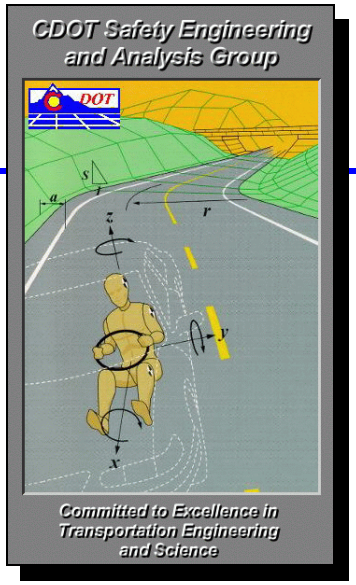
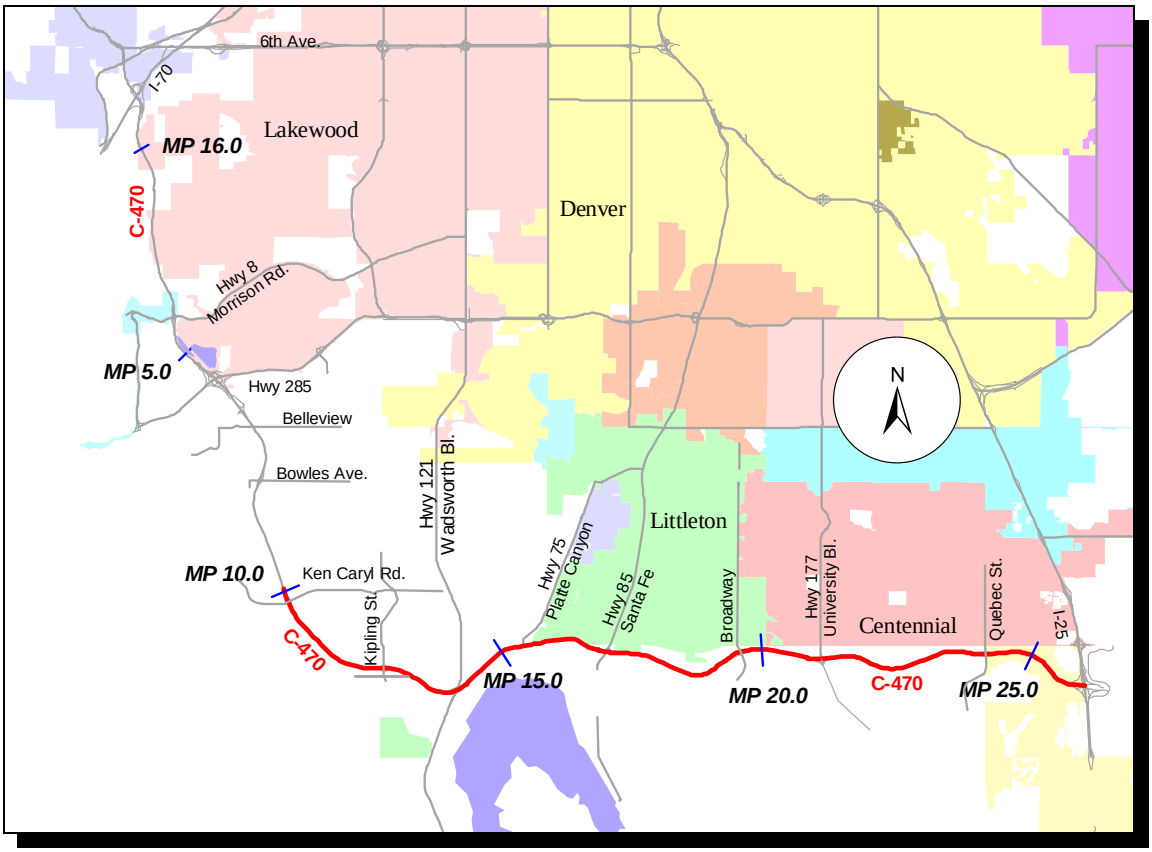


Traffic Safety Chapter

FOR THE C-470 CORRIDOR
ENVIRONMENTAL ASSESSMENT
Project No. NH 4701-103
Region 6
February 2005



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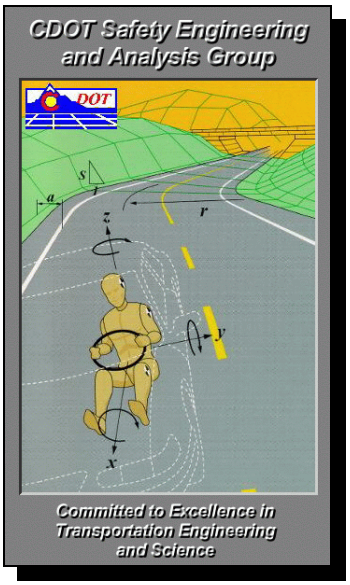

A Statement of Philosophy

The efficient and responsible investment of resources in addressing safety problems is a difficult task. Since crashes occur on all highways in use, it is inappropriate to say of any highway that it is safe. However, it is correct to say that highways can be built to be safer or less safe. Road safety is a matter of degree. When making decisions affecting road safety it is critical to understand that expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more accidents could have been prevented[1]. It is CDOT's objective to maximize accident reduction within the limitations of available budgets by making road safety improvements at locations where it does the most good or prevents the most accidents.

Part I: Evaluation of Existing safety Problems

Introduction

The Transportation Equity Act for the 21st Century (TEA-21) of 1998 requires explicit consideration of safety in the transportation planning process. While this government mandate is well intentioned, little is known about how to accomplish it. The National Environmental Policy Act of 1969 (NEPA)[2] suggests a relevant model from the standpoint of applying principles to practice in the transportation planning process. The adoption of NEPA translated into a well established methodology and institutionalized processes aimed at protecting the environment. In the process of developing Environmental Impact Statements (EIS) or Environmental Assessments (EA) for transportation projects, we construct models of existing and future air quality, delineate wetlands, survey habitats of threatened and endangered species, measure noise levels, test water quality and develop specific mitigation strategies. For each of the transportation alternatives under consideration we describe and mitigate environmental impacts explicitly. We adopted a similar approach for the evaluation of the design alternatives from a safety stand point. In order to meet this requirement we employed a recently developed concept of the Level of Service of Safety[3] (LOSS). The LOSS concept makes it possible to accomplish the following:

- Qualitatively describe the degree of safety or un-safety of a roadway segment.
- Effectively communicate the magnitude of the safety problem to other professionals or elected officials.

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[1] Hauer, E. (1999) *Safety Review of Highway 407: Confronting Two Myths*. TRB

[2] 42 United States Code. Paragraphs 4321-4370c.

[3] Kononov, J. & Allery, B. (2003) *Level of Service of Safety-Conceptual Blueprint and Analytical Framework*. In Transportation Research Record: Journal of The Transportation Research Board, No. 1840, TRB, National Research Council, Washington, D.C., 2003, pp. 57-66

- Bring the perception of roadway safety in line with the reality of safety performance reflecting a specific facility.

- Provide a frame of reference from a safety perspective for planning major corridor improvements.

The study area includes: An eastern portion of State Highway (SH) 470A (C-470) from the Ken Caryl Road interchange at approximately milepost (MP) 10 to the I-25 interchange at milepost 26.21. The scope of this study is as follows:

- Assess the magnitude and nature of the safety problem within the study limits.

- Relate accident causality to roadway geometrics, roadside features, traffic control devices, traffic operations, driver behavior and vehicle type.

- Suggest cost effective counter measures to address identified problems.

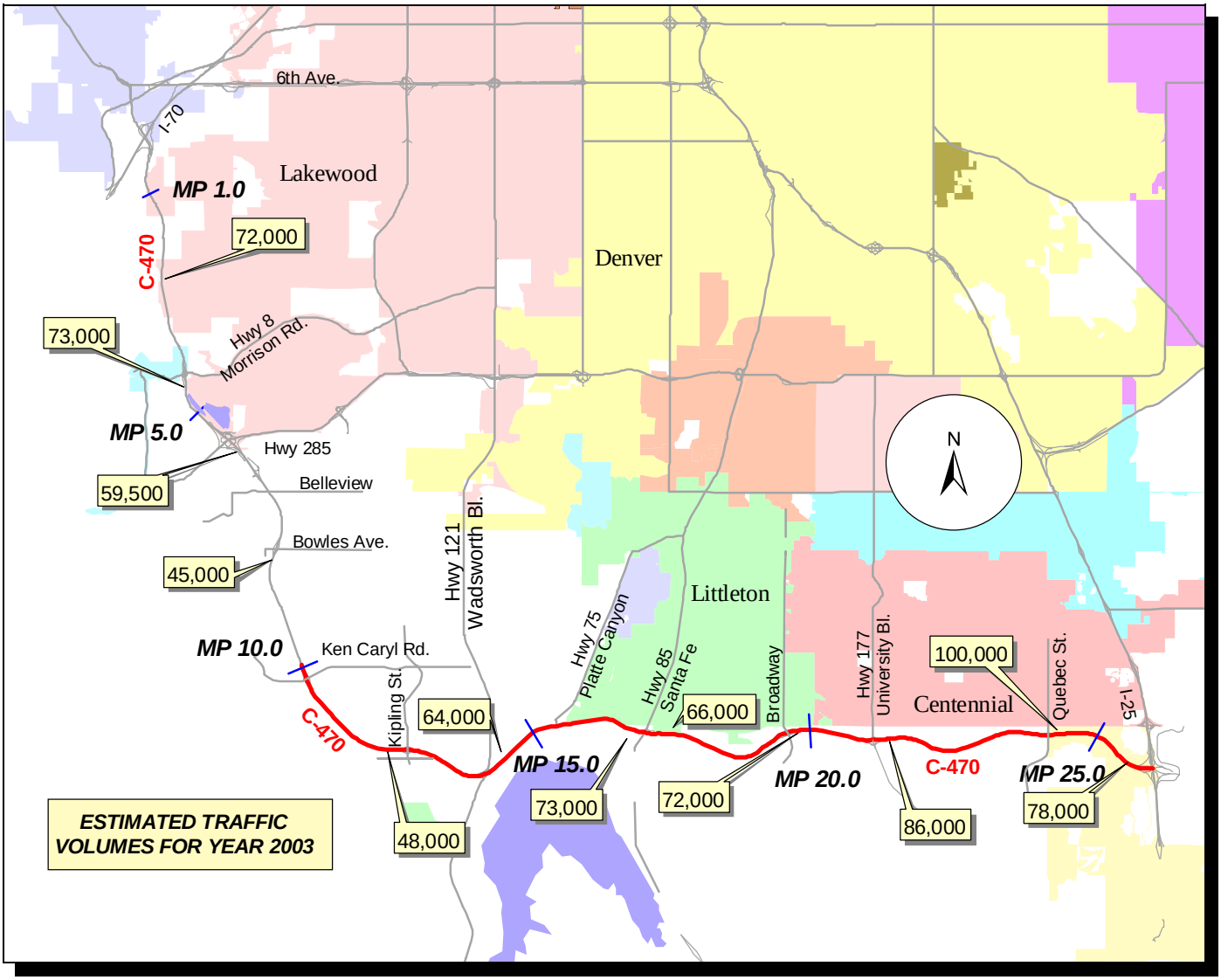
- Provide guidance on how to identify the preferred alternative from a safety standpoint.

The safety chapter of the EA will prepare a framework for the evaluation of alternatives from a safety standpoint.

Site Location and Conditions

This study examines over 16 miles of C-470 from the Ken Caryl Rd. interchange area on the southwest side of the Denver metro region eastward to the end of C-470 at the I-25 interchange. C-470 is classified as a Federal-Aid Primary (FAP), urban expressway in this area. The study corridor traverses a suburban environment in rolling terrain typical of western Denver. The year 2003 average daily traffic estimates for several locations along the overall length of the highway are indicated in Figure 1 below.

