

DEVELOPMENT OF THE DES MOINES ACCESS MANAGEMENT PLAN

CTRE Project 03-137

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INTRODUCTION

According to Iowa crash records, almost 10% of all crashes in Iowa occur at commercial driveways. Most of these crashes occur on arterials within municipalities. In recent years, nearly a quarter of these crashes have occurred in the Des Moines metropolitan area. This makes the Des Moines metropolitan area a prime candidate for improved access management.

Access management may be defined as managing access to access to land developments along arterial roadways while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity and speed (1). This is accomplished through management of the adjacent land development's internal circulation and site layout, driveway design and spacing, medians and median breaks, traffic signals, and other roadway characteristics. Case study research in Iowa has shown that access management is an extremely effective highway safety tool—well-managed routes are, on average, 40% safer than poorly managed routes (2). The Des Moines metropolitan area has many miles of four-lane, undivided arterials constructed when less was known about the importance of managing access to adjacent land development.

This project involved a cooperative effort of the Des Moines Area Metropolitan Planning Organization (Des Moines Area MPO) and the Center for Transportation Research and Education (CTRE) at Iowa State University to develop a comprehensive access management study and program for the Des Moines metropolitan area. The goal of the study is to use the knowledge developed to make improvements that will reduce access-related crashes. It is also anticipated that this project will help local officials make better decisions about access management so that future safety and operational problems can be avoided.

A major purpose of this study was to identify candidates for access management along existing arterials in the Des Moines metropolitan area. Recently, the population of the Des Moines metropolitan area has been increasing at a moderate to high rate. Much of this growth has been the result suburban development in new areas to the west and north of the City of Des Moines. As a result, there are now many new retail, food, and other commercial businesses as well higher volumes of traffic on the arterial street network. Therefore, access management is a potential issue both on existing and planned or new portions of the network.

Project Tasks

The four major work tasks for this project were as follows:

- Task 1. **Problem identification using the Iowa crash database and other spatial data.** This task involved finding an answer the following question: based on crash data and roadway improvements characteristic (base record) data, which routes in the Des Moines metro area are the best candidates for improving access management? This task produced a set of GIS maps and crash data that could be used by the Des Moines Area MPO to educate local officials about access management problems and convince

them of the need to reduce them. Some problem routes were found on local jurisdiction routes, while others were found on concurrent Iowa DOT/local jurisdiction routes. When problems were found on concurrent Iowa DOT/local jurisdiction routes, coordination with appropriate Iowa DOT officials will need to occur if improvements are to be made. Note: CTRE was the lead organization for this task with assistance from the Des Moines Area MPO.

Task 2. **Development of access management elements for the MPO long-range transportation plan and the transportation program.** This task involved finding an answer the following questions: What already programmed projects should have access management elements? What new projects should be planned and programmed based on access management considerations (mainly safety and operational benefits?) Note: The Des Moines Area MPO was the lead organization for this task with assistance from CTRE.

Task 3. **Integration of access management planning with local land use planning.** This task involved finding an answer the following question: where are future access management problems likely to occur given city and county commercial land development plans? This task was designed to put the Des Moines Area MPO into a position to work with cities and counties on land use plans and subdivision plans that will support access management rather than conflict with it. Since cities and counties are responsible for local land use regulations, this task is essential if access management is to be improved and maintained in the future. Note: The Des Moines Area MPO was the lead organization for this task with assistance from CTRE.

Task 4. **Education of local transportation and land use professionals and local elected officials regarding access management.** This task will basically use materials already developed by CTRE (including an access management video, handbook, and tool kit). However, the education program needed to be customized to fit local conditions and needs. This task will help ensure that new access management projects gain momentum and that future access management problems are avoided. Note: CTRE was the lead organization on this task with assistance from the Des Moines Area MPO.

The methodology and results for each of these tasks is presented in the following sections.

TASK 1: BACKGROUND

Since Task 1, identification of the existing access management problem, was the most complicated and time-consuming of the four tasks, the majority of this report is dedicated to its results.

For this study, all of the arterials located within the Des Moines MPO planning area were included. The majority of this area is located within the city of Des Moines and suburban areas to the north and west, including the cities of Altoona, Ankeny, Bondurant, Clive, Des Moines, Grimes, Johnston, Norwalk, Pleasant Hill, Polk City, Urbandale, Waukee, West Des Moines, and Windsor Heights. Figure 1 shows the cities located within the Des Moines Area MPO boundaries.

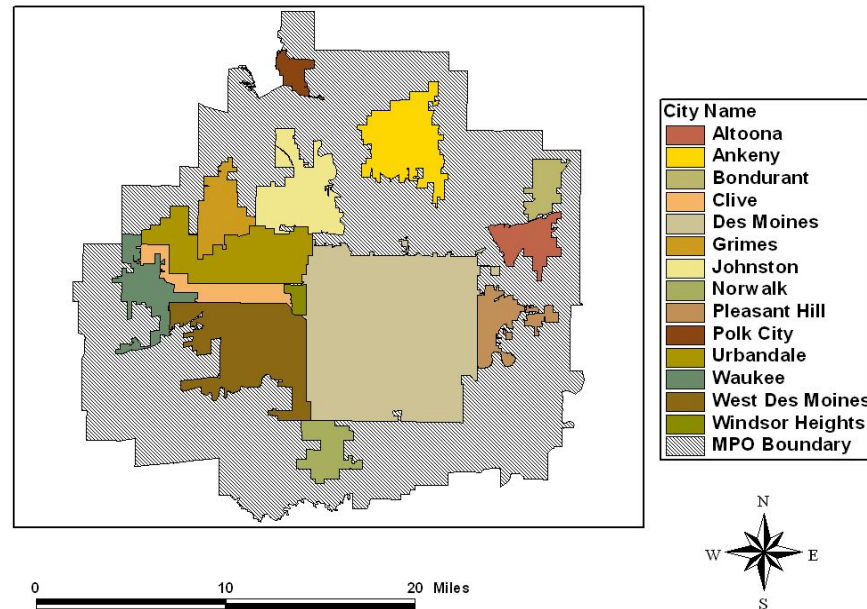


Figure 1. Cities located within the Des Moines Area MPO boundaries

With the exception of Windsor Heights (the only community in the Des Moines area that has no area available for expansion), the populations of all of the cities in the study area have increased from 1980 to 2000. For instance, the population of Johnston has increased by over 237% from 1980 to 2000. The populations of Clive, Grimes, Norwalk, Waukee, and West Des Moines have all increased by over 100% since 1980. All of these cities are located to the west of Des Moines except Norwalk, which is to the south. Table 1 shows each city's population for 1980, 1990, and 2000, as well as the percentage of change from 1980 to 2000. As Table 1 shows, the areas in the study area had a total population of nearly 363,000 in 2000. The population of the Des Moines metro area is anticipated to approach 500,000 during the next 30 years, with most of the growth occurring in the suburban cities.

Table 1. Population change by city

City	1980	1990	2000	Percent change (1980-2000)
Altoona	5,764	7,191	10,274	78.24%
Ankeny	15,429	18,583	26,923	74.50%
Bondurant	1,283	1,584	1,857	44.74%
Clive	6,064	7,462	12,851	111.92%
Des Moines	191,003	193,187	197,533	3.42%
Grimes	1,973	2,653	5,064	156.66%
Johnston	2,617	4,702	8,825	237.22%
Norwalk	2,676	5,725	6,971	160.50%
Pleasant Hill	3,493	3,676	5,095	45.86%
Polk City	1,658	1,908	2,339	41.07%
Urbandale	17,869	23,500	29,066	62.66%
Waukee	2,227	2,512	5,135	130.58%
West Des Moines	21,894	31,695	46,300	111.47%
Windsor Heights	5,474	5,190	4,761	-13.03%
Total	279,424	309,568	362,994	29.91%

(Source: SETA, Iowa State University)

Task 1 Methodology

This section of the report details the methodology used to create a roadway segment mapping and database system for principal and minor arterials in the Des Moines Metropolitan Area in order to locate and proactively identify access management problems. This task used ESRI ArcView 3.2 GIS (Geographic Information Systems) and ArcGIS 8.3 to develop a mapping system of the segments, corresponding attribute tables for each segment, a database of crashes related to each segment, and databases created for analysis of the segments, their crashes, and possible problems related to access management. All of the data used for this study were obtained from the Iowa DOT, except when noted.

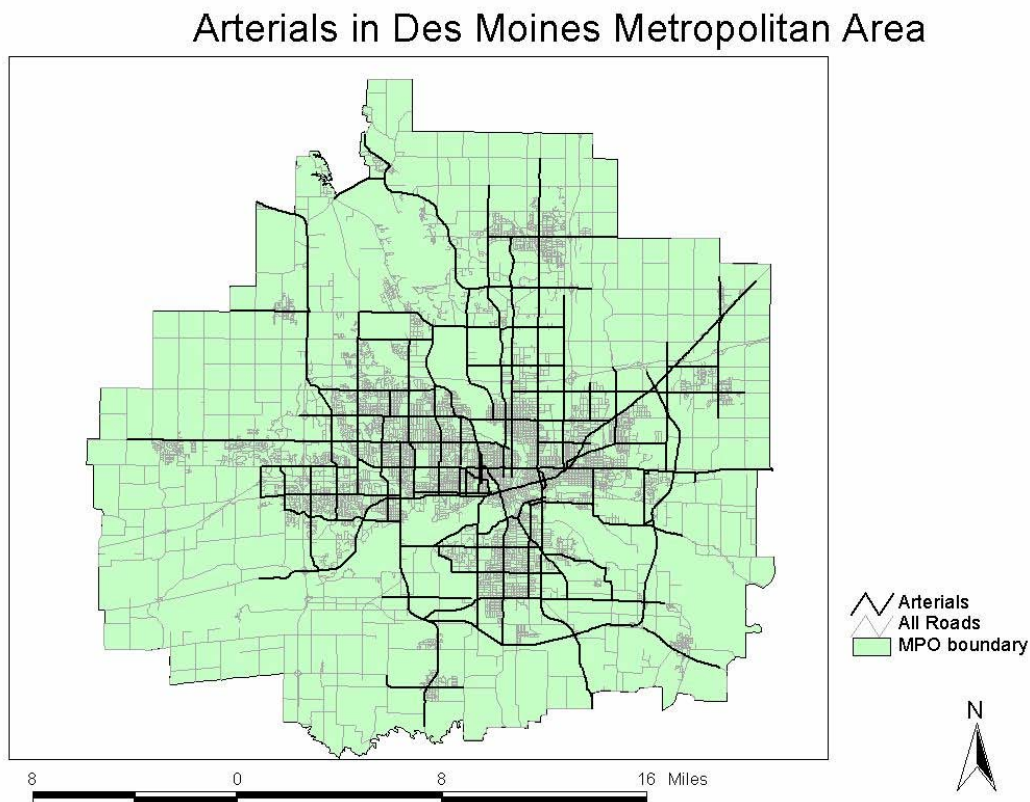
There were two reasons for utilizing GIS technologies to create and analyze the chosen segments. First, GIS technology allowed the study team to develop an ArcView project visualizing each segment's current land use, driveway locations and density, crash type, and location. The segments' crash, roadway, and traffic data were used to calculate crash frequencies, rates, and severity. In addition, the segments' crash type information was used to assess the relative access management of each segment.

