION	MOVEMENT	2005 FTEIS		2000 MIS	
		DENSITY (pc/mi/ln)	LOS	DENSITY (pc/mi/ln)	LOS
I-70 / MANCHESTER	EB DIVERGE	32.4	D	32	D
	WB MERGE	19.5	B	16.8	B
I-70 / U.S. 40 WEST	EB DIVERGE	30.8	D	30.5	D
	EB MERGE	29	D	30.4	D
	WB DIVERGE	20.2	C	17.3	B
	WB MERGE	19.9	B	17.9	B
I-70 / VAN BRUNT	EB DIVERGE	31.4	D	31	D
	EB MERGE	27.4	C	30	D
	WB DIVERGE	23.6	C	20.7	C
	WB MERGE	16	B	16	B
I-70 / JACKSON	WB DIVERGE	18.9	B	16	B
	EB MERGE	30.4	D	30	D
I-70 / 31ST	EB DIVERGE	31.5	D	31.2	D
I-70 / 27TH	EB DIVERGE	32	D	31.7	D
	WB MERGE	21.4	C	17.1	B
I-70 / 23RD	EB DIVERGE	34.3	D	34	D
	EB MERGE	29.5	D	30.1	D
	WB DIVERGE	21.2	C	16.3	B
	WB MERGE	20.8	C	16.6	B
I-70 / 18TH	EB DIVERGE	34	D	33.7	D
	EB MERGE	33.6	D	34.3	D
	WB DIVERGE	22.6	C	17.8	B
	WB MERGE	20.7	C	16.4	B
I-70 / BENTON	WB MERGE	14.4	B	13.2	B
	EB DIVERGE	**37.6**	**E**	**37.3**	**E**
I-70 / PROSPECT	EB DIVERGE	25.9	C	25.7	C
	EB MERGE	31.6	D	33.1	D
	WB DIVERGE	20.5	C	17	B
	WB MERGE	14.2	B	12.5	B
I-70 / BROOKLYN	EB DIVERGE	**40.4**	**F**	**40.3**	**F**
	WB MERGE	15.3	B	12.9	B
I-70 / PASEO	EB DIVERGE	**36.5**	**F**	**36.3**	**F**
	EB MERGE	**33.7**	**F**	**36.6**	**F**
	WB DIVERGE	17.8	B	14.2	B
	WB MERGE	14.7	B	12.9	B

(pc/mi/ln) - passenger car equivalent per mile per lane

Weave Sections - HCS analysis was performed for all the weaving sections along I-70 in the study area for the AM and PM peak hours. **Table D-10** shows the effects of several sub-standard weaving areas in the corridor. As with other capacity failures in the corridor, these failures are typical of corridor "chokepoints" that can spill-back and compromise mainline operations.

Table D-10: Summary of HCS analysis for weaving segments

LOCATION	WEAVE TYPE	2005 FTEIS		2000 MIS	
		DENSITY (pc/mi/ln)	LOS	DENSITY (pc/mi/ln)	LOS
AM Peak Period					
EB I-70 B/T 18TH & 23RD	A	12.5	B	13.32	B
EB I-70 B/T MANCHESTER & I-435	B	11.76	B	12.57	B
EB I-70 B/T PASEO & BROOKLYN	A	11.64	B	12.12	B
WB I-70 B/T 23RD & 18TH	A	**45.94**	**F**	**44.08**	**F**
WB I-70 B/T I-435 & MANCHESTER	B	**35.65**	**E**	**35.01**	**E**
WB I-70 B/T BENTON & PROSPECT+	B	34.1	D	**42.19**	**E**
WB I-70 B/T BROOKLYN & PASEO	A	**36.16**	**E**	34.93	D
EB I-70 B/T I-470 LOOP RAMPS	A	10.64	B	9.58	A
WB I-70 B/T I-470 LOOP RAMPS*	A	**52.54**	**E**	**41.88**	**E**
PM Peak Period					
EB I-70 B/T 18TH & 23RD	A	**35.03**	**E**	34.49	D
EB I-70 B/T MANCHESTER & I-435	B	24.85	C	27.73	C
EB I-70 B/T PASEO & BROOKLYN	A	28.21	D	27.89	C
WB I-70 B/T 23RD & 18TH	A	16.85	B	12.02	B
WB I-70 B/T I-435 & MANCHESTER	B	17.94	B	16.92	B
WB I-70 B/T BENTON & PROSPECT+	B	15.4	B	13.19	B
WB I-70 B/T BROOKLYN & PASEO	A	16.02	B	12.45	B
EB I-70 B/T I-470 LOOP RAMPS	A	28.6	D	25.12	C
WB I-70 B/T I-470 LOOP RAMPS*	A	21.95	C	15.37	B

+ The MIS evaluated the westbound weave between Benton and Prospect as a Type "A" weave
* Constrained Weaving
(pc/mi/ln) - passenger car equivalent per mile per lane

Summary

The preceding analysis shows that relatively severe congestion does exist in the I-70 corridor coincides with the commuter peak. Moreover, this analysis shows that much of this congestion is likely caused by sub-standard merge, diverge, and weave areas. However, even with these problems corrected, the corridor is currently operating at or near its basic capacity. That is to say, in addition to improving the merge, diverge, and weave sections in the corridor, basic capacity enhancements (e.g., lane additions) are prudent to address the existing needs.

Additionally, it does not appear that operations in the corridor have changed significantly between 2000 and 2005. It is interesting to note that peak period volumes are not significantly changing even though the daily traffic volumes are growing as the corridor's population grows and shifts to the west (away from major regional employment centers). This is likely due to driver's changing their trip time, destination, and/or route to avoid the over-saturated freeway corridor during the peak periods. This trend usually creates a "latent" demand in the corridor. That is to say that if capacity is added, corridor peak period traffic volumes are likely to jump as travel times are reduced and drivers adjust their travel decisions to account for the improved conditions.

Finally, we explored some specific locations that appear to be major corridor "chokepoints", as is discussed in the following.

- <u>Downtown Loop</u>
  The Downtown loop is congested in the peak hours due to a lane balance issue and tight weaving sections between interchanges. The incoming AM peak is a bottleneck largely because of the congestion from I-670. The outgoing PM peak experiences congestion due to a lane drop at Prospect Avenue: there is one incoming lane from the downtown loop, one incoming lane from downtown, two incoming lanes from I-670 but only three outgoing lanes east of Prospect Avenue.

- <u>Benton/Jackson Curves</u>
  These curves have substandard interstate operations and geometrics due to poor sight distance and high roadway curvature (speed limit: 55 mph). Although these curves are not a major source of congestion at present, these are areas of high crash rates according to the MIS.

- <u>I-435</u>
  I-70 at the I-435 interchange experiences congestion in the AM peak period in the westbound direction and in the PM peak period in the eastbound direction. This is caused by lane drops through the interchange and steep grades on I-70 leaving the interchange.

- <u>Noland Road</u>
  I-70 at the Noland Road interchange experiences congestion in the AM peak period in the westbound direction and in the PM peak period in the eastbound direction. This can likely be attributed to insufficient ramp capacity, (especially during the PM peak period), grades, and acceleration and deceleration lanes between ramps and mainline.

- I-470
  At the I-70/I-470 interchange congestion tends to occur on I-470 and not on I-70 including tight weaving sections on I-470 north and south of I-70. This congestion affects traffic flow onto and off of I-70.