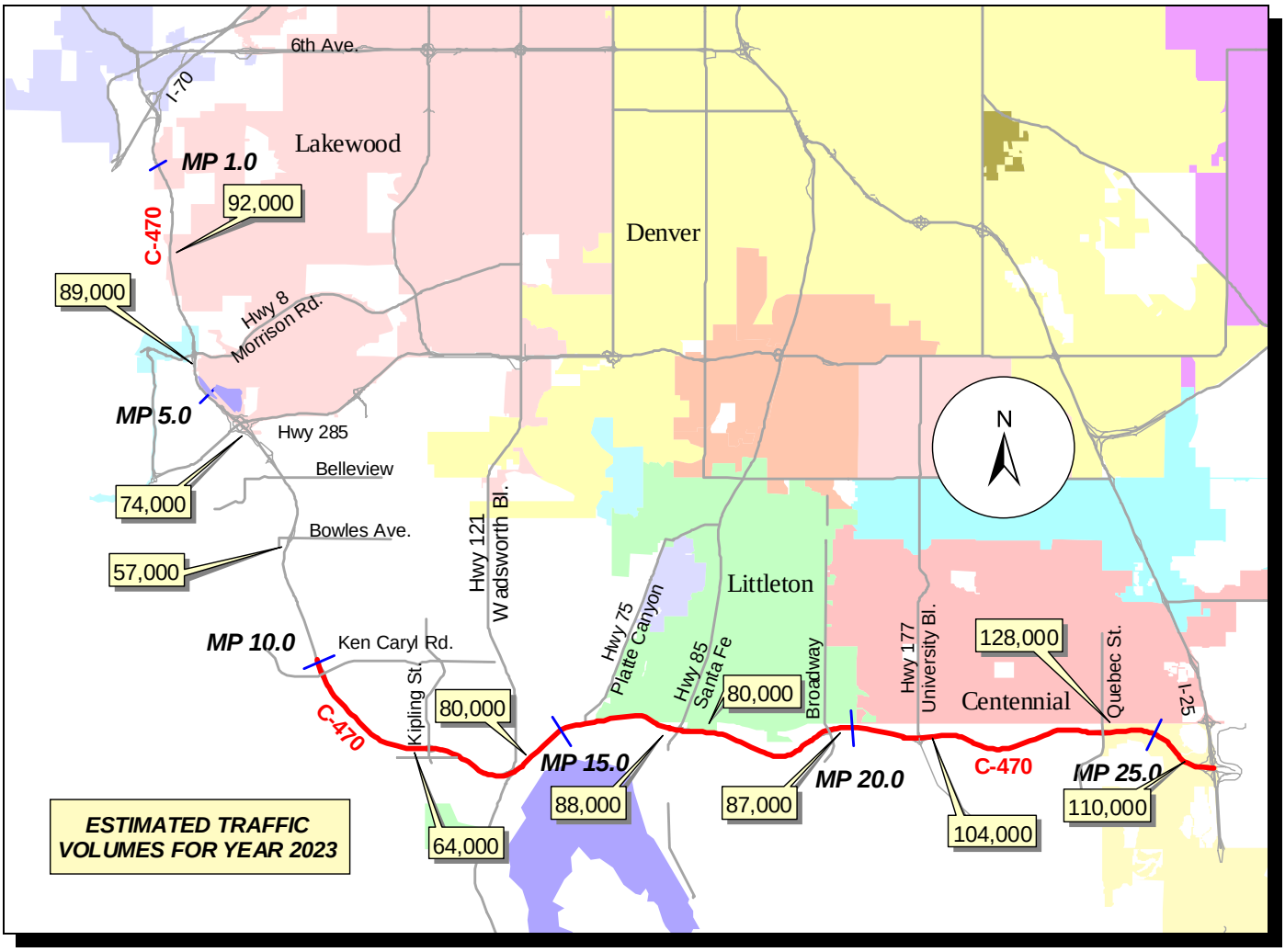
Figure 1: C-470 Location Map and Mainline Volume (Estimated 2003 ADT)



The estimated 2003 traffic volume varies by over 40% along the study length with the lowest volume occurring between Bowles Ave. and Kipling St. The highest volume is noted on the east end between Broadway and the I-25 interchange (MP 19-26). Figure 2, below, presents the estimated future ADT for the year 2023 at the same locations as shown above.

Truck traffic makes up an overall average of 6% of the traffic stream. The posted speed limit is 65 mph through the study section.

Figure 2: C-470 Location Map and Mainline Volume (Estimated 2023 ADT)

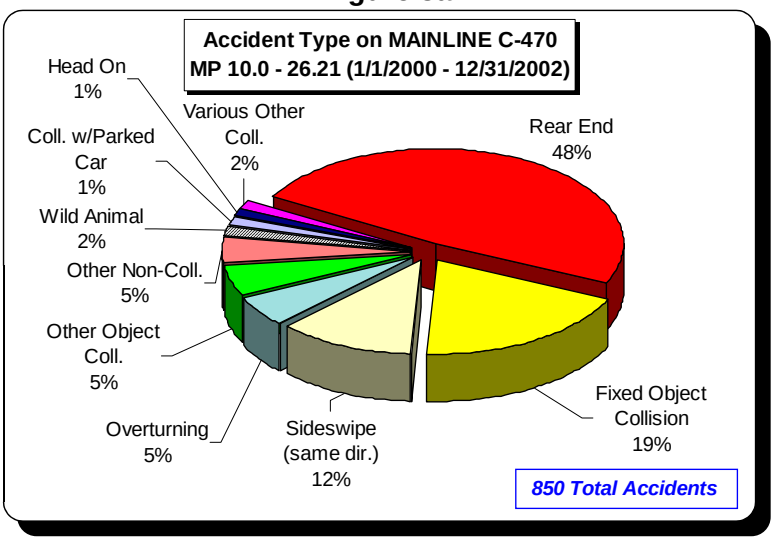


The twenty year projections for traffic growth suggest an increase in volume of 20% - 30% may be expected along the study segment. Currently, highway users experience congested conditions, unnecessary delay and increased crash potential in several locations during peak morning and afternoon volume periods. Drivers at interchange merge-diverge zones contending with the increased vehicle density and reduced maneuvering room of peak hours initiate disruptions in the traffic stream that inevitably cause breakdown in the overall traffic flow and rapid backups. Without additional capacity, these conditions can only be expected to worsen with increased future freeway usage.

Accident History and Problem Analysis

The accident history for the period of January 1, 2000 through December 31, 2002 was examined to identify the accident type distribution profile. Approximately 1,565 accidents occurred within the study corridor during the 3 year study period. This includes those accidents reported on the crossing streets and ramps within interchanges.

Figure 3a



On an accident severity basis, this 3 year total includes:

Property Damage Only (PDO) crashes:
1,140 or 73% of the total

Injury (INJ) crashes:
417 or 27% of the total

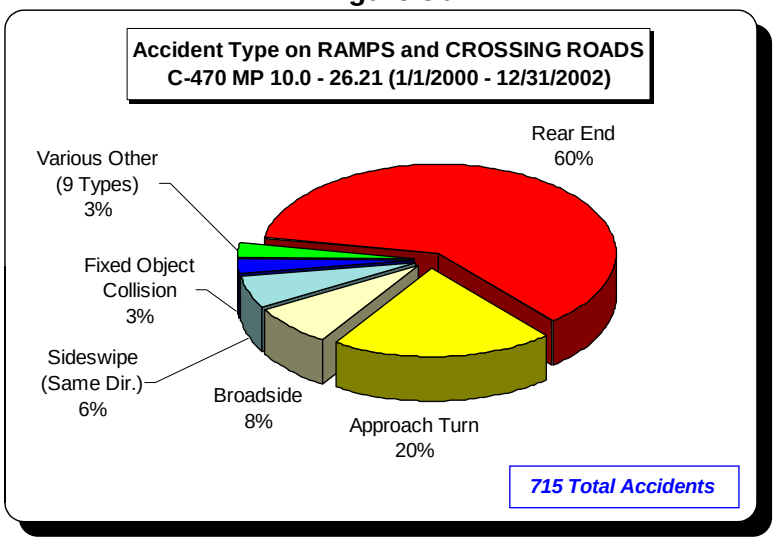
Fatal (FAT) crashes:
8 or 0.5% of the total

Of the eight fatal accidents, most (7) involved eastbound at-fault vehicles and three crashes involved alcohol. Three of these fatal accidents, occurring between MP 14.97 and 15.1, involved eastbound vehicles crossing the median in the vicinity of a highway curve. Two fatal collisions occurred between MP's 23 & 24. The Region is installing a cable rail median barrier within this general area.

Figures 3 show accident types and proportions detected over the 3 year study period. Figure 3a presents the distribution profile by accident type for the mainline segment of C-470 while figure 3b details the type of accidents occurring on interchange cross streets and ramps.

Rear end collisions are the predominant accident types on both the mainline and interchange locations of the C-470 corridor. Collisions of this type typically imply the existence of congested traffic circumstances resulting from capacity limitations on the existing highway. The higher fraction of approach turn and broadside type accidents shown in Figure 3b also reflects intersection-related conflicts associated with the ramp intersections at interchanges.

Figure 3b



Observed safety issues related to freeway ***segments*** (not those occurring at interchange ramps or crossing roadways) will be examined in the following section of this study. Similarly, an examination of safety problems associated with the included interchanges will follow separately.

FREEWAY SEGMENTS

Safety Performance Function Analysis

We have refined the assessment of the magnitude of safety problems on freeway segments through the use of Safety Performance Functions (SPF). The SPF reflects the complex relationship between traffic exposure, measured in ADT, and accident count for a unit of road section measured in accidents per mile, per year. The SPF models provide an estimate of the normal or expected accident frequency and severity for a range of ADT among similar facilities. Two kinds of Safety Performance Functions were calibrated. The first one addresses the total number of accidents and the second one looks only at severe accidents or those involving an injury or fatality. SPFs allow us to assess the magnitude of the safety problem from a frequency and severity standpoint.

All of the dataset preparation was performed using the Colorado Department of Transportation (CDOT) accident databases. Accident history for various facilities was prepared over a period of 13 years. Average Daily Traffic (ADT) for each roadway segment for each of the 13 years was entered into the same dataset. Figure 4 illustrates how the dataset was prepared for urban freeway facilities.

Figure 4

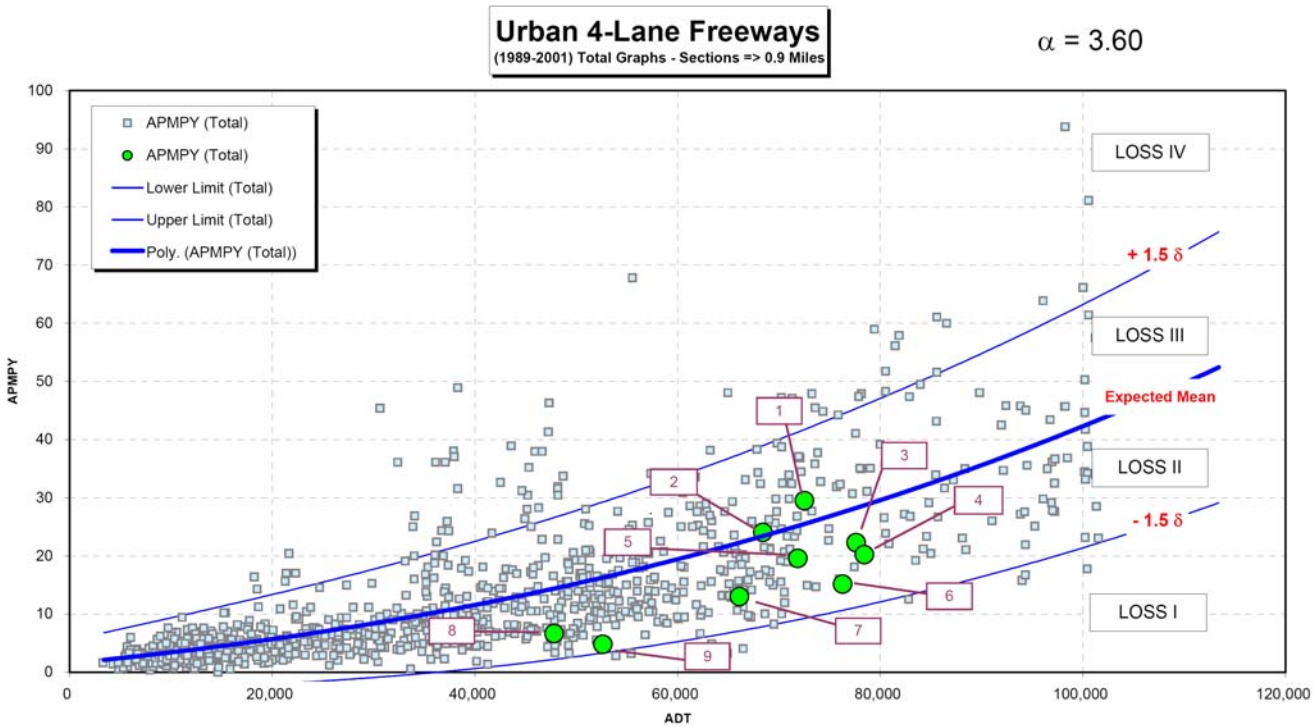
Development of the SPF lends itself well to the conceptual formulation of *Level of Service of Safety* (LOSS). The level of service concept uses qualitative measures that characterize the safety of a roadway segment referenced to expected performance and severity. If the level of safety predicted by the SPF will represent a normal or expected number of accidents at a specific level of ADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety.