A benefit to using ArcView GIS technology instead of traditional mapping techniques is the ability to integrate data into maps. This integration allows for "smarter" maps, which allows for data analysis to occur within the program and results to be displayed in map form.

Arterial Road Network Selection

Using ArcView 3.2 and the road network provided by the Des Moines MPO, shapefiles from the road network in the Des Moines metropolitan area were selected and a new shapefile for the project was created. The road network from the Des Moines metropolitan area includes roads of all functional classifications, but only principal and minor arterials were included for this study, since they typically provide access to land uses which generate many trips each day, such as commercial land use.

The road data file with functional classification provided by the Des Moines Area MPO did not contain all of the roadway data that was needed for this study. Therefore, the Iowa Department of Transportation (DOT) geospatial database was used for the rest of the study. From the Iowa DOT geospatial database, the corridors identified as principal and minor arterials were selected. The Des Moines Area MPO made these selections based on its previous work with functional classification of the urban arterial system. The selected corridors were then given corridor ID numbers for use throughout this study. Figure 2 shows the arterials selected for this study.



Arterial Network Segmentation

In order to determine specific locations with potential for access management improvements, the selected corridors were broken into 180 smaller segments for further analysis. The average segment length was 2.04 miles. The corridors were broken into segments primarily at major arterial intersections.

Crash Data Analysis

For this study, Iowa crash records for 1997, 1998, 1999, and 2000 (the most recent available records), were examined to determine high crash locations in the Des Moines metropolitan area. The crash database was obtained from CTRE and is property of the Iowa DOT.

From the Iowa crash database, crashes that occurred along the study corridors from 1997 to 2000 were selected. This resulted in a total selection of 29,810 crashes. A map of the total crashes located in the Des Moines metropolitan area is illustrated in Figure 3. Although this figure is not particularly useful for analysis purposes, it illustrates that crashes are widely distributed across the metropolitan area.

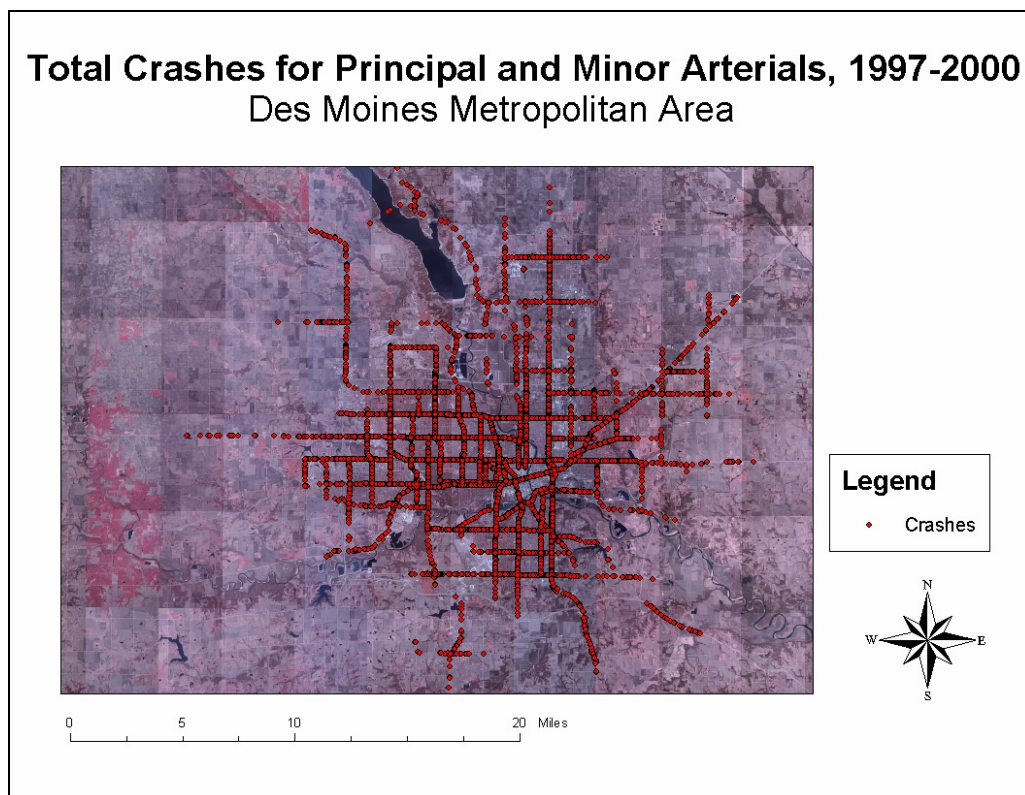


Figure 3. Total crashes in the Des Moines Metropolitan Area

To assess the potential for improvement of access management along the corridors, the probable access-related crashes were selected from all 29,810 crash records. This was done by selecting crashes by type in order to determine and locate crashes that were most likely the result of a conflict while accessing an adjacent property. For this study, probable access-related crashes were defined as the following types of crashes:

- Broadside
- Rear-end collision
- Rear-end/right-turn collision
- Rear-end/collision
- Broadside/right angle collision
- Broadside/right entering collision
- Broadside/left entering collision

The access-related crashes along the study corridors are illustrated in Figure 4. There were a total of 18,089 probable access-related crashes. See Table 2 for a breakdown of these crashes. It should be noted that some of these crashes occurred within the functional area of public road intersections; however, since there are also driveways within the functional area, either excluding or including these crashes as access-related leads to some attribution error. The method of crash selection chosen for this study very likely overstates the number of crashes attributed to property access.

Nearly half (48.7%) of the probable access-related crashes identified in the Des Moines metro area were rear-end collisions. In urban areas along major arterials, rear-end collisions are typically the result of stop-and-go traffic situations where there are numerous traffic signals and commercial driveways. Right-turn crashes accounted for over 29% of the total crashes and left-turn collisions accounted for over 21% of the total crashes. Roadways with traversable medians were observed to have a much higher percentage of left-turn collisions compared to those with non-traversable medians, which are usually raised medians in the Des Moines metro area.

Probable Access-Related Crashes for Principal and Minor Arterials, 1997-2000
Des Moines Metropolitan Area

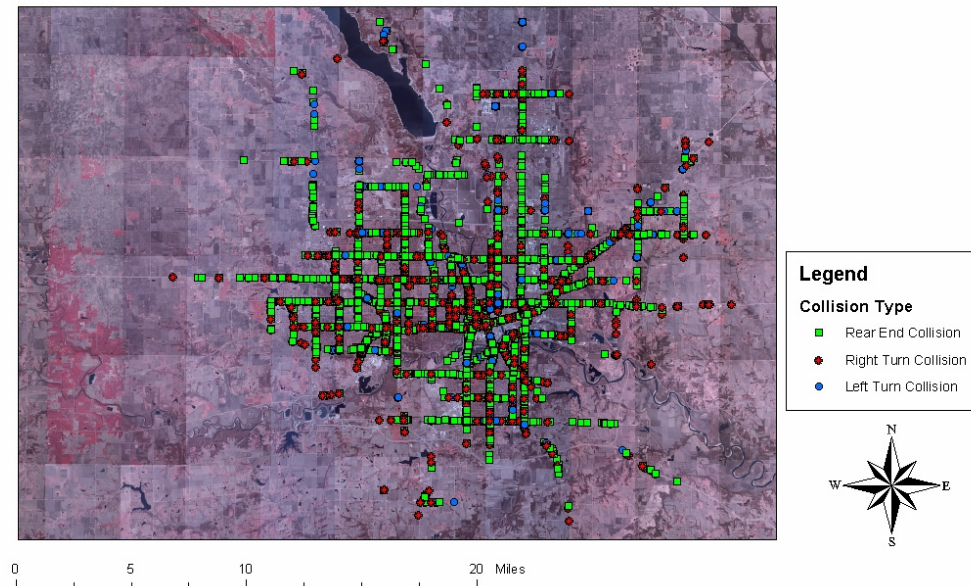


Figure 4. Probable access-related crashes

Table 2. Breakdown of probable access crashes

Collision type	Crash frequency	Percent of total
Rear-end	8,811	48.7 %
Right-turn	5,337	29.5 %
Left-turn	3,941	21.8 %
Total	18,089	100.00%

Crash Frequency

The frequency of crashes that occurred from 1997 to 2000 was observed for each study corridor. Both the frequency of the total crashes and the frequency of probable access-related crashes were determined. This was done in ArcView GIS, so that corridors with a high density of crashes could be shown graphically on maps.

Using the newly created Corridor ID field in the crash database, the crash frequency for each corridor was summarized in ArcView. As described earlier, the probable access-related crashes are those that include rear-end, right-turn, and left-turn collisions. The crash frequencies were later used in the study to determine crash rates per million vehicle miles traveled (VMT) for each of the study corridors.

Vehicle Miles Traveled

For this study, crash rates will be used for the corridor ranking system, therefore the total VMT must be determined for each corridor. VMT is a measure of how much travel occurs in a corridor and depends on traffic level, segment length, and the period of time

included. A new field for VMT was created in the road database and calculated in ArcView. VMT was calculated in the following equation:

$$\text{Sum of VMT} = \text{Length of roadway} * \text{Time period} * \text{Weighted AADT}$$

Where

$$\text{Time period} = 4 \text{ (years)} * 365 \text{ (days per year)}$$

$$\text{Weighted AADT} = (\text{Segment length} * \text{AADT}) / \text{Corridor length}$$

$$[(\text{AADT}) = \text{Annual Average Daily Traffic}]$$

Crash Rates

Using the calculated VMT and crash frequencies, crash rates were calculated for each corridor based on total crashes and probable access-related crashes.

Crash rates indicate approximately how many crashes occurred per million VMT. For example, if a crash rate is 6.50, there were 6.5 crashes for every million vehicle miles traveled. Crash rates were used in this study to allow for valid safety comparisons among the segments. Crash rates were calculated in ArcView using the following formula:

$$\frac{\text{Crash frequency} * (1,000,000)}{\text{Sum VMT}} = \text{Total Crash Rate (per million vehicle miles)}$$

Crash Severity

Next, the total severity of crashes per corridor was calculated to determine which corridors produced the highest dollar value of crash costs. The Iowa DOT assigns each crash a severity ranking of 1 to 4, which has a corresponding level of severity and dollar amount to approximate the cost of the crash. Table 3 indicates each level of severity and its assigned dollar amount. As shown in the table, a severity ranking of 4 indicates possible injury or property damage, which is assigned a dollar value of \$2,500. These values are only estimates of the damage per each crash record.

Table 3. Description of loss values assigned to severity rankings

Severity ranking	Level of severity	Dollar amount
1	Fatal	\$1,000,000
2	Major injury	\$150,000
3	Minor injury	\$10,000
4	Possible injury or property damage	\$2,500

Source: Michael Pawlovich, Iowa DOT Highway Division, Engineering Bureau, Office of Traffic and Safety

To quantify the potential economic benefits of improved access management for each corridor, severity was calculated and summed for the roadways for probable access-related crashes. Southeast 14th Street had the highest crash severity, with over \$143,000,000 in damages over the four year time period. University Avenue had the second-highest crash severity with nearly \$130,000,000 in damages. The severity of these two corridors was relatively high compared to the remaining corridors.