LOSS-I - Indicates low potential for accident reduction
LOSS-II- Indicates better than expected safety performance
LOSS-III - Indicates less than expected safety performance
LOSS-IV - Indicates high potential for accident reduction

Gradual change in the degree of deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in accidents/mile as ADT increases. This increase is consistent with a negative binomial error structure and reflects over-dispersion typical of this highway environment. Possible explanation for the over-dispersion in the urban freeway dataset may be the influence of different ramp volumes on the freeway safety performance. LOSS reflects how the roadway segment is performing in regard to its expected accident frequency and severity at a specific level of ADT. It only provides an accident frequency and severity comparison with the expected norm. It does not, however, provide any information related to the nature of the safety problem itself. If a safety problem is present, LOSS will only describe it's magnitude from a frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostic and pattern recognition techniques.

Figure 5 depicts the SPF calibrated specifically for all or *total accident* occurrence on urban 4-lane freeways. Data for three years of accident history (averaged together) on C-470 has been partitioned into nine separate segments, each including one interchange, and plotted for evaluation. The total accident SPF and inj+fat accident SPF analyses (shown in Figure 6) describe the magnitude of safety problems from a frequency and severity standpoint.

Figure 5: SPF for Total Accidents



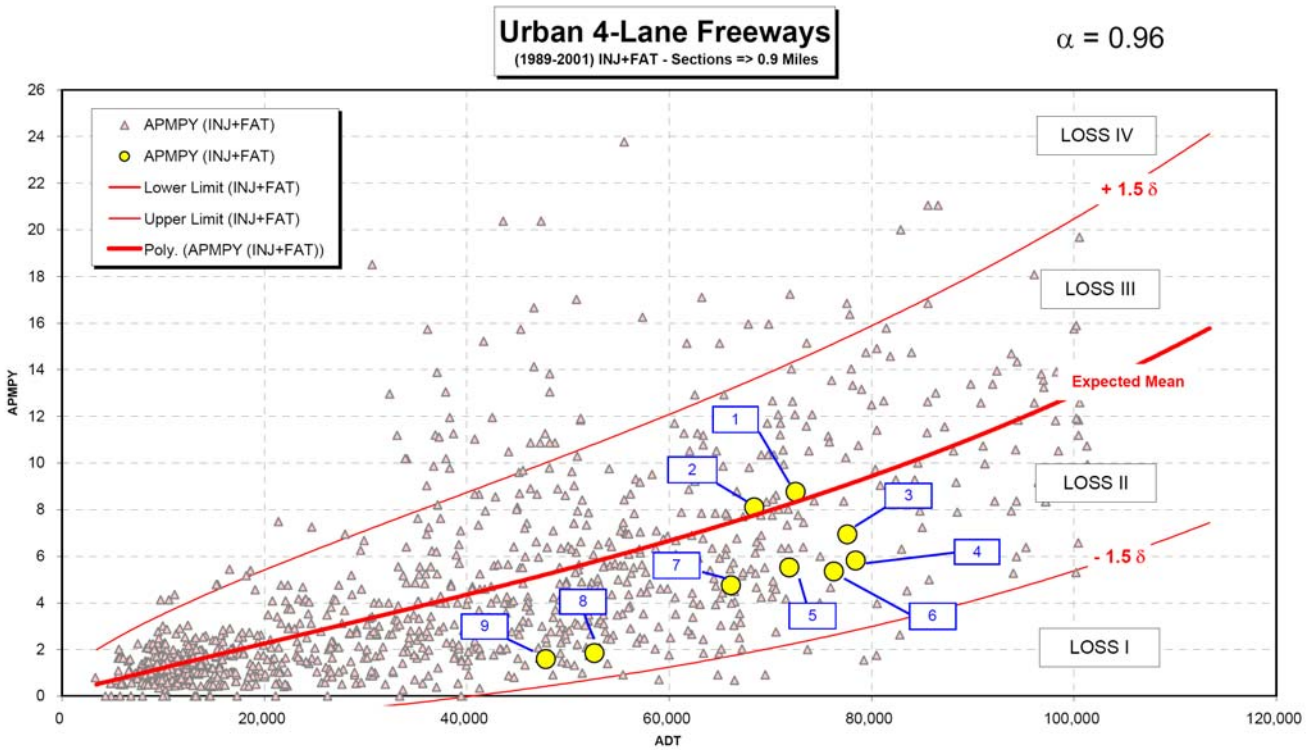
Legend

#	Location
1	MP 16.13 - 17.69, Includes Santa Fe Interchange Area.
2	MP 17.70 - 19.09, Includes Lucent Blvd. Interchange Area.
3	MP 22.63 - 24.88, Includes Quebec St. Interchange Area.
4	MP 24.89 - 26.21, Includes I-25 Interchange Area.
5	MP 19.10 - 20.30, Includes Broadway. Interchange Area.
6	MP 20.31 - 22.62, Includes University Blvd. Interchange Area.
7	MP 13.17 - 16.12, Includes Wadsworth & Platte Canyon (SH's 121 & 75) Interchange Areas
8	MP 9.03 - 11.34, Includes Ken Caryl Rd. Interchange Area.
9	MP 11.35 - 13.16, Includes Kipling Pkwy. Interchange Area.

From figure 5, it can be observed that most sections of mainline C-470 operate in the LOSS II zone (better than expected safety performance when compared with similar facilities). This is not unexpected as this highway is of comparatively recent construction and was designed to an interstate standard. Closer review indicates short segments near the Santa Fe Dr. interchange (SPF test location 1 above) and Lucent Blvd. interchange (SPF test location 2) exhibit recent total accident frequency levels in the LOSS III envelope which is slightly worse than expected for this type of highway. Figures 7, below, show the accident type breakdown for several of the SPF locations plotted in the above graph. In general, the observed SPF recorded on C-470 parallels the statewide model at the present user level with the few noted exceptions.

Figure 6 depicts the SPF graph calibrated for *injury and fatal accidents only* on urban, 4-lane freeways. Similar to the result for *total accident* frequency, we note that the majority of the corridor operates at a LOSS II level with slightly higher crash occurrence near the Santa Fe and Lucent Blvd. interchanges (locations flagged 1 & 2 below).

Figure 6: SPF for Injury and Fatal accidents



Legend

#	Location
1	MP 16.13 - 17.69, Includes Santa Fe Interchange Area.
2	MP 17.70 - 19.09, Includes Lucent Blvd. Interchange Area.
3	MP 22.63 - 24.88, Includes Quebec St. Interchange Area.
4	MP 24.89 - 26.21, Includes I-25 Interchange Area.
5	MP 19.10 - 20.30, Includes Broadway. Interchange Area.
6	MP 20.31 - 22.62, Includes University Blvd. Interchange Area.
7	MP 13.17 - 16.12, Includes Wadsworth & Platte Canyon (SH's 121 & 75) Interchange Areas
8	MP 11.35 - 13.16, Includes Kipling Pkwy. Interchange Area.
9	MP 9.03 - 11.34, Includes Ken Caryl Rd. Interchange Area.

The following charts present the types of accidents making up the SPF points at locations 1 - 5 in the SPF graphs above (5 highest accident frequency locations). The charts depict only the accidents occurring on the mainline (non-ramp, non-cross rd. accidents) of C-470 to correspond to the SPF study.

Figure 7a

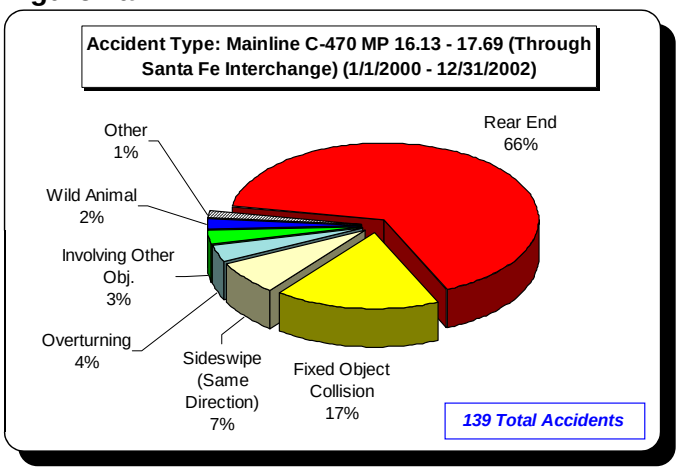


Figure 7b

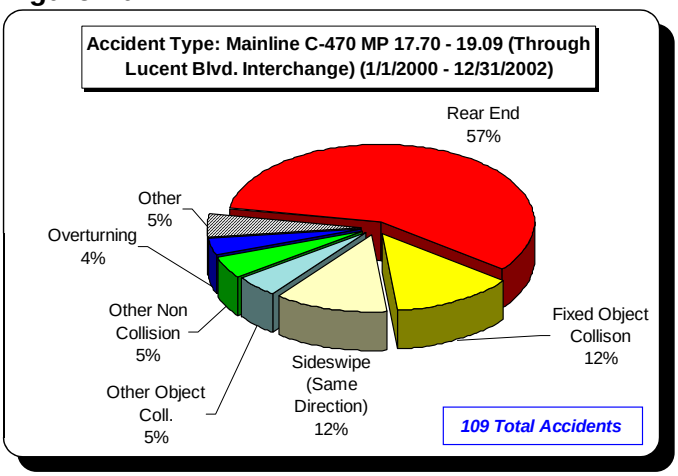


Figure 7c

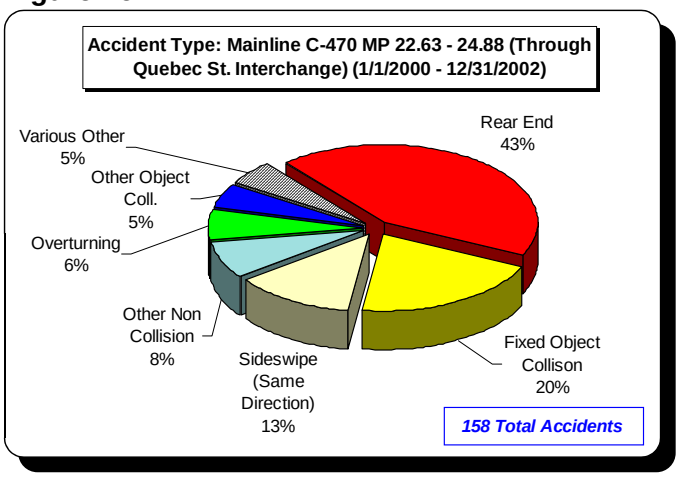


Figure 7d

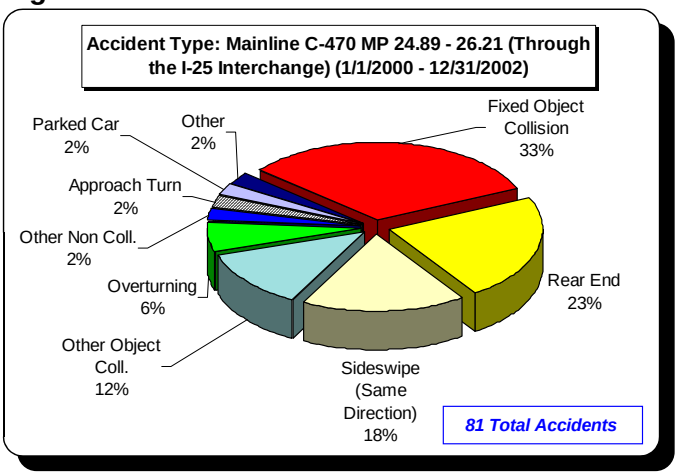


Figure 7e

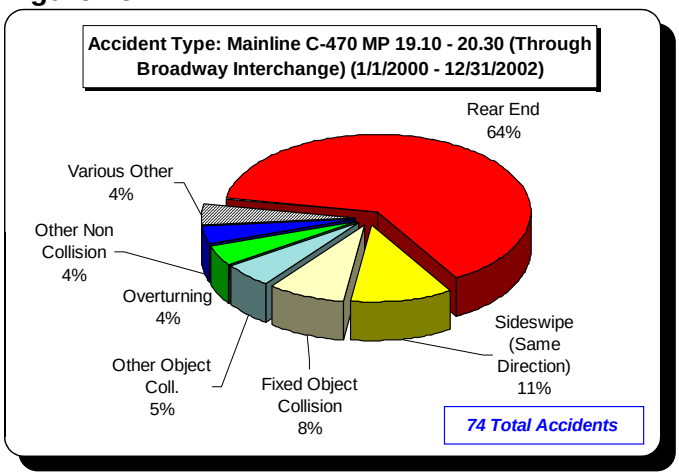


Figure 7a shows that rear-end collisions are the most common type of accident occurring on C-470 around the Santa Fe interchange area, accounting for over 60% of the total. Fixed object collisions (guardrail, median barrier, etc.) make up an additional 17% of the mainline crashes in this section. The rear-end collisions are commonly occurring during the morning and afternoon peak volume periods indicating that traffic congestion is a significant contributing factor.

The crash breakdown for the 1.4 mile segment of mainline 470 encompassing the Lucent Blvd. interchange is depicted in Figure 7b. Similar to the above segment surrounding the Santa Fe interchange, congestion-related rear-end collisions and crashes with various fixed objects account for nearly 70% of the overall total.

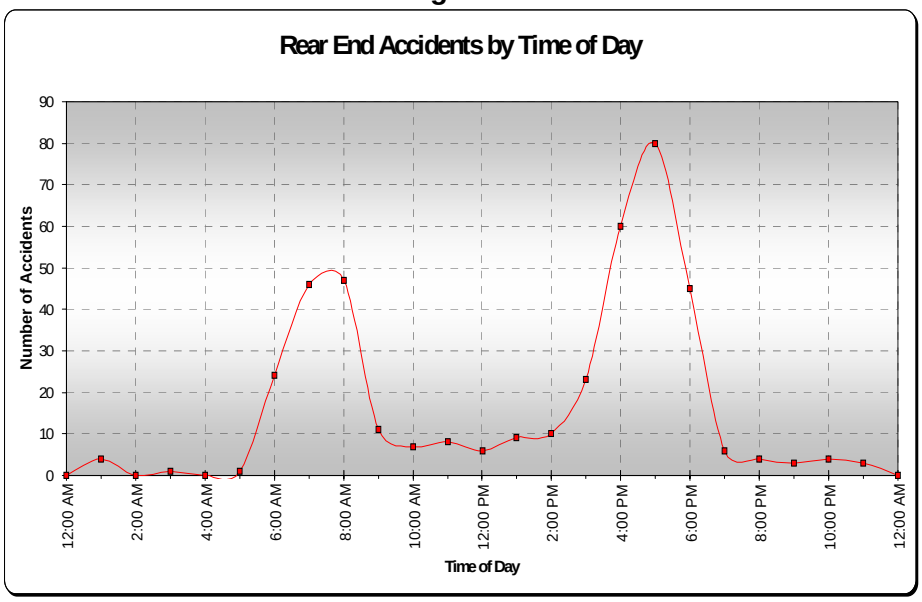
Figure 7c shows the crash breakdown for the segment surrounding Quebec St. In this segment, rear-end crashes prevail with an afternoon bias between 3 and 6:30 pm, again suggesting peak-hour congestion as a major contributing factor. A planned median cable rail project is slated for this segment by the Region. With evidence of median incursion and cross-over type loss of control incidents, this type of improvement is well justified.

In addition to the peak hour volume constraints, the accidents reported in the I-25 interchange zone, shown in Figure 7d also reflect intensified merging and weaving maneuvers associated with the I-25 and Yosemite ramps. In this segment, many collisions with fixed objects such as guardrail, median barrier and delineator posts are associated with loss of control during lane changes or other maneuvering during congested conditions.

Mainline C-470 accident history around the Broadway interchange continues to exhibit a congestion-related pattern with rear-end & same direction sideswipe crashes accounting for nearly 75% of the overall total. Again, most of these accidents are the direct result of one or more of the involved vehicles either unexpectedly slowing or actually stopping, due to congestion, on a high-speed freeway.

Across these 5 segments, rear end collisions account for an average of over 50% of the total accidents on C-470. Figure 8 shows how the incidence of rear end collisions varies with time of day, indicating that the frequency of these crashes escalates significantly during congested peak volume period traffic flows. In fact, 75% of the total rear end crashes occur between 6 am and 9 am and between 4 pm and 7 pm.

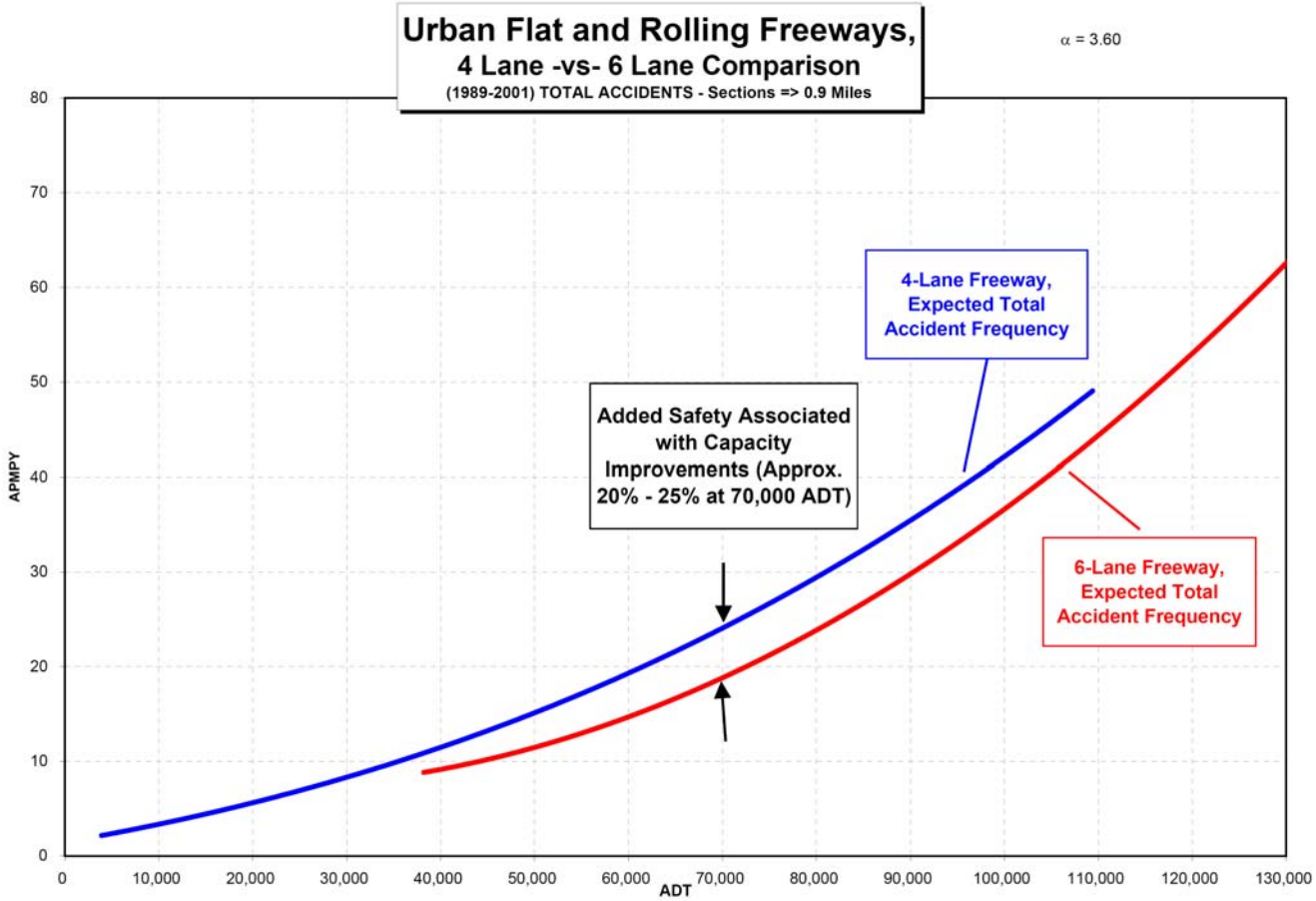
Figure 8



Safety Benefit Through Capacity Improvement

Capacity improvement, in the form of additional traffic lanes, through this segment of C-470 is an alternative that would result in significant operational improvements. Generally, freeway facilities of 6 or more lanes are expected to have fewer accidents than 4 lane facilities carrying the same amount of traffic. This can possibly be explained by increased gap availability for weaving, merging and diverging. Increased capacity, therefore, also yields a safety dividend. Figure 9 depicts the safety dividend expected to accompany freeway capacity improvement. In this case, widening a facility from 4 lanes to 6 lanes.