Commercial Driveway Density

The number or density per mile of driveways along a corridor is a good indicator of corridors in need of access management. More specifically, the density of commercial driveways is a good indicator of the level of access management, as these driveways generate more trips per day when compared with driveways that serve residential and other land uses. Roadways with a high number of commercial driveways per mile are more susceptible to probable access-related crashes. Such situations may also present opportunities for driveway consolidation, driveway sharing, or alternative accessways.

Total and commercial driveway densities were calculated for each corridor. Driveway locations were identified by viewing 2002 color infrared orthophotos, which were downloaded from the Iowa State University Geographic Information Systems Support and Research Facility website (<http://www.gis.iastate.edu>). The orthophotos were viewed in ArcView 3.2 along with the roadway features for this study. By zooming into the orthophotos, driveway locations were easily identified, as the color infrared orthophotos are at a one-meter resolution, which provides a clear image of land development and roadway features. Land use GIS coverages were used to determine which driveways provided access to commercial businesses and which served other land use types, such as residences. The most recent land use data was provided by the Des Moines Area MPO.

Once the driveways for each corridor were identified, the driveways within commercial land use were selected using ArcView. A field was added to the driveway shapefile indicating the driveways serving commercial land use. The commercial driveway density was then calculated by dividing the total number of commercial driveways by the total corridor length. See Figure 5 for a map of total driveway locations, and Figure 6 for commercial driveway locations.

It is important to note that the driveway inventory developed using the color orthophotos is likely not 100% accurate. The infrared orthophotos appeared somewhat distorted in certain areas and driveway locations are hard to recognize in highly urbanized areas where there are tall buildings and shadows. Therefore, there is likely to be human error in the inventory process. However, through comparisons with field data collection, it was determined that this method provided at least 95% accuracy in determining commercial driveway density at a much lower cost than a full field inventory.

Driveway Locations for Principal and Minor Arterials Des Moines Metropolitan Area

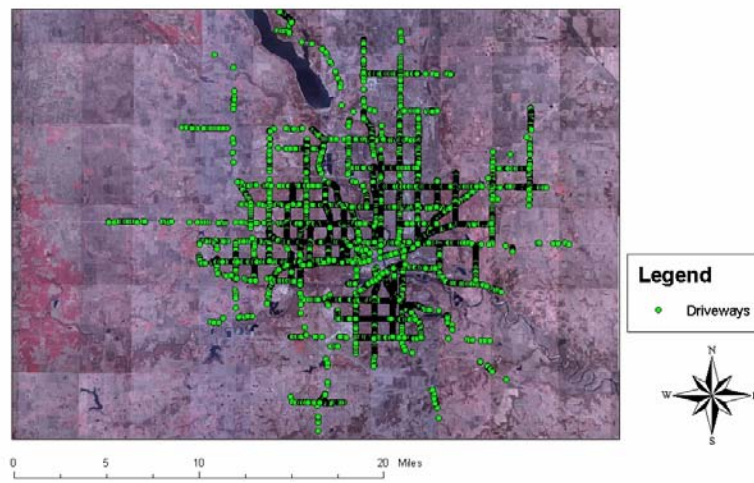


Figure 5. Driveway locations

Commercial Driveway Locations for Principal and Minor Arterials Des Moines Metropolitan Area

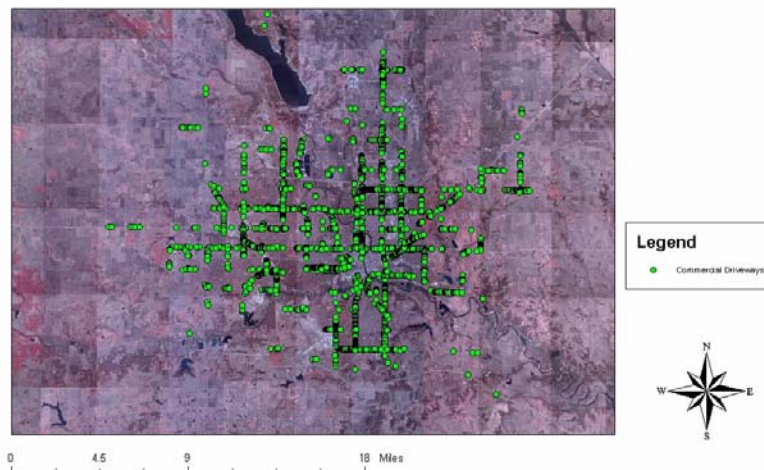


Figure 6. Commercial driveway locations

RoadView

The Iowa DOT provided VideoLog images for each of the study arterials that they manage, which includes many miles of arterials included in the study. The Mandelli RoadView Player allows these images to be displayed sequentially in a way that simulates driving along the road. The VideoLog images provide a wide-angle view so that driveways and adjacent land uses are visible.

Images from the VideoLog were used to identify and locate problem segments among the high-priority access segments and to confirm what the crash data analysis and driveway

density analysis indicated. As Figure 7 illustrates, the VideoLog pictures provide a very clear image. The images were used to develop more roadway inventories such as median type, turn-lanes, traffic signals, sight distance, driveway locations, and potential treatment options for the most promising segments.



Figure 7. Video log image, East Euclid Avenue

Crash Frequency Results

Crash rates for the probable access-related crashes, crash severity for probable access-related crashes, and commercial driveway densities were calculated for each of the 180 study segments.

As shown in Table 4, many of the segments of the Des Moines area arterial network have a low number of access-related crashes. Over 100 of the 180 segments studied had fewer than 100 access-related crashes during the period studied. On the other hand, there were 16 segments (9% of the total) that had over 250 access-related crashes. In other words, access-related crashes are highly concentrated along a few corridors on the Des Moines metro arterial system. These are promising locations for additional analysis and possible treatment.

Table 4. Probable access crash frequency summary

Probable access crash frequency	Segment count	Percent of total	Average segment length (miles)
0 to 50	83	46.11%	1.98
51 to 100	29	16.11%	2.06
101 to 150	25	13.89%	2.16
151 to 200	13	7.22%	1.92
201 to 250	14	7.78%	1.76
251 to 300	6	3.33%	2.23
301 to 350	4	2.22%	2.23
351 to 400	0	0.00%	-
401 to 450	5	2.78%	2.84
451 to 500	0	0.00%	-
501+	1	0.56%	3.66
Total	180	100.00%	-

Crash Rate Results

As mentioned previously, crash rates were calculated in order to compare the frequency of access-related crashes along each segment while adjusting for exposure (travel). It should be noted that crash rates per million VMT were calculated for each segment for probable access-related crashes only. The crash rates varied from 0 to as high as 33 crashes per million vehicle miles traveled. This upper value is considered extremely high.

Of the 180 segments, 153 (nearly 87%) had crash rates ranging from 0 to 5.99 crashes per million VMT. The average crash rate for probable access-related crashes was 3.36 crashes per million VMT. There were 67 segments with a crash rate ranging from 0 to 1.99 crashes per million vehicle miles traveled and 57 segments with crash rates ranging from 2.00 to 3.99. There were only 7 segments with a crash rate higher than 10.00 crashes per million VMT. These would be considered the most promising for further analysis and access management treatments. Table 5 summarizes these findings.

Table 5. Probable access crash rate summary

Crash rate (probable access crashes)	Segment count	Percent of total
0.00 to 1.99	67	38.07%
2.00 to 3.99	57	32.39%
4.00 to 5.99	29	16.48%
6.00 to 7.99	10	5.68%
8.00 to 9.99	6	3.41%
10.00 to 11.99	5	2.84%
12.00+	2	1.14%
Total	176	100.00%

*Four of the segments (6, 7, 9, and 10) are not included due to lack of travel (AADT) data.

Crash Severity Results

The crash severity for each segment was calculated in order to estimate the dollar cost in damages for crashes. As was mentioned previously, fatal crashes are assigned a value of \$1,000,000; major injuries, \$150,000; minor injuries, \$10,000; and property damage/possible injuries, \$2,500. Costs for each crash include those to drivers, passengers, and any other persons involved (such as pedestrians or cyclists) for all vehicles involved in the crash.

Table 6 shows a breakdown of total crash severity costs for all of the 180 study segments. The table also indicates the average segment length and average frequency of crashes per segment for each level of severity.

The average total crash severity for the 180 segments was \$8,916,722. As shown below, the majority of the segments, with a total of 84 segments (46%), had from 0 to \$4,999,999 in estimated damages. For these 84 segments, the average segment length was 1.97 miles long, with an average crash frequency of 19.3 crashes. The second largest group, with 35 (19%) of the total segments, experienced a total of \$5,000,000 to \$9,999,999 in total damages. The average segment length for these segments was 2.09

miles long with an average crash frequency of 84.63 crashes. Only 12 segments had a total crash severity of \$25,000,000 or higher. These segments were deemed promising for further investigation.

Table 6. Crash severity (probable access crashes) summary

Crash severity (\$ millions)	Segment count	Percent of total	Average segment length (miles)	Average crash frequency
0 to 4.99	84	46.67%	1.97	19.29
5 to 9.99	35	19.44%	2.09	84.63
10 to 14.99	23	12.78%	1.98	133.04
15 to 19.99	16	8.89%	1.96	203.06
20 to 24.99	10	5.56%	2.10	246.90
25 to 29.99	5	2.78%	2.24	317.60
30 to 34.99	2	1.11%	2.21	371.00
35 to 39.99	2	1.11%	2.47	405.00
40 to 44.99	2	1.11%	3.46	446.00
45 to 49.99	0	0.00%	-	-
50+	1	0.56%	3.66	697.00
Total	180	100.00%	-	-

Commercial Driveway Density Results

The commercial driveway density was calculated for each of the 180 segments. It was found that a large number of conflict points occur along arterials with a high density of commercial driveways. These conflict points can lead to high rates of left-turn, right-turn, and rear-end collisions. For the study segments, commercial driveway density results ranged from 0 to 47 commercial driveways per mile.

Of the 180 study segments, 88 (49%) had a commercial driveway density between 0 and 4.99. In other words, about half of the Des Moines area arterial network appears well-managed in a physical sense. There were 34 segments (19%) with a commercial driveway density per mile between 5.00 and 9.99. There were 20 segments (11%) that had a density between 10.00 and 14.99 commercial driveways per mile. There were only 38 segments (21%) with a commercial driveway density equal to or exceeding 15.00 commercial driveways per mile. These segments were deemed the most promising for further investigation.

Table 7 shows the average crash rate and average crash severity for each category of commercial driveway density. Segments with a commercial driveway density of 0 to 4.99 had an average crash rate of 1.98 crashes per million VMT and a total average severity of over \$4 million. The segments with a commercial driveway density exceeding 5.00 driveways per mile have higher access-related crash rates and access-related crash severities.