Figure 9

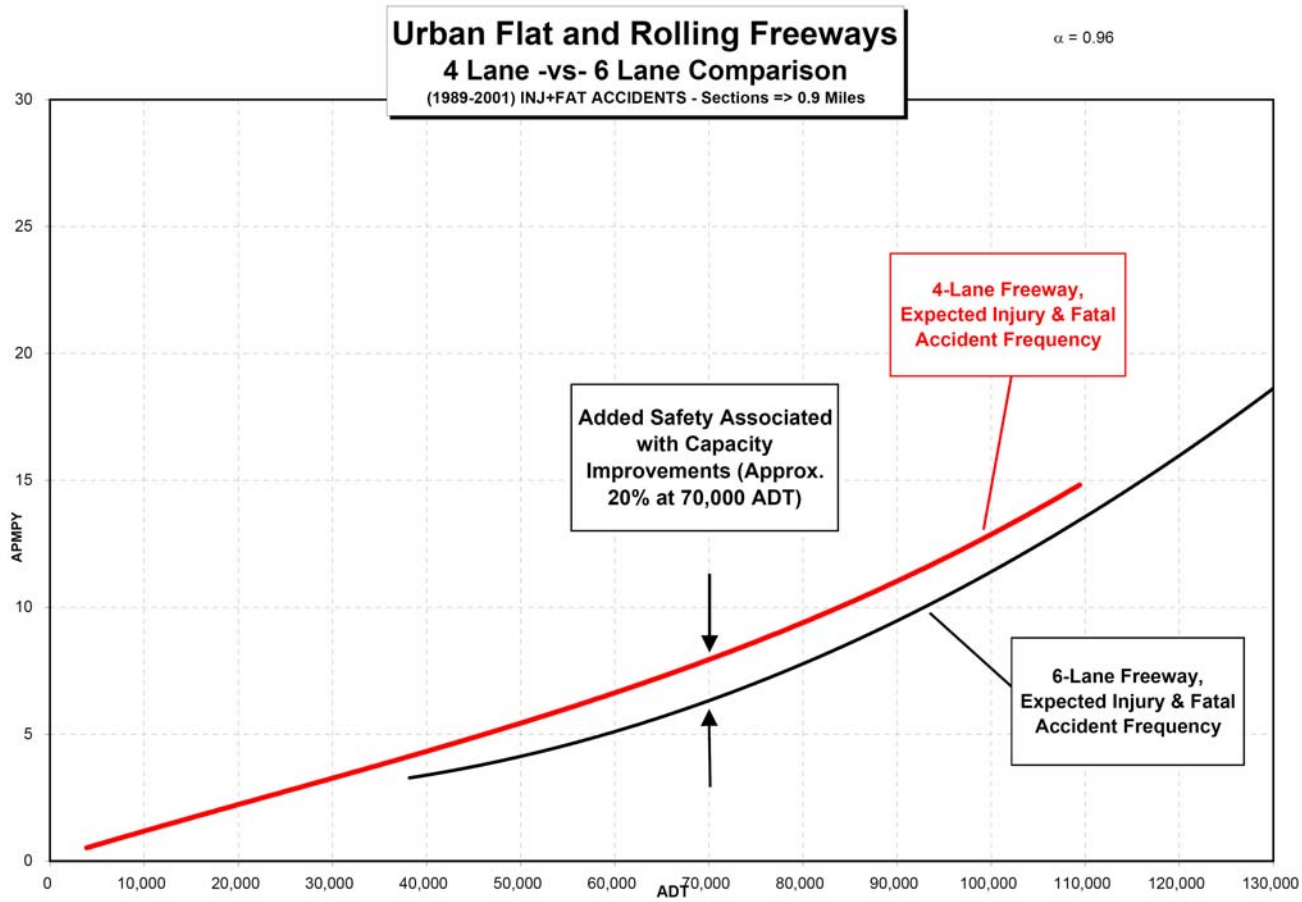


As shown above, in the urban freeway environment, widening from 4 to 6 lanes is expected to yield an overall reduction in collisions of up to 25% at an ADT of 70,000 vehicles per day. Considering a present mainline average crash frequency of 270 accidents per year, additional capacity could also mean a safety benefit of up to 68 prevented accidents per year. Again, this is in addition to the operational benefits attached to capacity improvements.

Figure 10 further indicates the safety dividend in severe accidents associated with widening. At an average ADT of 70,000, studies indicate that up to 20% of severe injury and fatal accidents

occurring on the present 4-lane configuration may be prevented. This segment of C-470 recorded 263 combined injury and fatal collisions during the 3-year study period. Widening to 6 lanes could therefore realize a reduction of up to 18 severe crashes annually at the present volume levels. Ultimately, widening to 8 lanes is anticipated in order to capture long term operational benefits. The safety gains accompanying major widening of this type is expected to exceed those attained in this 4-lane to 6-lane discussion.

Figure 10



Accident Pattern Analysis

We have further examined roadway segments for accident concentrations and patterns. The roadway within project limits was tested for the presence of patterns related to accident type, severity, direction of travel, road conditions, spatial distribution of accidents and time of day. Pattern recognition analysis was performed using diagnostic normative percentages for safety problems in an urban, 4 - lane freeway environment. These diagnostic norms are developed using the same data points as those graphed in the SPF analysis. The calculated norms are presented in table 1 (Statewide Avg. percentages for similar hwys.) on the following page along with data on C-470 for the 3-year study period. Several accident types on C-470 exhibiting higher than expected frequency of occurrence have been identified. Evaluation of individual detected patterns for total number of collisions included and common accident characteristics further defines locations with genuine addressable problems.

Table 1
Diagnostic Norms for Urban, 4-Lane Freeways and Observed C-470 (Mainline) Performance

Accident Description	C-470 Observed % of Total Accidents	Statewide Avg. for Similar Hwys.
PDO	67.76%	68.19%
INJ	31.29%	31.24%
FAT	0.94%	0.58%
Single Vehicle Accidents	28.24%	30.19%
Two Vehicle Accidents	56.47%	54.65%
Three + Veh Accidents	15.29%	15.02%
Unknown Number of Veh	0.00%	0.14%
On Road	72.82%	68.76%
Off Road Left	12.35%	14.50%
Off Road Right	12.94%	14.35%
Off Road at Tee	0.00%	0.02%
Off Road in Median	1.76%	0.56%
Unknown Road Location	0.12%	1.81%
Overturning	5.41%	5.76%
Other Non Collision	4.59%	2.46%
School Age Pedestrians	0.00%	0.01%
All Other Pedestrians	0.00%	0.26%
Broadside	0.12%	1.07%
Head On	1.29%	0.69%
Rear End	48.71%	45.53%
Sideswipe, Same Direct.	11.65%	13.15%
Sideswipe, Oppos. Direct	0.47%	0.28%
Approach Turn	0.35%	1.09%
Overtaking Turn	0.24%	0.25%
Parked Motor Car	1.41%	1.59%
Railway Vehicle	0.00%	0.00%
Bicycle	0.00%	0.05%
Motorized Bicycle	0.00%	0.01%
Domestic Animal	0.12%	0.03%
Wild Animal	1.53%	1.79%
Light or Utility Pole	0.47%	1.21%
Traffic Signal Pole	0.00%	0.03%
Sign	1.06%	1.10%
Bridge Rail	0.82%	0.83%
Guard Rail	4.35%	5.43%
Median Barrier	1.76%	7.88%
Bridge Abutment	0.00%	0.22%
Column or Pier	0.00%	0.03%
Culvert or Headwall	0.00%	0.12%
Embankment	1.65%	1.01%
Curb	0.12%	0.42%

Accident Description (continued)	C-470 Observed % of Total Accidents	Statewide Avg. for Similar Hwys.
Delineator Post	4.71%	1.59%
Fence	2.94%	1.13%
Tree	0.24%	0.14%
Large Boulder	0.00%	0.02%
Rocks in Roadway	0.00%	0.02%
Barricade	0.00%	0.31%
Wall or Building	0.24%	0.15%
Crash Cushion	0.00%	0.32%
Mailbox	0.00%	0.02%
Other Fixed Object	0.35%	0.22%
Involving Other Object	5.18%	2.12%
Road Maint. Equip.	0.12%	0.10%
Unknown Acc. Type	0.12%	1.57%
Total Fixed Objects	18.71%	22.17%
Total Other Objects	5.29%	2.24%
Daylight	54.35%	63.67%
Dawn or Dusk	3.29%	4.63%
Dark - Lighted	6.59%	13.36%
Dark - Unlighted	13.41%	12.55%
Unknown Lighting	22.35%	5.78%
No Adverse Weather	67.06%	76.34%
Rain	3.88%	5.25%
Snow, Sleet, Hail	6.47%	11.72%
Fog	0.12%	0.30%
Dust	0.00%	0.01%
Wind	0.12%	0.54%
Unknown Weather	22.35%	5.85%
Dry Road	64.35%	71.48%
Wet Road	6.59%	8.83%
Muddy Road	0.00%	0.08%
Snowy Road	2.00%	3.05%
Icy Road	2.94%	7.88%
Slushy Road	0.94%	1.29%
Foreign Material Road	0.00%	0.12%
With Road Treatment	0.00%	0.09%
Dry, Icy Rd. Trtmnt.	0.24%	0.17%
Wet, Icy Rd. Trtmnt.	0.24%	0.05%
Snowy, Icy Rd Trtmnt	0.12%	0.08%
Icy, Icy Rd Trtmnt	0.12%	0.20%
Slushy, Icy Rd Trtmnt	0.00%	0.06%
Unknown Condition	22.47%	6.60%
Total Accidents:	850	19,886

Figure 11

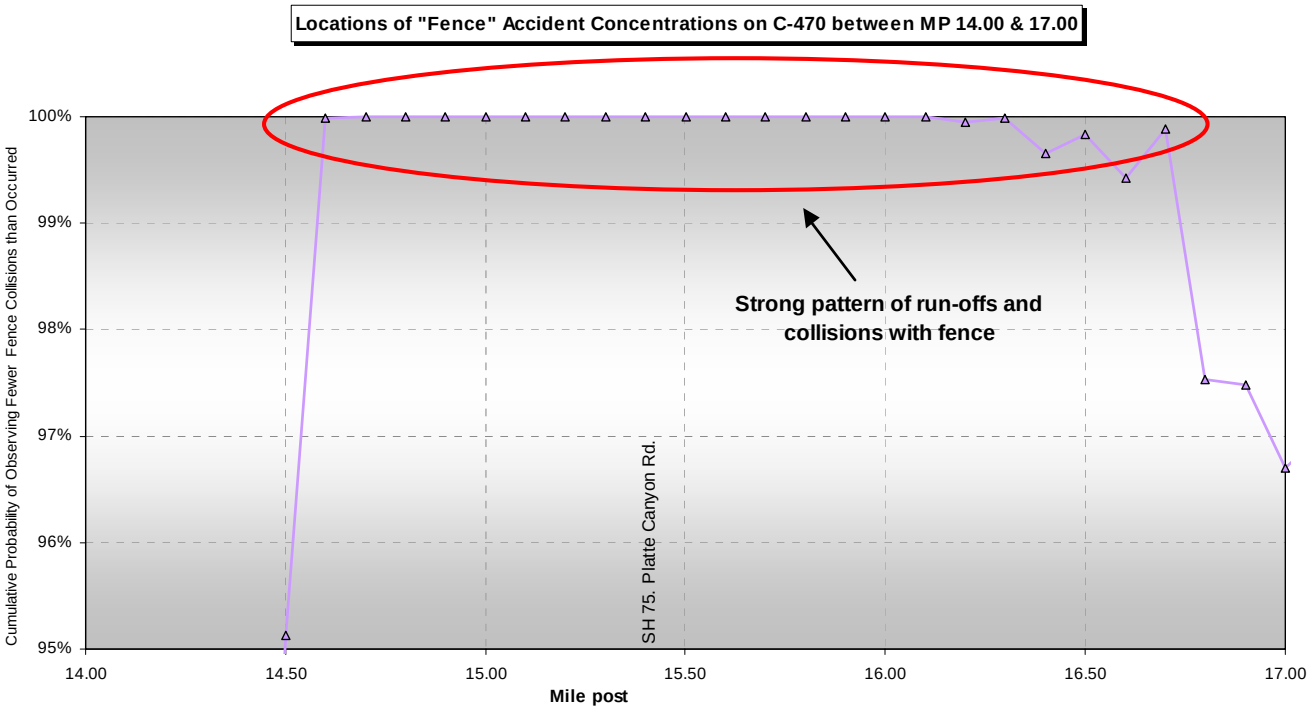


Figure 11 shows locations with high frequencies of collisions with roadside fencing. This well-defined pattern of collisions with off-highway features reflects run-off-road accidents in the vicinity of a curve near MP 15.0. Two of the three fatal accidents in this area involved eastbound vehicles crossing the median. The curve is somewhat isolated by nearly mile-long tangents, a condition sometimes associated with the potential for loss of control at a curve. Consideration may be given to installation of a median barrier such as the cable rail safety fencing, recently installed east of this location, together with outside and median shoulder rumble strips at this curve if not already implemented. The reverse curve between MPs 16 and 17 also records occasional run-off incidents. This curve appears to have a shorter radius than other nearby curves on C-470. Some drivers were not able to negotiate the turns and subsequently lost control resulting in a run off. Crashes at each curve location occurred with good road conditions and lighting. Together with the existing median guardrail, outer and median shoulder rumble strips may further help reduce the occurrence of run-off-road accidents. Geometric and cross sectional changes such as curve flattening or sideslope flattening can also moderate accident frequency and severity here and may be considered during major reconstruction.

Locations with statistically high incidence of rear-end crashes along the C-470 corridor are revealed in the pattern graph of Figure 12. Clearly, crashes of this type can be seen as the major problem on C-470 with extended areas exhibiting rear-end accident patterns. In particular, a strong, continuous pattern of collisions occurs between MP 16.5 and MP 21.5 with lesser concentrations developing near MPs 14.4 and 24.0. Further examination of the wide pattern shows a time of day and directional bias in accident occurrence at various locations. Figure 8 shows the general time variation along the entire study corridor with conspicuous clusters during the morning and afternoon commuting periods. Figures 13 & 14 further break this down directionally, indicating pronounced rear-end accident occurrence during typical morning rush hours (approximately between 5:30 am and 8:30 am) in the eastbound lanes. Similar accident concentration is displayed during the afternoon volume peak (3 pm - 6 pm) in the westbound lanes of this pattern area.

Figure 12

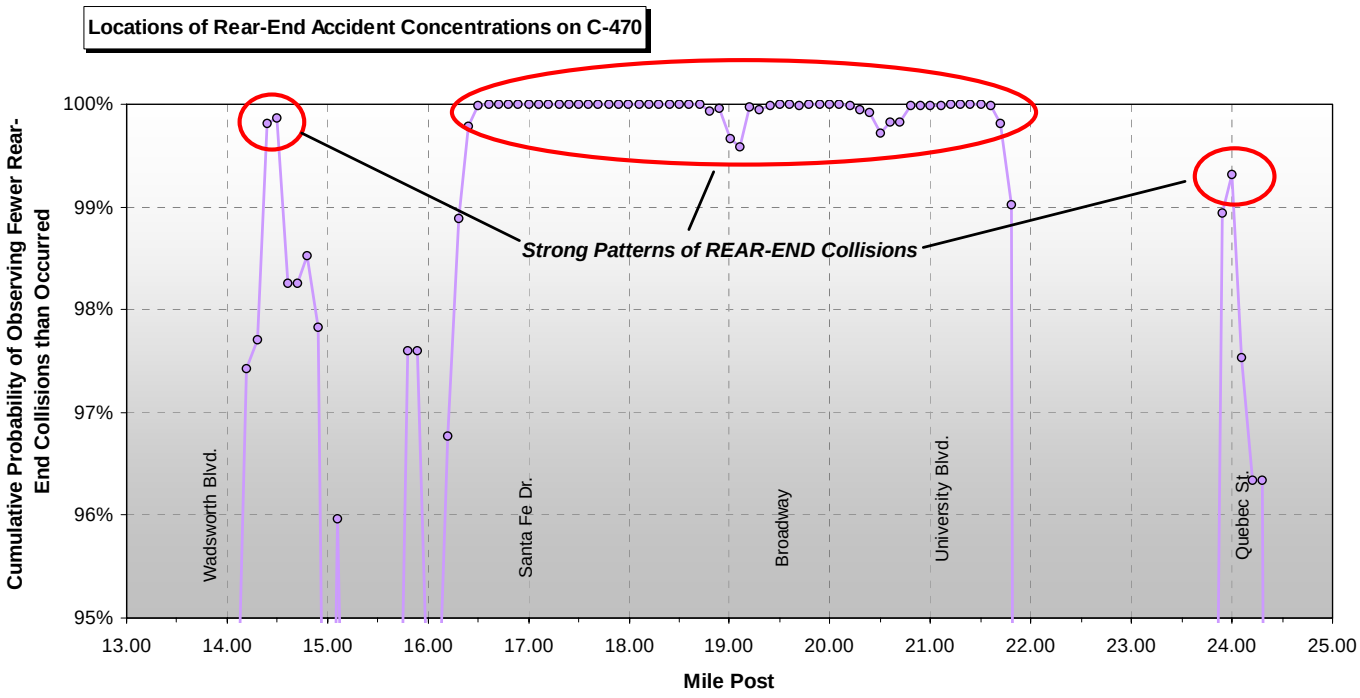


Figure 13

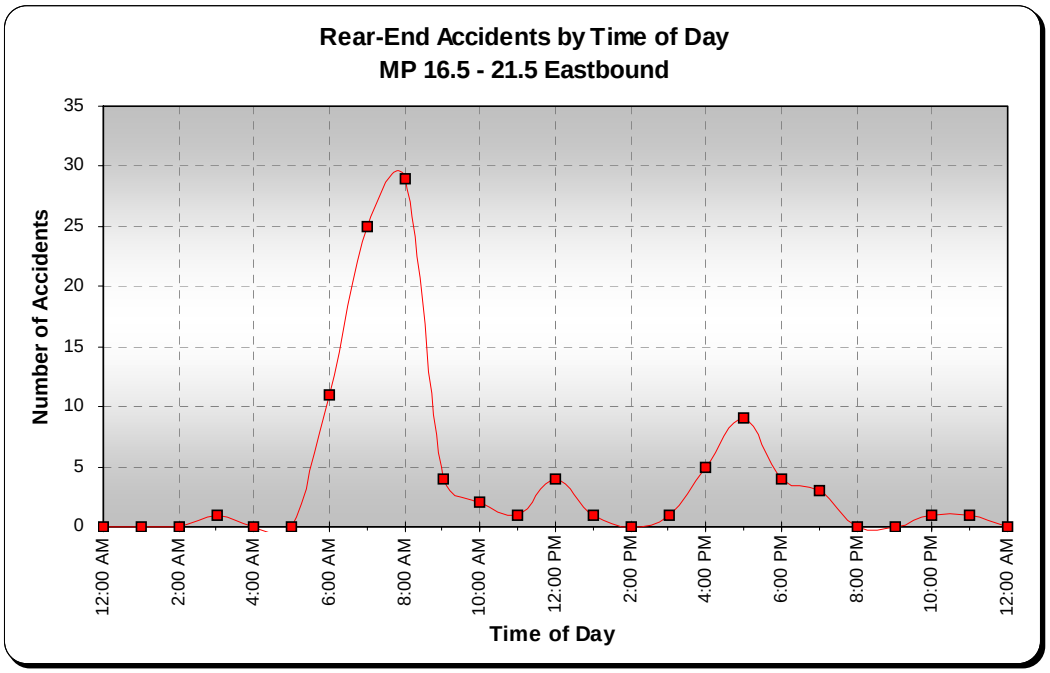
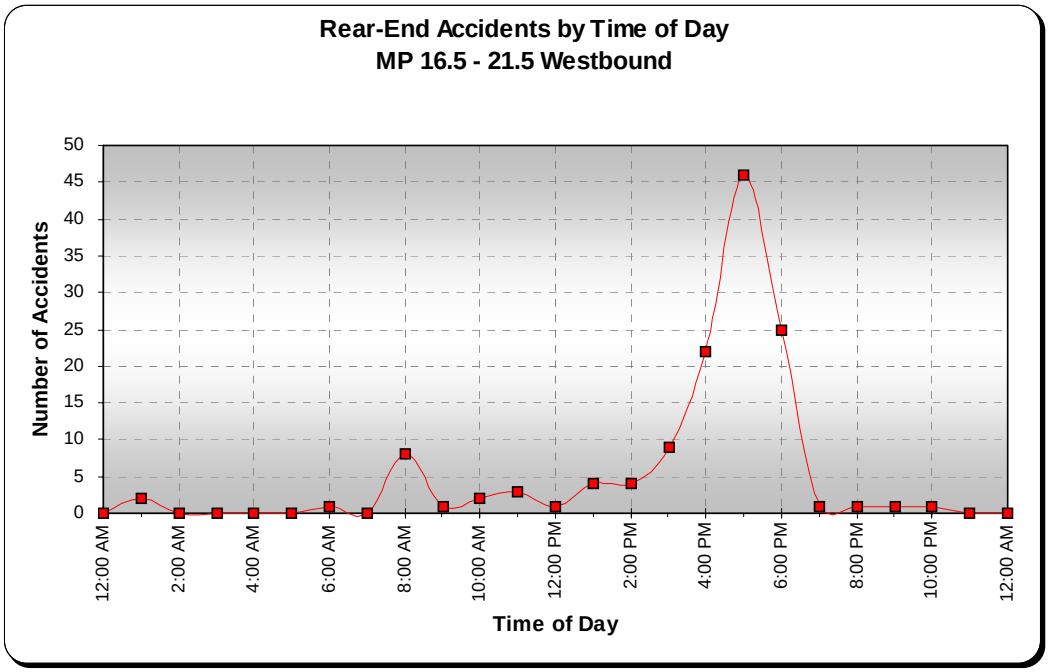


Figure 14



Examining the rear end accidents in the pattern area by direction, minor clusters predictably develop in the area of interchange ramp merge-diverge zones. In the *eastbound* direction, minor rear-end accident concentration is noted at the following locations among others:

Wadsworth on-ramp to eastbound C-470, am peak
Santa Fe on-ramp to eastbound C-470, am peak
Lucent Blvd. on-ramp to eastbound C-470, am peak
Broadway on-ramp to eastbound C-470, various times
University Blvd. on-ramp to eastbound C-470, am peak

Rear-end accident concentration in the *westbound* lanes are noted at the following:

A broad area in the vicinity of Santa Fe interchange (MP 16.6-17.5), pm peak
University Blvd. interchange area (MP 20.9-21.3), mid-day to pm peak
MP 22.95-23.1, downgrade near bridge, pm peak
Quebec interchange off ramp & on ramp merge areas to westbound C-470, pm peak

An increase in rear-end accident frequency is typical during high ADT periods. Added traffic capacity will be the most effective improvement in reducing these congestion-related accidents. Additionally, providing on-ramp acceleration lanes as long as practical at interchanges may help minimize speed reduction and disruption to through traffic lanes. In some instances, the parallel type acceleration lane may create less disturbance in the mainline traffic flow as well. At several of the above locations (westbound in the Santa Fe interchange area, westbound from 22.95-23.1 and near the University Blvd. Interchange) downhill grades make slowing or stopping for unexpected traffic congestion even more difficult. Again, providing extended ramp lanes in these areas to segregate slowing traffic may marginally help reduce the incidence of rear-end collisions.

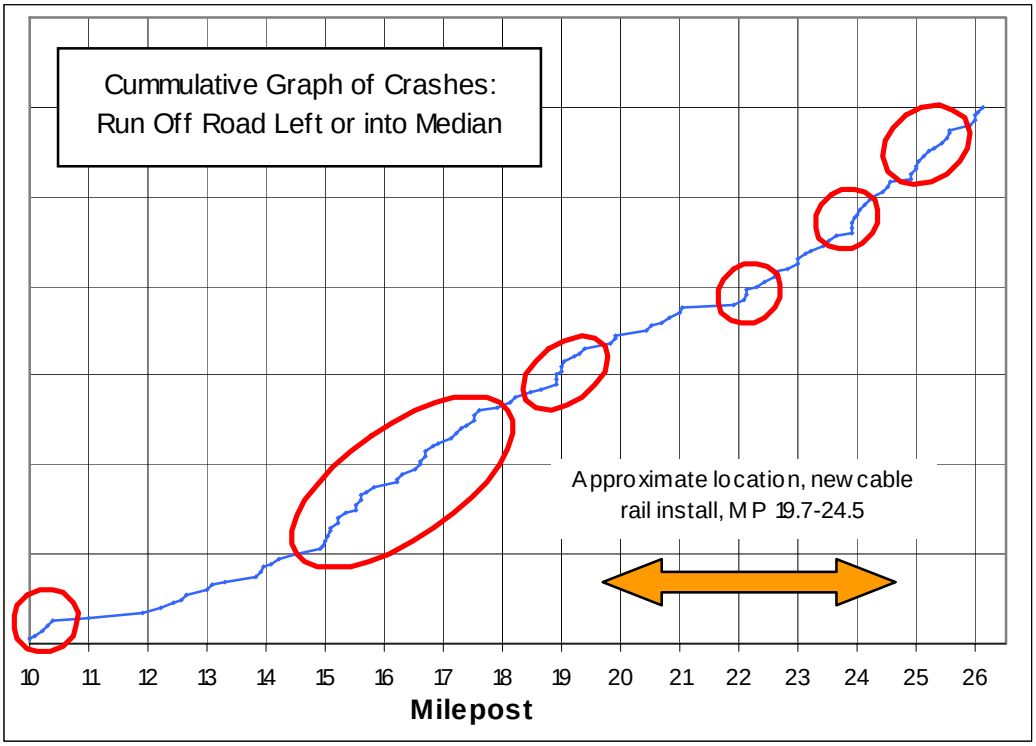
Additional minor collision patterns and clusters are noted within the study corridor. Only 3 or 4 accidents over several years, however, constitute some of these clusters. In other cases, the accidents making up the type pattern vary sufficiently in circumstance and exact location such that common, cost effective countermeasures are not available.