Table 7. Segment count by commercial driveway density

Commercial driveway density	Segment count	Percent of total	Average crash rate (probable access-related crashes)	Average crash severity (probable access-related crashes)
0 to 4.99	88	48.89%	1.98	\$4,423,806.82
5.00 to 9.99	34	18.89%	4.92	\$6,985,294.12
10.00 to 14.99	20	11.11%	4.45	\$11,150,125.00
15.00 to 19.99	17	9.44%	4.82	\$20,741,911.76
20.00 to 24.99	10	5.56%	4.55	\$19,596,750.00
25.00 to 29.99	3	1.67%	2.87	\$12,609,166.67
30.00 to 34.99	3	1.67%	4.45	\$22,353,333.33
35.00 to 39.99	2	1.11%	5.19	\$21,783,750.00
40.00 to 44.99	2	1.11%	4.72	\$19,963,750.00
45.00+	1	0.56%	7.51	\$18,250,000.00
Total	180	100.00%	-	-

As Table 7 implies, there are strong correlations between commercial driveway density, access-related crash rates, and access-related crash severity. Several key correlations (simple Pearson's r , where 1.00 is a perfect correlation and 0.00 is no correlation) for the study corridors were as follows:

- Access-related crash rate and access related crash severity: $r = 0.698$
- Access-related crash rate and commercial driveway density: $r = 0.624$
- Access-related crash severity and commercial driveway density: $r = 0.574$

This means that these measures are highly interrelated and that they are, to some extent, interchangeable measures of promise for access management improvement. For ranking purposes for the remainder of Task 1, the three factors (rate, severity, and density) were used in an equally weighted index.

This statistical analysis also indicated that access management issues are highly concentrated on a relatively few arterial corridors in the Des Moines metropolitan area. Figure 8 shows this in a graphical manner. From Figure 8, we can see that 34 segments (19%) are responsible for almost 50% of the access-related crash severity total in the Des Moines metropolitan area while almost 100 (56%) low-ranked segments only contribute to 20% of the severity total. About half of the arterial segments in the Des Moines metro area have low commercial driveway densities, low crash rates for probable access-related crashes and low crash severities. As such, they are not promising candidates for further investigation. On the other hand, there are 10 to 20 corridor segments that are very promising for further investigation since they are where driveways and probable access-related crashes are concentrated.

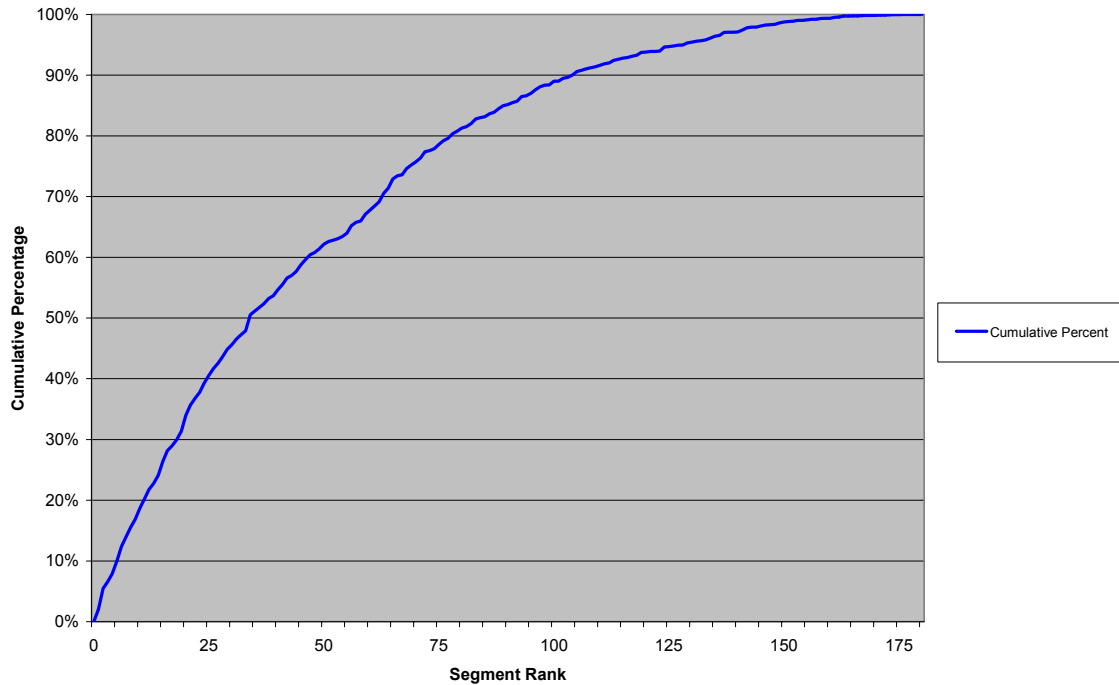


Figure 8. Cumulative percent of access severity by segment ranking

The rest of this study identifies the arterial segments with the highest access-related crash rates, access-related crash severities, and commercial driveway densities and discusses possible access management solutions in a very general way. It should be noted here that many of the most promising segments for access management improvements are located in areas of the Des Moines metropolitan area that developed prior to 1970 (e.g. commercial portions of the cities of Des Moines, West Des Moines, and Ankeny). Since that time, knowledge about the value of access management has increased greatly and street design practices and land use planning practices have been improved as a result.

The segments listed below should be considered for further, more detailed investigation because they are the most promising in terms of potential benefits through improved access management. Due to constraints such as narrow right-of-way, it may prove infeasible to use many of the most commonly used and effective access management treatments in a specific corridor. Each promising corridor will have to be studied in greater detail because such detailed study is beyond the scope of this study.

High Crash Rate Segments

The majority of segments considered to have high crash rates are located in the city of Des Moines. This is not surprising because the arterial network in the City of Des Moines is the oldest network in the metro area and includes many miles of 4-lane arterial with no raised medians, which tend to have high crash rates. The segment with the highest probable access-related crash rate was Fleur Drive between Locust Street and East Army Post Road in the City of Des Moines, with nearly 34 crashes per million VMT. Table A-1 shows the 20 segments with the highest probable access-related crash rates.

High Crash Severity Segments

The segment with highest total crash severity was along Grand Avenue between 29th Street and Hubbell Avenue in the city of Des Moines, with nearly \$55 million in total severity costs. Fleur Drive from Locust Street to East Army Post Road, the highest-ranked segment in terms of crash rates, had the second-highest severity ranking with over \$42 million in total costs. Many of the high crash severity segments were also identified as having high crash rates. As was noted before, these two indicators are strongly correlated, as detailed in Table A-2.

High Commercial Driveway Density Segments

Finally, the segments with the highest commercial driveway densities were identified. Table A-3 shows 20 segments with high commercial driveway densities. Two segments along Southwest 9th Street have the highest commercial driveway densities with 47 and 42 commercial driveways per mile, respectively. Douglas Avenue, Ingersoll Avenue, and University Avenue all have multiple segments with a high density of commercial driveways.

Candidates for Further Consideration for Access Management

Table A-4 shows candidate segments for future consideration of access management. These segments were identified based on an equal weighting of crash rates, severity, and commercial driveway densities. This table shows that Southwest 9th Street from Thomas Beck Road to McKinley Avenue was ranked as the top candidate for further investigation. This segment is the single most promising segment on the network for improved access management. Southwest 9th Street from 29th Street to Hubbell Avenue is another very promising candidate. Other segments listed in the table are along Grand Avenue, Southeast 14th Street, and University Avenue. University Avenue also includes potential segments for further research.

Figure 9 shows the locations of 10 segments which are considered the most promising candidates for further consideration. The majority of these segments are 4-lane, undivided arterials located in the city of Des Moines. Grand Avenue, which extends from West Des Moines to the eastern half of Des Moines, has two segments shown. All of these segments are candidates for the application of access management treatments to improve both safety and traffic flow.

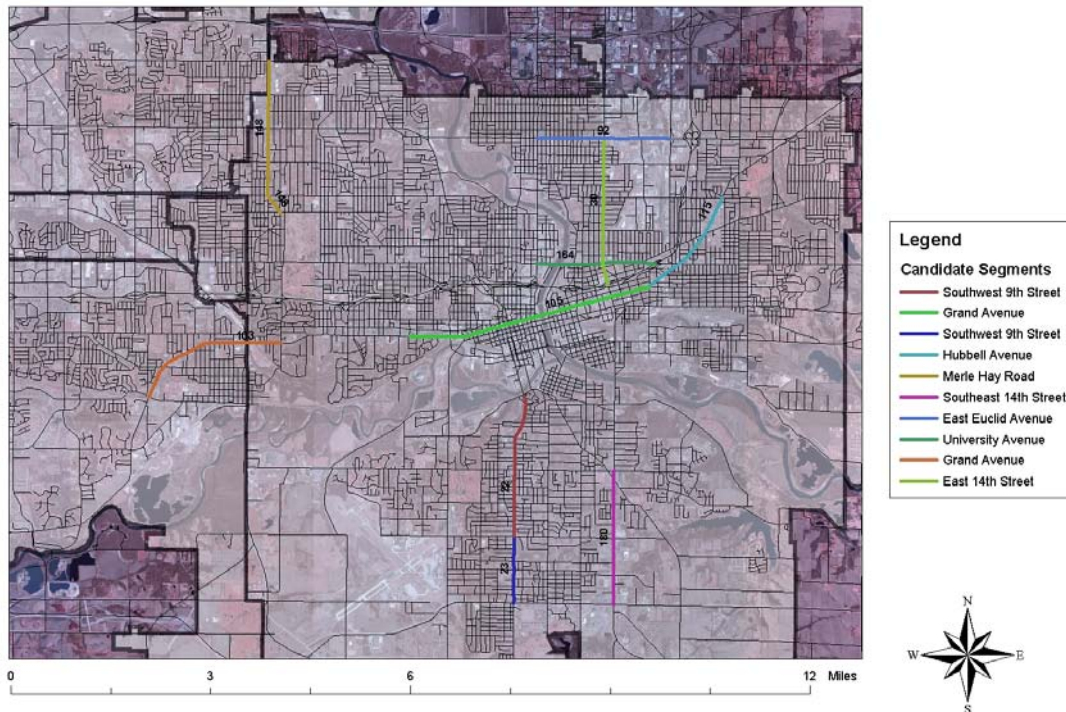


Figure 9. Most promising segments for further consideration

Figure A-1 indicates other promising segments that could be considered for future research. As the figure shows, the majority of these segments are located in the northwestern part of Des Moines. University Avenue has 3 segments, as shown in Figure A-1. These segments could also be considered good candidates for access management treatments. However, the first 10 segments should be given the highest priority for further consideration, as they have higher crash rates, severity, and commercial driveway densities.

As noted above, Southwest 9th Street from Thomas Beck Road to McKinley Avenue was determined to be the highest-ranked segment in terms of access-related crash severity, access-related crash rate, and commercial driveway density. This particular segment had a total of 336 probable access-related crashes from 1997 to 2000, with a crash rate of 5.57 probable access-related crashes per million VMT. These 336 crashes resulted in a total severity of nearly \$33 million in total crash costs. The segment is 2.09 miles long with a total of 88 commercial driveways, or over 42 commercial driveways per mile. This is an extremely high commercial driveway density.

Figure A-2 shows Southwest 9th Street and the probable access-related crashes, which are stacked where multiple accidents occurred along the segment. As the figure shows, there is an abundance of crashes near the major intersections at Park Avenue and McKinley Avenue. However, there are also numerous crashes along the length of the segment and near commercial driveways. So, for this segment, both intersection improvements and access management treatments should be considered.

Access Management Issues and Treatments for Promising Segments

The majority of the segments identified for further research are located in older locations of Des Moines. These segments were identified based on high probable access-related crash rates, crash severity, and commercial driveway densities. The following section investigates problem areas along these segments and potential solutions to the problems in a very general way. On some of them, a series of small changes (such as driveway consolidation or sharing) would improve safety. On others, major changes (such as installation of medians) might prove more effective. For some, conditions are such that making any improvement in access management would be difficult. These are generally arterials where commercial development has been allowed to occur very close to the street right-of-way. Table 8 lists the ‘Top Ten’ candidate segments for improved access management.

Table 8. Promising segments for improved access management

Road name	Segment location
Southwest 9th Street	Thomas Beck Road to McKinley Avenue
Grand Avenue	29th Street to Hubbell Avenue
Southwest 9th Street	McKinley Avenue to East Army Post Road
Hubbell Avenue	East Grand Avenue to Guthrie Avenue
Merle Hay Road/Merklin Way	Meredith Drive to Franklin Avenue
Southeast 14th Street	East Park Avenue to Army Post Road
East Euclid Avenue	2nd Avenue to East 14th Street
University Avenue	2nd Avenue to I-235
Grand Avenue	E.P. True Parkway to 56th Street
East 14th Street	East Euclid Avenue to I-235

Table 9 lists the collision type percentages for each of the most promising candidate segments. Most of these routes are in the city of Des Moines, although the second segment of Grand Avenue, located in an older portion of West Des Moines, is an exception. On average, from all of the study segments, 18.97% of the probable access-related collisions were left-turn collisions, 33.03% were right-turn collisions, and 48.01% were rear-end collisions. In Table 13, the 5 italicized percentages are those where the collision type for the particular segment is higher than the average. Southeast 14th Street has the highest percentage of rear-end crashes, making up over 62% of the crashes. Southeast 14th is notable in that most of it already has traffic lanes separated by a raised median. This median has eliminated many of the left-turn crashes. Only one segment has a right-turn crash percentage higher than the average; Grand Avenue in Des Moines has over 42% right-turn collisions. Such collisions are normally associated with vehicles accessing adjacent properties.

As Table 9 shows, 8 of 10 candidate segments have a left-turn collision percentage higher than the average. Over 39% of the total probable access-related collisions along Grand Avenue from E.P. True Parkway to 56th Street are left-turn collisions (this is the West Des Moines segment). Based on the high percentage of left-turn collisions as shown in the Table 9, these segments have safety issues associated with median openings or have traversable medians or no medians. Likewise, rear-end collisions are typically the product

of high traffic signal and commercial driveway densities, an issue that needs to be addressed for these segments.

Table 9. Promising segments and collision type

Road name	Segment location	% rear-end collisions	% right-turn collision	% left-turn collisions
Southwest 9th Street	Thomas Beck Road to McKinley Avenue	55.37%	25.99%	18.64%
Grand Avenue	29th Street to Hubbell Avenue	43.43%	42.42%	14.14%
Southwest 9th Street	McKinley Avenue to East Army Post Road	33.45%	28.22%	38.33%
Hubbell Avenue	East Grand Avenue to Guthrie Avenue	45.62%	32.02%	22.36%
Merle Hay Road/ Merklin Way	Meredith Drive to Franklin Avenue	55.01%	17.12%	27.87%
Southeast 14th Street	East Park Avenue to Army Post Road	62.08%	18.04%	19.88%
East Euclid Avenue	2nd Avenue to East 14th Street	48.80%	27.20%	24.00%
University Avenue	2nd Avenue to I-235	43.24%	29.71%	27.06%
Grand Avenue	E.P. True Parkway to 56th Street	35.80%	24.90%	39.30%
East 14th Street	East Euclid Avenue to I-235	50.53%	19.43%	30.04%

Table 10 shows the commercial driveway densities for the 10 most promising candidate segments. Southwest 9th Street from McKinley Avenue to East Army Post Road has the highest density of commercial driveways, averaging 47 per mile. Southwest 9th Street from Thomas Beck Road to McKinley Avenue has the second-highest commercial driveway density, averaging over 42 per mile. The lowest commercial driveway density from the 10 candidate segments is Grand Avenue, averaging over 16 commercial driveways per mile. However, this particular segment runs through the heart of downtown Des Moines, as shown in Figure A-3. Therefore, the full commercial driveway count was likely inaccurate due to building shadows, as discussed previously.

Table 10. ‘Top Ten’ candidate segments and commercial driveway density

Corridor	Road name	Segment location	Commercial driveway density (per mile)
1	Southwest 9th Street	Thomas Beck Road to McKinley Avenue	42.09
2	Grand Avenue	29th Street to Hubbell Avenue	16.39
3	Southwest 9th Street	McKinley Avenue to East Army Post Road	47.00
4	Hubbell Avenue	East Grand Avenue to Guthrie Avenue	38.09
5	Merle Hay Road/ Merklin Way	Meredith Drive to Franklin Avenue	22.26
6	Southeast 14th Street	East Park Avenue to Army Post Road	30.52
7	East Euclid Avenue	2nd Avenue to East 14th Street	24.06
8	University Avenue	2nd Avenue to I-235	16.50
9	Grand Avenue	E.P. True Parkway to 56th Street	34.64
10	East 14th Street	East Euclid Avenue to I-235	16.67

Table 11 summarizes the access-related issues and potential access management treatments for the candidate segments for further research. As the table indicates, most of these segments have a high commercial driveway density, which suggests that driveway consolidation and sharing could be a promising treatment.

Table 11. Issues and potential treatments for ‘Top Ten’ candidate segments

Corridor	Issues	Potential Treatments
1	High density of commercial driveways. High percentage of rear-end collisions.	Driveway consolidation. Increased traffic signal spacing.
2	High density of commercial driveways. High percentage of right-turn collisions.	Driveway consolidation. Right-turn lanes.
3	High percentage of left-turn collisions.	Raised median.
4	High density of commercial driveways.	Driveway consolidation.
5	High percentage of rear-end and left-turn collisions.	Driveway consolidation. Raised median. Increased traffic signal spacing.
6	High percentage of rear-end collisions.	Driveway consolidation. Increased traffic signal spacing. Fewer median openings.
7	High density of commercial driveways.	Driveway consolidation.
8	High density of commercial driveways.	Driveway consolidation.
9	High percentage of left-turn collisions.	Raised median.
10	High percentage of rear-end and left-turn collisions.	Raised median. Increased traffic signal spacing.

Southwest 9th Street from Thomas Beck Road to McKinley Avenue (Des Moines)

Southwest 9th Street has a high commercial driveway density as well as a very high percentage of rear-end collisions. For this segment, a potential solution would be to consolidate driveways where several driveways provide access to a single business. There are two traffic signals within 260 feet; one at the 2400 block of Southwest 9th Street and the other at Bell Avenue, which has resulted in numerous rear-end collisions. The blue

dots in Figure A-4 are the traffic signal locations and the green dots are rear-end collisions.

Grand Avenue from 29th Street to Hubbell Avenue (Des Moines)

Grand Avenue has a very high percentage of right-turn collisions. Figures A-5 and A-6 show two separate locations along this particular segment with right-turn collision patterns (shown as a red asterisk). The right-turn collisions are clustered near certain intersections. For example, there is a large cluster of right-turn collisions along Grand Avenue at and near M.L. King Jr. Parkway, as shown in Figure A-5. Additionally, there are right-turn collisions at almost every intersection through the downtown area, as shown in Figure A-6. A possible solution for this segment would be to add right-turn lanes. However, since this segment is located in and near the downtown area, it is likely that any solutions would be both disruptive to land development and expensive.

The high density of traffic signals may contribute to the number of rear-end collisions along this study segment. Along this 3.66 mile segment, there are 25 traffic signals, resulting in a traffic signal density of 6.83 signals per mile. There may be opportunities to decrease rear-end collisions along this corridor, but it may be difficult given that it is in the downtown area.

Southwest 9th Street from McKinley Avenue to East Army Post Road (Des Moines)

Southwest 9th Street from McKinley Avenue to East Army Post Road had the second-highest percentage of left-turn related collisions. The safety of this segment would be improved with the addition of raised medians, especially in places where driveways provide access in close proximity to major intersections.

Hubbell Avenue from East Grand Avenue to Guthrie Avenue (Des Moines)

Hubbell Avenue from East Grand Avenue to Guthrie Avenue has a high density of commercial driveways, with over 38 commercial driveways per mile. There are many probable access-related crashes along this segment, many of them clustered at or near driveway locations and intersections. Figure A-8 shows a portion of this segment from East 23rd Street to Easton Boulevard where there are locations with numerous rear-end and left-turn collisions. The number of left-turn collisions (shown in blue) could be decreased with the addition of a raised median. Other crashes along this portion of the segment could be potentially reduced through the consolidation of driveways, which would reduce the number of conflict points along the segment. Due to the nature of commercial development and land use along this corridor, this segment appears to be an excellent candidate for a detailed access management study.

Merle Hay Road from Meredith Drive to Franklin Avenue (Des Moines)

Merle Hay Road (which becomes Merklein Way) from Meredith Drive to Franklin Avenue has a high percentage of both rear-end and left-turn collisions. As shown in Figure A-9, from Madison Avenue to Douglas Avenue there is a large number of rear-end and left-turn collisions. The area just west of this segment is occupied by Merle Hay Mall, a regional shopping center that generates a high volume of traffic. To the east of this segment is a combination of “strip” retail and business offices with a high driveway

density, which creates many conflict points. A possible solution for this segment would be to consolidate driveways, particularly on the east side of Merle Hay Road.

There is a raised median with a left-turn lane providing access to Merle Hay Mall, which is very close to Douglas Avenue (approximately 700 feet to the south). As the figure shows, there are numerous left-turn related collisions between Douglas Avenue and this median opening. Consideration might be given to a median closure at this location. There is a traffic signal with a protected left-turn phase just north (approximately 600 feet from the left-turn lane) with notably fewer crashes.

Southeast 14th Street from East Park Avenue to Army Post Road (Des Moines)

Southeast 14th Street from East Park Avenue to Army Post Road has 62% rear-end collisions. This is a high percentage of rear-end collisions as compared to the other study segments. Additionally, there are many locations on this segment with a high number of left-turn collisions. Figures A-10, A-11, and A-12 show specific locations with numerous rear-end and left-turn related collisions clustered at or near commercial driveways. Portions of this segment already have a raised median, so consolidating driveways or the application of frontage or backage roads at selected locations would be possible solutions for this segment. In addition, close traffic signal spacing or an excessive number of median openings may be leading to an increase in rear-end collisions.

East Euclid Avenue from 2nd Avenue to East 14th Street (Des Moines)

East Euclid Avenue from 2nd Avenue to East 14th Street has numerous areas with high levels of rear-end collisions as shown in Figure A-13. The most feasible solution for this particular segment would be to reduce the density of commercial driveways by consolidating them. Solutions are limited for this segment, as it is already heavily developed and lacks right-of-way for additional lanes or medians.

University Avenue from 2nd Avenue to I-235 (Des Moines)

As shown previously, this segment has a high percentage of left-turn collisions, with over 27% of the total access crashes being left-turn collisions. Figure A-14 shows a portion of this segment with numerous rear-end collisions scattered around commercial driveways. There are also a handful of driveways along this segment which have numerous left-turn related collisions. Again, one of the most feasible solutions for this segment would be to reduce the density of commercial driveways through consolidation.