Corridor-Wide Collision Observations

Collisions with delineator posts are statistically over-represented among the overall accident count. This accident type is a consequence of control loss and, ultimately, running-off-the-road. The highway segments from MP 18.5 to 19.5 and MPs 23 to 24.5 exhibit a slightly higher incidence of this crash type. We note that some of these loss-of-control incidents result from the sudden maneuvering required when drivers traveling at highway speeds encounter unexpected slow-moving or stationary, congested traffic. Again, by reducing general congestion, capacity improvement in the form of widening is expected to reduce the frequency of this type of crash. In other collisions with delineator posts we note the accident was initiated by irregular lane changes. The use of durable pavement marking materials or inlaid striping methods may marginally reduce this accident type.

Over the corridor as a whole, it appears that C-470 records a lower percentage of vehicle collisions with median barrier compared to other similar highways while the percentage of median crossovers and crashes in the opposing lanes is slightly high. Additionally, the percentage of head-on and opposing direction sideswipe collisions is at or slightly above statewide averages for this highway type. These conditions suggest that installation of additional median barrier may be an effective safety improvement. Figures 15 & 16 (a & b) graphically depicts the locations where vehicles have run off the road to the left side and/or into the median.

Figure 15



In Figure 15, the circled areas identify isolated locations with slightly increased frequencies of median incursion or crossovers. The Region has recently installed median cable rail from MP 19.7 - 24.5. This type of median barrier is expected to improve safety significantly along this segment.

In conjunction with major widening or other large-scale improvements undertaken in the future, planners may consider additional median barrier installation following review of the accident reduction performance of this latest cable rail project.

Figure 16a specifically indicates locations of those crashes involving run-off the left roadside

Figure 16a

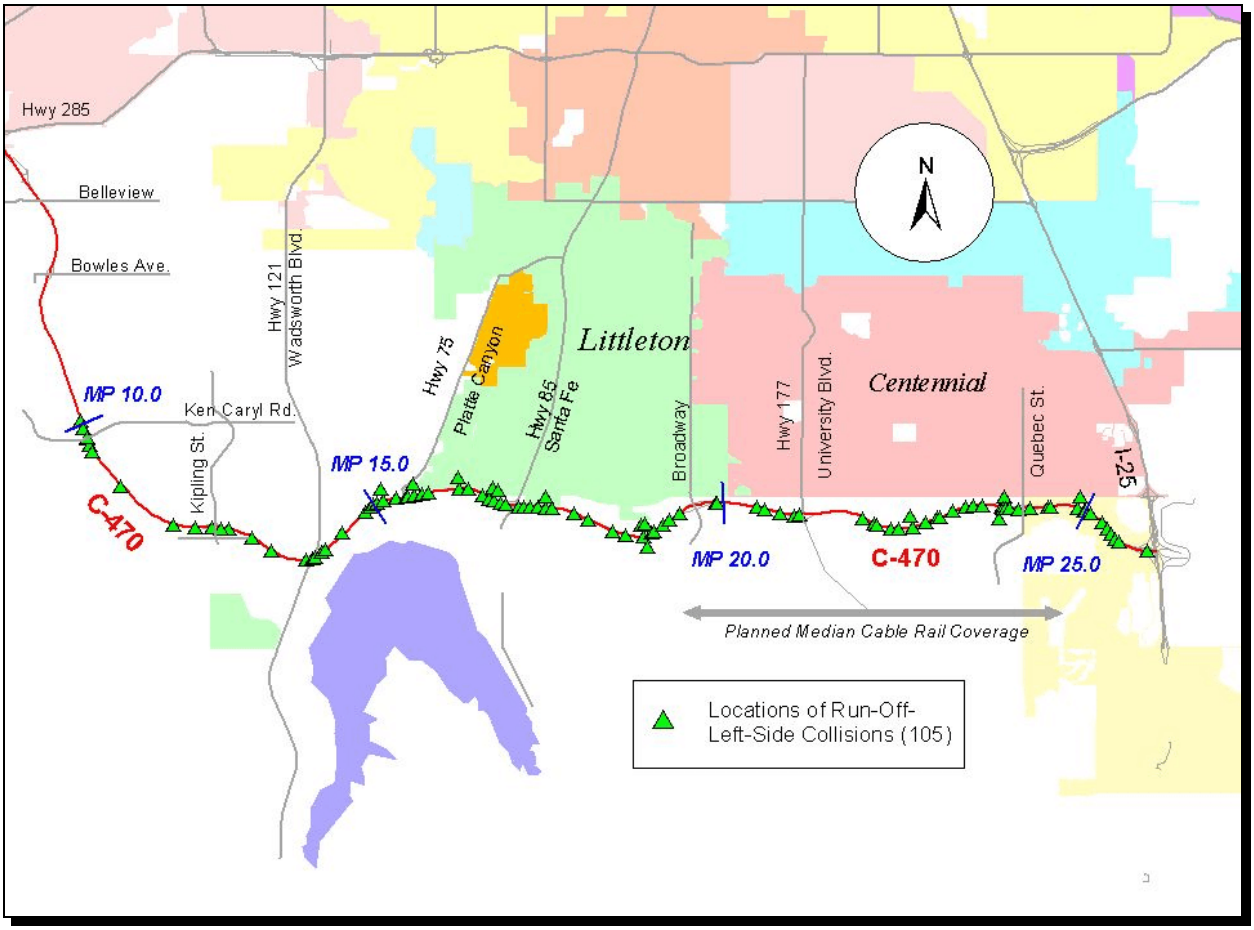
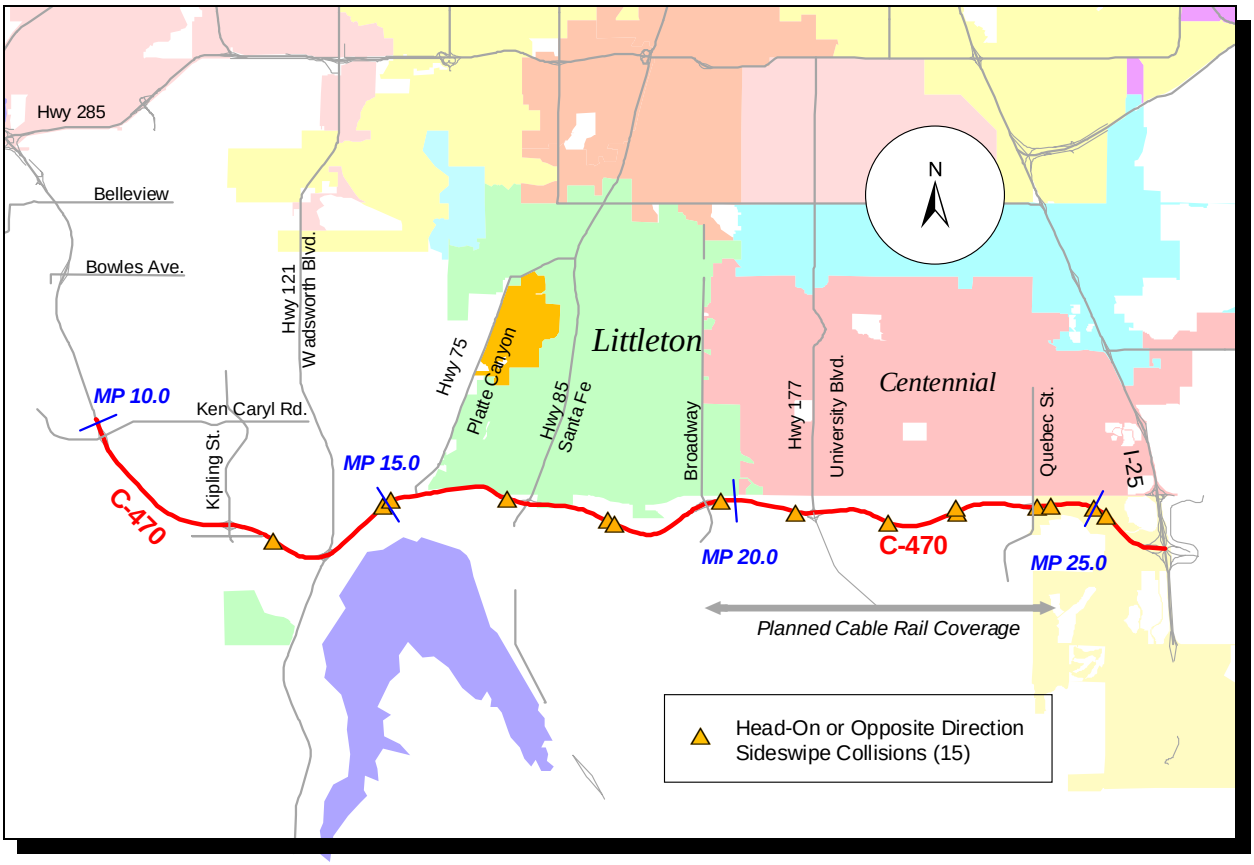


Figure 16b identifies the locations where head-on and opposing direction sideswipe collisions occurred during the study period. The planned cable rail section will enclose an area where several of these severe accidents have historically taken place.

Figure 16b



On a corridor-wide basis, fewer collisions than average occur under adverse road surface conditions or during poor weather along this segment of C-470 indicating that CDOT Maintenance Section 8 has an effective winter maintenance and treatment system in place. The efficient road maintenance practices exhibited are a crucial component in ensuring a high level of roadway safety. With this in mind, however, review of those crash locations involving icy, snowy or slushy road conditions indicate minor concentrations occurring in the Santa Fe, Quebec and Yosemite interchange areas, including associated ramps. Most of these involving westbound vehicles.

The previous analysis of freeway segments confirms the presence of congestion related safety problems. This conclusion supports the fact that new alternatives will need to provide additional capacity.

In the following sections of the study, safety at the included interchanges is examined. Safety problems detected on the crossing streets, ramps and ramp intersections will be identified.