Grand Avenue from E.P. True Parkway to 56th Street (West Des Moines)

Grand Avenue from E.P. True Parkway to 56th Street is another candidate segment for further research. This segment is the only one in the “top ten” located outside the city of Des Moines. Of the top ten, this segment has the highest percentage of left-turn crashes, with over 39% of crashes being left-turn related.

Figures A-15, A-16, and A-17 illustrate certain problem areas along the West Des Moines segment of Grand Avenue. As Figures A-16 and A-17 show, there are numerous left-turn related collisions at or near commercial access points. The best solution for this segment would be to reduce the commercial driveways in order to reduce access-related

crashes. This segment also lacks a raised median or two-way left turn lane, which raises the likelihood of left-turn related crashes.

East 14th Street from East Euclid Avenue to I-235 (Des Moines)

Over 50% of the total access-related crashes are rear-end collisions along East 14th Street from East Euclid Avenue to I-235. Figures A-18, A-19, and A-20 show specific locations along the segment where probable access-related crashes are a problem. As the figures show, there are a lot of rear-end collisions (shown in green) throughout the segment.

These are likely a result of stop and go traffic due to the high density of both driveways and traffic signals. A solution for this segment would be to assess traffic signal spacing, as well as consolidating commercial driveways through sharing and relocating access to side streets.

The Next Ten Most Promising Corridors

Tables A-1 through A-4 and Figure A-1 show the twenty most promising segments for consideration of improved access management in the Des Moines area. Since access-related crash rates, crash severity, and commercial driveway density are all highly concentrated in a few corridors in the metro area, the bulk of the most promising locations for improving access management are included in either the first ten or twenty corridors identified. Once again, most of the corridors included in the “next ten” list are within the older city of Des Moines, but the list also includes University Avenue in Windsor Heights (recently widened) and South Ankeny Boulevard (US 69) in Ankeny.

TASK 2: ACCESS MANAGEMENT PLANNING AND PROGRAMMING ELEMENTS

The Des Moines Area MPO plans to use the results of the problem identification process to improve the planning and programming of transportation projects in the Des Moines metropolitan area. Historically, Des Moines Area MPO planning and programming has had very little focus on improving access management along corridors in the Des Moines metropolitan area. Instead, the Des Moines Area MPO focused on a statewide crash ranking and some parts of the general facilities design standards when considering access management.

This report provides additional criteria and data that may be used in planning and programming improvements to existing facilities in the future. For example, the segments identified as the most promising candidates for access management improvements might be given additional emphasis in future programming in order to avoid creating new situations similar to the problem areas identified earlier in this report.

This report suggests the use of design guidelines for the development of new corridors to encourage good access management practices as new areas are developed. This report recommends that the Des Moines Area MPO adopt Chapter 5 of the Iowa Statewide Urban Designs and Specifications (SUDAS) as the access management guidelines for the Des Moines Area MPO as well as its members.

The Des Moines Area MPO plans to incorporate the results of the Des Moines Metropolitan Access Management Plan into two required documents, the Long-Range Transportation Plan (LRTP) and the Transportation Improvement Program (TIP). The LRTP is a multimodal transportation system plan that outlines the major transportation projects for the next 30 years in the Des Moines Area MPO's Planning Area. The Des Moines Area MPO plans to include the results of this report as it updates the Streets and Highway element of the LRTP.

The TIP implements the LRTP by outlining the spending of federal funds for transportation improvements. The Des Moines Area MPO currently has a scoring process to identify the most important projects requesting federal funding. The findings of this report will be incorporated into this scoring process in future years.

TASK 3: INTEGRATION OF ACCESS MANAGEMENT AND LOCAL LAND USE PLANNING ACTIVITIES

Iowa is a typical state in that transportation agencies (such as the Iowa DOT) have no statutory land use planning authority. The local governments have land use planning authority and therefore, education about the relationship between land use decisions and transportation decisions is a critical part of this report.

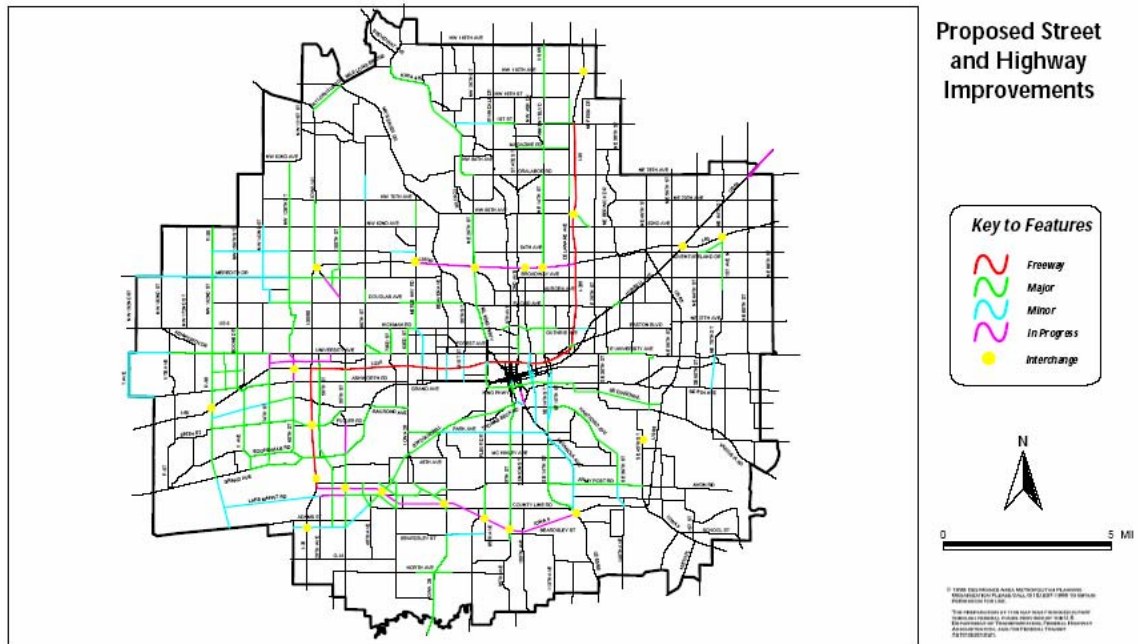
As part of Task 3, The Des Moines Area MPO reviewed the planned metro area transportation projects that would create new at-grade arterial facilities and compared them with future land use plans provided by the local communities. Corridors where future at-grade arterials are planned and commercial land use is also planned were considered to be “high risk” for the development of future access management issues. Most of these areas are in suburban communities, which is where most of the new transportation facilities will be built and where much of the new commercial development will occur.

Some of the areas identified as “high risk” for future access management issues are

- Altoona near the US 65 bypass.
- Ankeny, in several locations, including along Delaware, Oralabor, and US 69 in the southern part of the city.
- Clive, along US 6 (Hickman Road).
- Johnston, along Merle Hay Road.
- Pleasant Hill, along IA 163 (University Avenue).
- West Des Moines, near the I-80 and I-235 corridors.
- The area to the south of West Des Moines and Des Moines along the new IA 5 bypass, especially in the vicinity of the proposed Southwest Connector.

The above list is by no means all-inclusive. These potential problem areas will be especially important to consider as a part of the next update to the Des Moines LRTP.

Figures 10 and 11 show proposed future street improvements and the compiled future land use map for the metropolitan area. These maps are both for the horizon 2025 year and were used to identify the potential long-term problem areas.

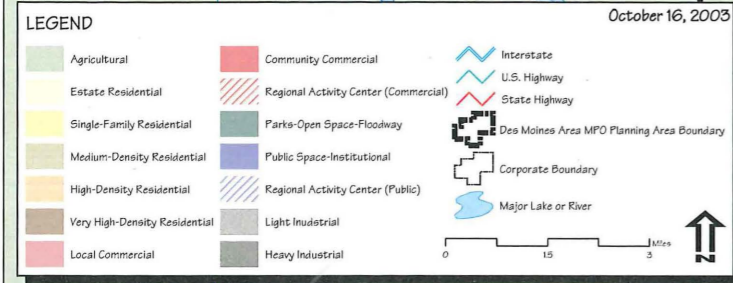


**Figure 11. Des Moines metro area future land use
(available at www.dmampo.org)**

Des Moines Metropolitan Planning Area

COMPREHENSIVE PLAN COMPILATION MAP

(Future Land Use Map)



NOTE:
This map represents the Des Moines Area Metropolitan Planning
Organization's member governments' future land use maps.
This map does not represent zoning, nor does it represent
existing land use.

Note: Content added to PDF

2003 Des Moines Area Metropolitan Planning Organization “Comprehensive Plan Compilation Map (Future Land Use Map)” of the Des Moines Metropolitan Planning Area was added to this PDF on December 17, 2015, to reflect the map used in the print version of this report from 2004.

The inserted map is a direct color scan at 400 dpi.

This map was inserted by the Iowa Department of Transportation Library staff based on the print version held up to that time.

No corresponding map titled “Comprehensive Plan Compilation Map” nor “Future Land Use Map” could be located at www.dmampo.org or <http://dmampo.org/maps/>

Note: Page numbering gap

The print version of this report has page numbers up to page 27, then an unnumbered gatefold of the 2003 Des Moines Area Metropolitan Planning Organization “Comprehensive Plan Compilation Map (Future Land Use Map)” (approximately 11 inches by 17 inches), and then resumes page number with page 31. The current PDF continues that practice.

The Des Moines Area MPO staff reviewed some of its member governments' site plan review processes, which vary considerably. Of the site plan review processes reviewed, all have minimum requirements for issues such as access spacing (e.g. driveway spacing) and require that developers' plans be approved by the city traffic engineer. The site plan review processes apply access management to a varying degree. As a result of this review, the MPO is considering suggesting "best practices" for site plan reviews (including the inclusion of access management considerations) for its member cities.

TASK 4: ACCESS MANAGEMENT EDUCATION FOR LOCAL OFFICIALS

After discussions with the Des Moines MPO Technical Advisory Committee (TAC) regarding the results of Task 1, the TAC indicated that previous CTRE educational materials, including the Access Management Handbook and the SUDAS section on access management, provided sufficient material for technical audiences, including both engineers and planners. The only gap in educational materials the TAC identified was with materials for non-technical audiences, for instance city councils, planning and zoning commissions, and business groups.

To meet the identified need for education material suitable for a non-technical audience, CTRE prepared a brief presentation, titled “Access Management 101,” on the benefits and impacts of access management. The main users of “Access Management 101” will be the Des Moines Area MPO staff, but the technical staff of cities within the MPO was identified as another potential group of users. “Access Management 101” is structured so that information about a specific arterial corridor can be incorporated. This might include information about crash frequency, crash rate, crash location, crash type, driveway density, driveway location, aerial photography and/or remote sensing images, and digital video log images.

CONCLUSION

Specific road segments in need of access management improvements in the Des Moines metropolitan area have been successfully identified using the process explained throughout this study. The next step is to begin programming and implementing access management strategies into the long range planning process for the Des Moines metropolitan area. Through access management techniques, the segments listed in this study could potentially improve safety by reducing the number of crashes, as well as by improving the level of service along the segments.

APPENDIX

Table A-1. Twenty highest crash rates (probable access related crashes)

Road Name	Location	Crash Rate (per million VMT)
Fleur Drive	Locust Street to East Army Post Road	33.96
28th Street	University Avenue to Grand Avenue	13.95
East 30th Street	East University Avenue to Vandalia Road	11.92
East 22nd Street/Easton Boulevard	Hubbell Avenue to East 38th Street	11.46
E.P. True Parkway	60th Street to 39th Street	11.33
Northeast 56th Street	8th Street Southwest to East University Avenue	10.93
Johnson Court /East 15th Street	Universtiy Avenue to East 14th Street	10.10
Indianola Avenue	Southwest 7th Street to Evergreen Avenue	9.64
Oralabor Road/Northeast 78th Avenue	Southwest State Street to Northeast 29th Street	9.52
Broadway Avenue/Northeast 46th Avenue	2nd Avenue to Northeast 22nd Street	8.99
60th Street	University Avenue to E.P. True Parkway	8.94
University Avenue	74th Street to 50th Street	8.83
Highway 65	Highway 5 to Dakota Street	8.56
University Avenue	50th Street to 22nd Street	7.88
Southwest 42nd Street	University Avenue to Grand Avenue	7.51
Northeast 38th Street/East 38th Street	Northeast 54th Avenue to Easton Boulevard	7.18
East Army Post Road	Proposed Iowa 28 to Fleur Drive	7.09
Highway 5	Scotch Ridge Road	7.07
Southwest State Street/2nd Avenue	Southwest Oralabor Road to North 66th Avenue	6.84
Northwest 62nd Avenue	Northwest 86th Street to Northwest Beaver Drive	6.68

Table A-2. Twenty highest crash severities (probable access related crashes)

Road Name	Location	Crash Severity
Grand Avenue	29th Street to Hubbell Avenue	\$ 54,685,000
Fleur Drive	Locust Street to East Army Post Road	\$ 42,260,000
Southeast 14th Street	I-235 to East Park Avenue	\$ 41,467,500
Southeast 14th Street	East Park Avenue to Army Post Road	\$ 39,002,500
MLK Jr Parkway	Euclid Avenue to Ingersoll Avenue	\$ 37,875,000
Merle Hay Road/ Merklin Way	Meredith Drive to Franklin Avenue	\$ 33,120,000
Southwest 9th Street	Thomas Beck Road to McKinley Avenue	\$ 32,742,500
East 14th Street	East Euclid Avenue to I-235	\$ 28,752,500
86th Street/ 22nd Street	Hickman Road to Ashworth Road	\$ 27,850,000
Hickman Road	73rd Street to Beaver Avenue	\$ 27,350,000
East Euclid Avenue	2nd Avenue to East 14th Street	\$ 25,657,500
Douglas Avenue	Merle Hay Road to MLK Jr Parkway	\$ 25,372,500
University Avenue	2nd Avenue to I-235	\$ 24,935,000
Guthrie Avenue	East 14th Street to East 29th Street	\$ 24,347,500
2nd Avenue	Northwest 54th Street to East Euclid Avenue	\$ 24,345,000
Ankeny Boulevard	Northeast 11th Place to Oralabor Road	\$ 24,290,000
East Army Post Road	Fleur Drive to Southeast 5th Street	\$ 22,755,000
2nd Avenue	East Euclid Avenue to I-235	\$ 22,017,500
Grand Avenue	E.P. True Parkway to 56th Street	\$ 21,755,000
University Avenue	55th Street to MLK Jr Parkway	\$ 21,237,500

Table A-3. Twenty highest commercial driveway densities

Road Name	Location	Commercial Driveway Density (per mile)
Southwest 9th Street	McKinley Avenue to East Army Post Road	47.00
Southwest 9th Street	Thomas Beck Road to McKinley Avenue	42.09
Ingersoll Avenue	31st Street to West 14th Street	41.01
East Army Post Road	Fleur Drive to Southeast 5th Street	38.63
Hubbell Avenue	East Grand Avenue to Guthrie Avenue	38.09
Grand Avenue	E.P. True Parkway to 56th Street	34.64
Broadway Avenue/ Northeast 46th Avenue	2nd Avenue to Northeast 22nd Street	30.88
Southeast 14th Street	East Park Avenue to Army Post Road	30.52
Delaware Avenue	East Euclid Avenue to Easton Boulevard	29.32
2nd Avenue	East Euclid Avenue to I-235	26.24
East 14th Street	Northeast 54th Avenue to East Euclid Avenue	25.01
East University Avenue	I-235 to East 30th Street	24.39
East Euclid Avenue	2nd Avenue to East 14th Street	24.06
Douglas Avenue	Merle Hay Road to MLK Jr Parkway	23.42
Beaver Avenue	Douglas Avenue to Franklin Avenue	23.01
University Avenue	86th Street to 55th Street	22.80
Ankeny Boulevard	Northeast 11th Place to Oralabor Road	22.59
Merle Hay Road/ Merklin Way	Meredith Drive to Franklin Avenue	22.26
Ingersoll Avenue	56th Street to 31st Street	21.86
Douglas Avenue	86th Street to Merle Hay Road	21.31

Table A-4. Promising segments for further research

Road Name	Location
Southwest 9th Street	Thomas Beck Road to McKinley Avenue
Grand Avenue	29th Street to Hubbell Avenue
Southwest 9th Street	McKinley Avenue to East Army Post Road
Hubbell Avenue	East Grand Avenue to Guthrie Avenue
Merle Hay Road/ Merklin Way	Meredith Drive to Franklin Avenue
Southeast 14th Street	East Park Avenue to Army Post Road
East Euclid Avenue	2nd Avenue to East 14th Street
University Avenue	2nd Avenue to I-235
Grand Avenue	E.P. True Parkway to 56th Street
East 14th Street	East Euclid Avenue to I-235
Douglas Avenue	Merle Hay Road to MLK Jr Parkway
Ankeny Boulevard	Northeast 11th Place to Oralabor Road
University Avenue	MLK Jr Parkway to 2nd Avenue
University Avenue	55th Street to MLK Jr Parkway
MLK Jr. Parkway	Euclid Avenue to Ingersoll Avenue
Hickman Road	73rd Street to Beaver Avenue
Ingersoll Avenue	56th Street to 31st Street
University Avenue	86th Street to 55th Street
East Army Post Road	Fleur Drive to Southeast 5th Street
Southeast 14th Street	I-235 to East Park Avenue

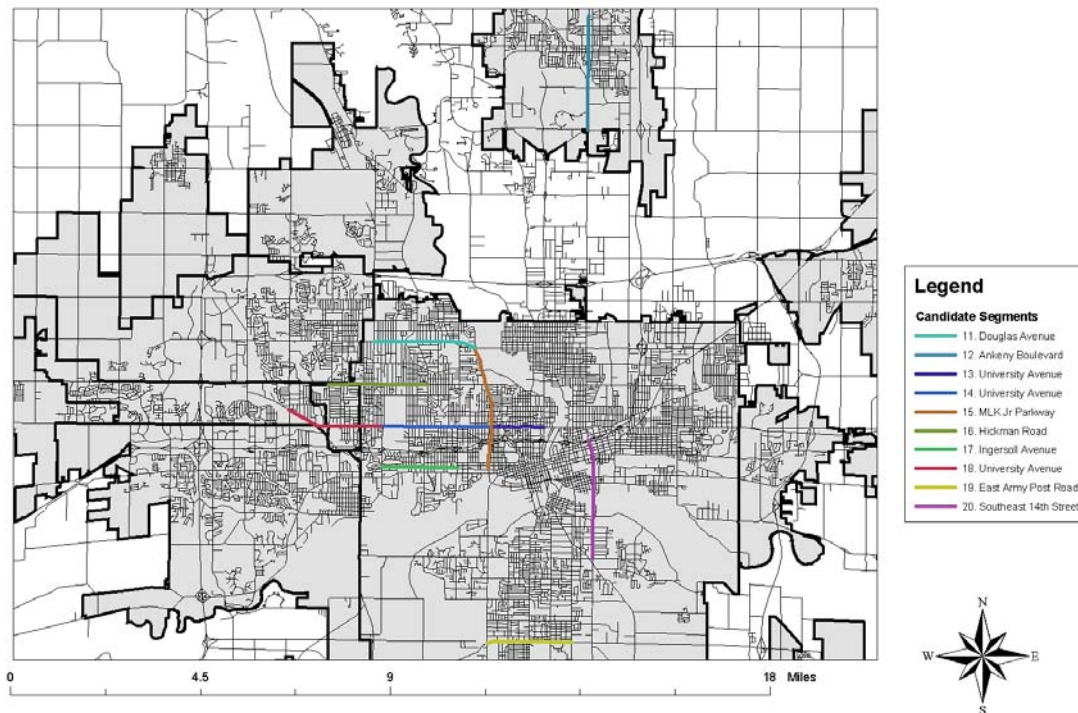


Figure A-1. Candidate segments 11-20 for further investigation



Figure A-2. Collisions on Southwest 9th Street

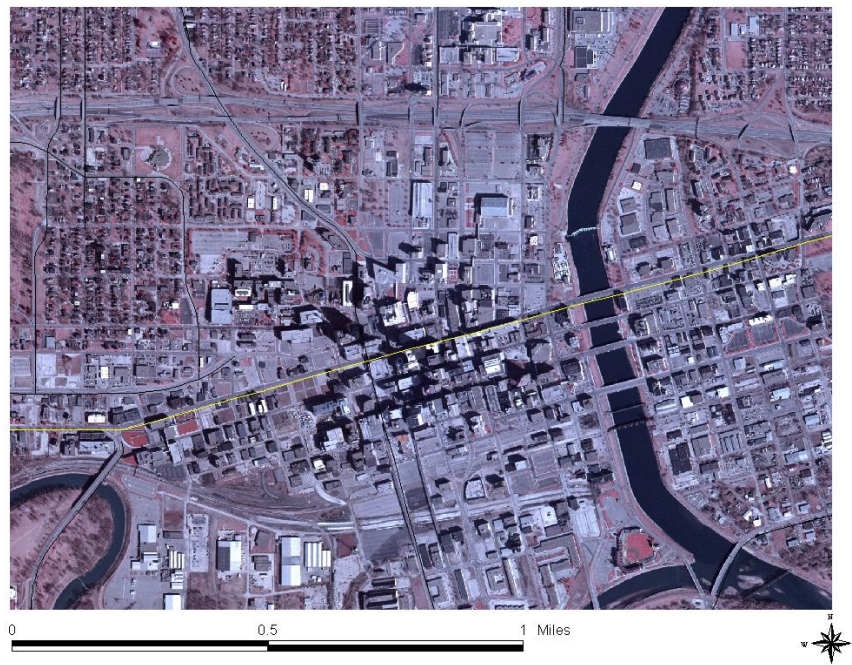


Figure A-3. Grand Avenue, downtown area



Figure A-4. Southwest 9th Street, traffic signals and rear-end collisions

**Rear-end collisions shown in green, traffic signals in blue*



Figure A-5. Grand Avenue, right-turn collisions

**Right-turn collisions shown in red, left-turn in red, rear-end in green*

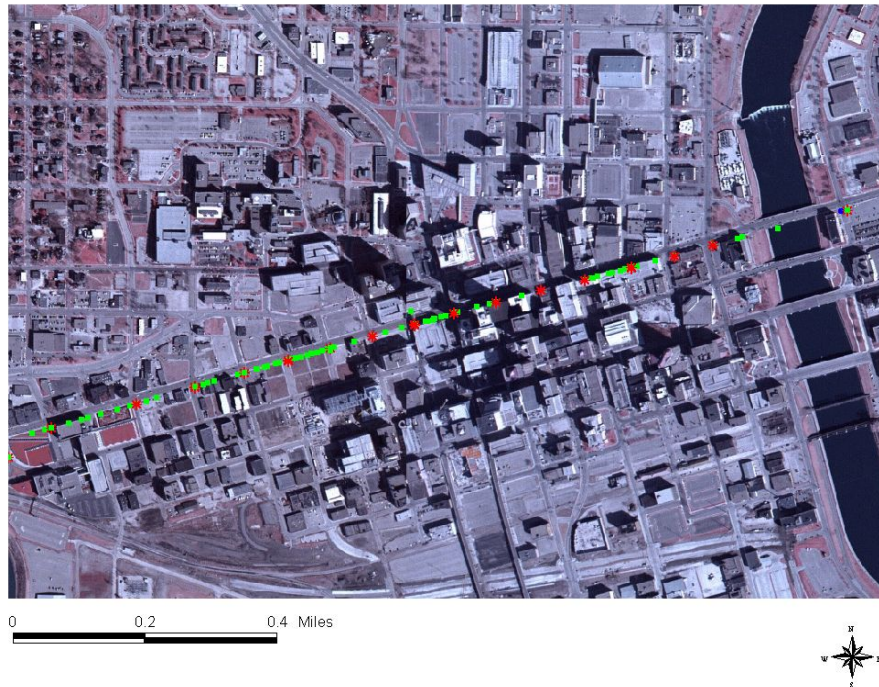


Figure A-6. Grand Avenue, right-turn collisions through downtown

**Right-turn collisions shown in red, rear-end in green*



Figure A-7. Southwest 9th Street, left-turn collisions

**Left-turn collisions shown in blue, rear-end in green*



Figure A-8. Hubbell Avenue, left-turn collisions

**Left-turn collisions shown in blue, rear-end in green*

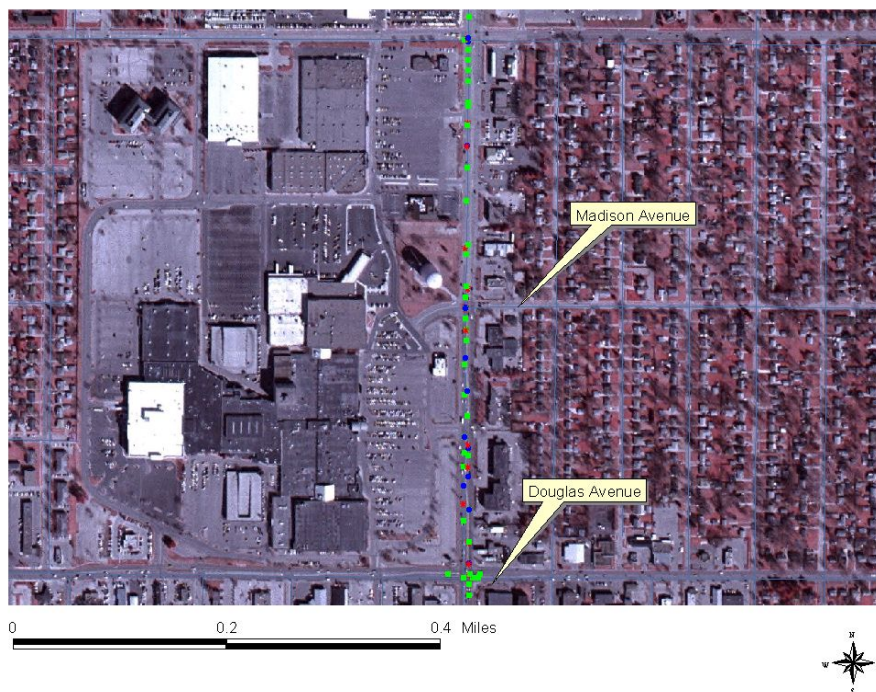


Figure A-9. Merle Hay Road, left-turn collisions

**Left-turn collisions shown in blue, rear-end in green*



Figure A-10. Southeast 14th Street, left-turn collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*



Figure A-11. Southeast 14th Street, left-turn collisions

**Left-turn collisions shown in blue, rear-end in green*

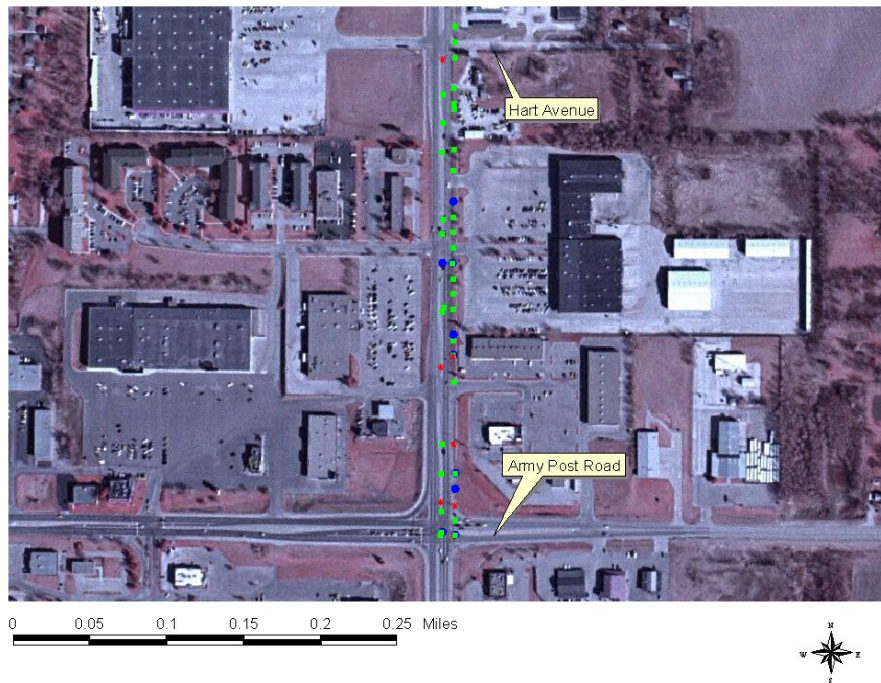


Figure A-12. Southeast 14th Street, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green*



Figure A-13. East Euclid Avenue, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green*



Figure A-14. University Avenue, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green*

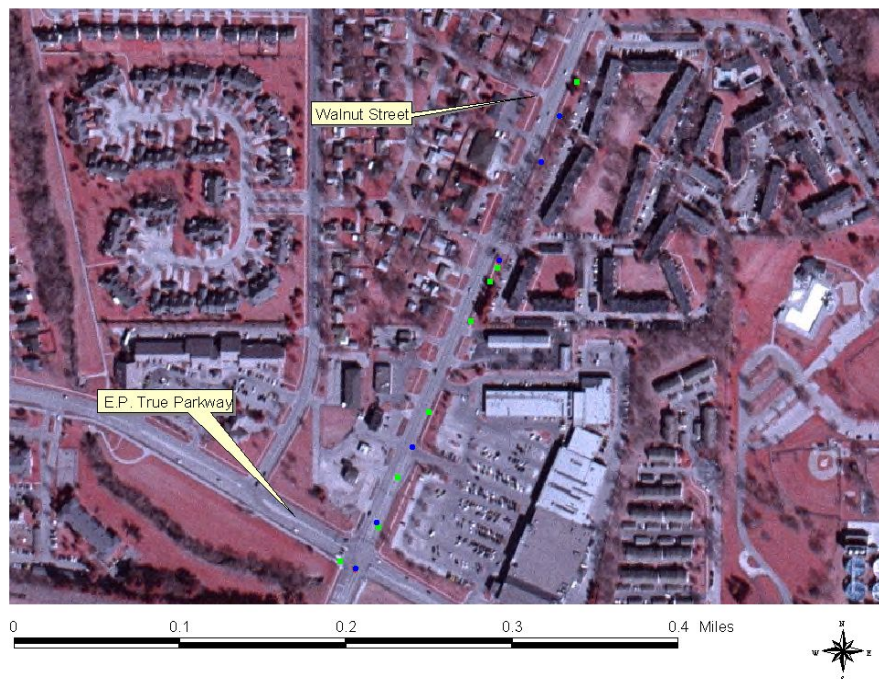


Figure A-15. Grand Avenue, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green*



Figure A-16. Grand Avenue, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*



Figure A-17. Grand Avenue, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*



Figure A-18. East 14th Street, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*



Figure A-19. East 14th Street, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*

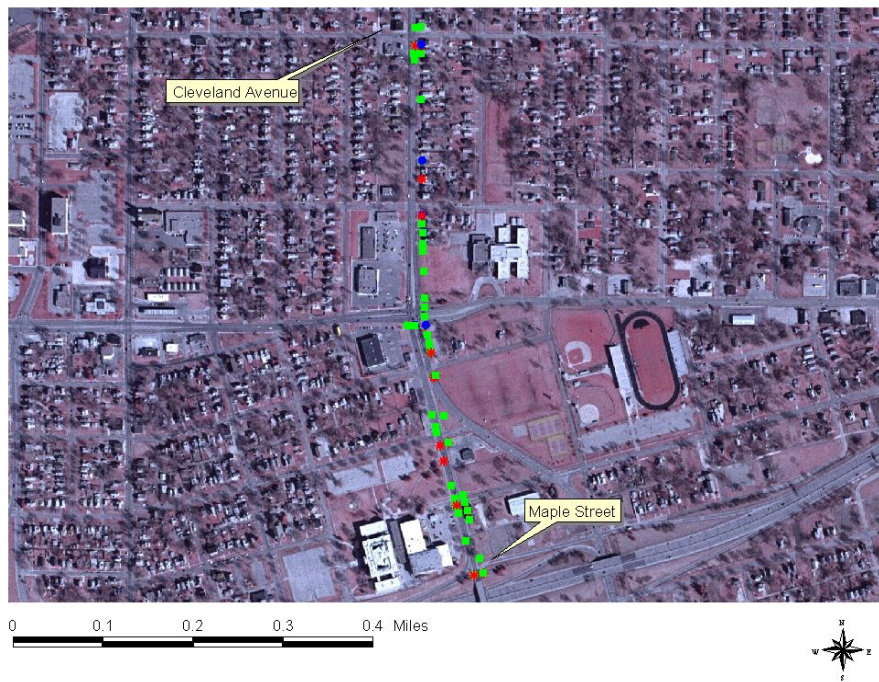


Figure A-20. East 14th Street, probable access-related collisions

**Left-turn collisions shown in blue, rear-end in green, right-turn in red*

REFERENCES

1. National Cooperative Highway Research Program. NCHRP Report 348: Access Management Guidelines for Activity Centers.
2. Maze, Tom and David Plazak, Access Management Research and Awareness Program, Phase IV Final Report, Center for Transportation Research and Education, Iowa State University, Ames, Iowa, CTRE Management Project 97-1, November 1999.