INTERCHANGE SAFETY

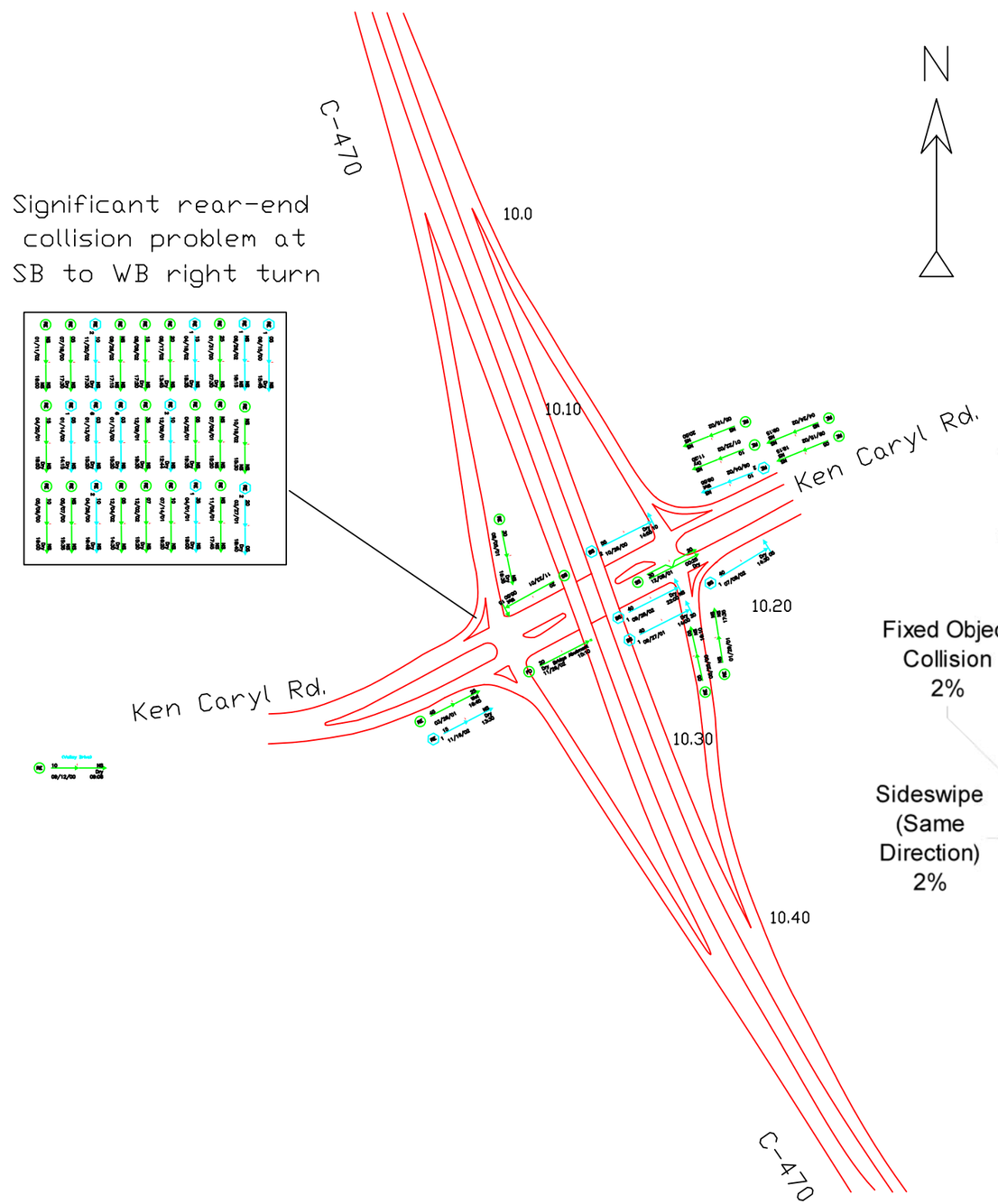
C-470 and Ken Caryl Rd. Interchange

An accident diagram as well as a chart showing the accident type distribution profile for interchange intersections, ramps and cross road is shown on the following page.

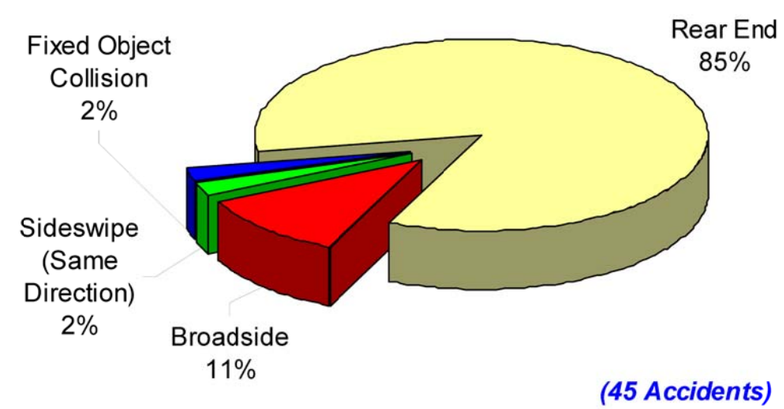
The accident type distribution profile shows that rear end collisions make up most of the accidents at the ramp terminals and on Ken Caryl Rd., accounting for 85% of the total. A significant number of these rear end accidents are occurring in the right turn movement from the southbound (EB C-470) off ramp to westbound Ken Caryl Rd. During the 3 year study period approximately 28 crashes were reported at this location. Improvements such as extended acceleration lanes on Ken Caryl Rd. can help moderate the incidence of these accidents. Ensuring optimum visibility from the intersection to the east can also help curtail the tendency for drivers to start and then unexpectedly stop to clear traffic.

Five broadside collisions are noted at the east side ramp terminal. At this location, east bound drivers are occasionally running through a red signal indication resulting in a crash with northbound drivers turning onto Ken Caryl from the westbound C-470 off ramp. Ensuring optimum visibility of the eastbound traffic signal for approaching vehicles can help reduce the incidence of these crashes.

C–470 & Ken Caryl Rd. Interchange



Accident Types at Ken Caryl Interchange Ramps & Crossroad Only

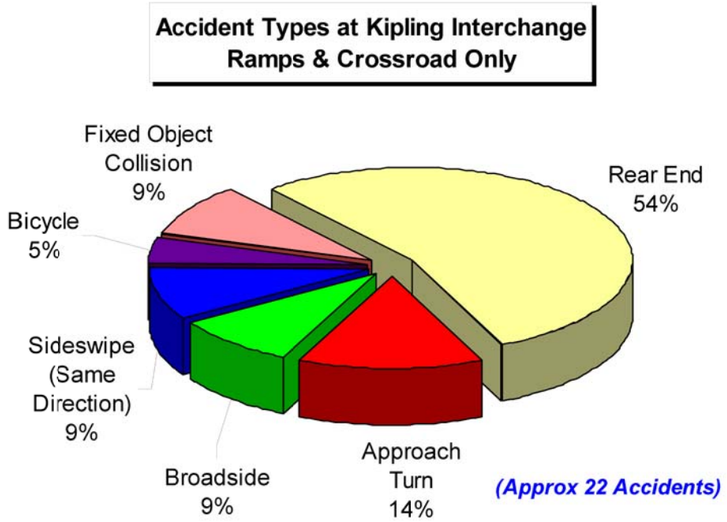


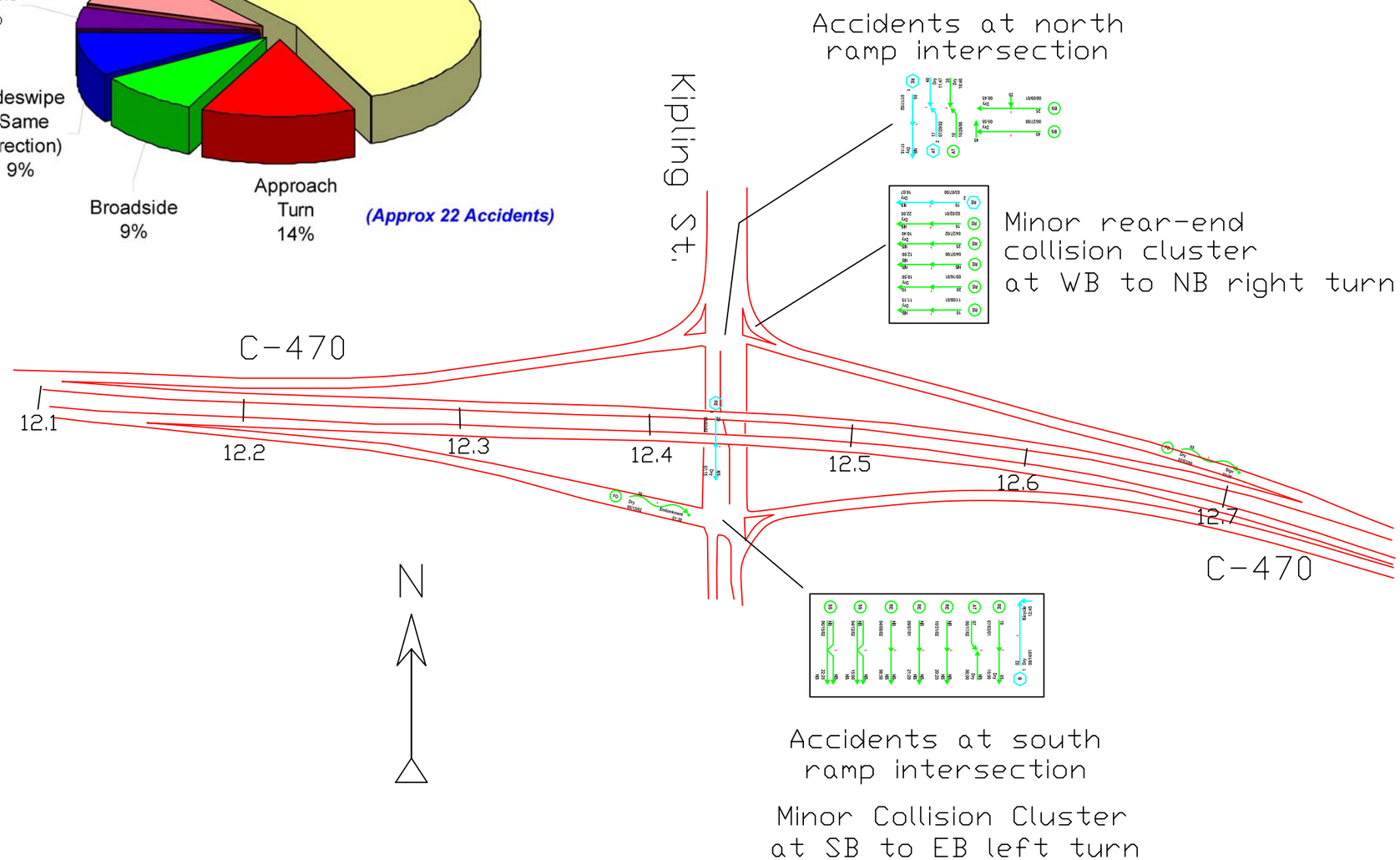
C-470 and Kipling Parkway Interchange

An accident diagram as well as an accident type distribution profile for interchange intersections, ramps and Kipling Pkwy. at the interchange is shown on the following page.

Overall, approximately 22 collisions on the interchange ramps and crossroad were reported. Although this accident frequency is not unexpected, two minor accident groupings were noted at the Kipling interchange. Six rear-end crashes occurred in the channelized right turn lane from the westbound C-470 off ramp to northbound Kipling. These are related to congestion on northbound Kipling. Extension of the northbound acceleration lane on Kipling was completed in conjunction with commercial development and may have alleviated much of this minor accident concentration. A minor cluster of eight crashes is noted at the south ramp intersection. The accidents forming this cluster did not exhibit distinguishing patterns, therefore no specific improvement is recommended at this location either.

C-470 & Kipling St. Interchange





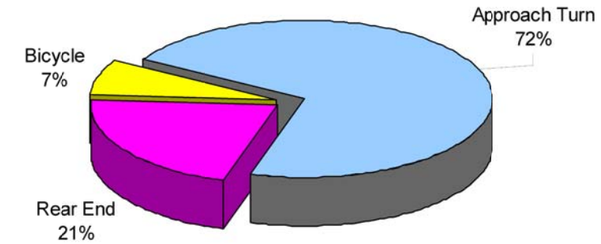
C-470 and Wadsworth Blvd. Interchange

An accident diagram as well as chart showing the accident type distribution profile for the included interchange ramps and Wadsworth and separate profiles for the north and south ramp intersections are shown on the following page.

Rear-end collisions account for most accidents at the Wadsworth interchange, making up over half of the 46 total accidents. Collisions of this type were not concentrated in specific locations but rather were broadly distributed throughout the interchange area including the ramps and Wadsworth itself. A minor cluster of approach-turn accidents is noted at the north ramp terminal involving northbound vehicles on Wadsworth turning left to travel on the westbound C-470 on-ramp colliding with southbound vehicles on Wadsworth. Consideration may be given to installing a protected only left turn phase for northbound traffic if not already implemented at this intersection. The south ramp intersection exhibited approximately 7 crashes at the signal with 5 additional collisions slightly removed but associated with the intersection operation. These were primarily rear-end collisions in the northbound and southbound lanes of Wadsworth. Improving traffic signal conspicuity with signal head back plates or LED lenses is an option that may help reduce this crash type.

C–470 & Wadsworth Blvd. Interchange

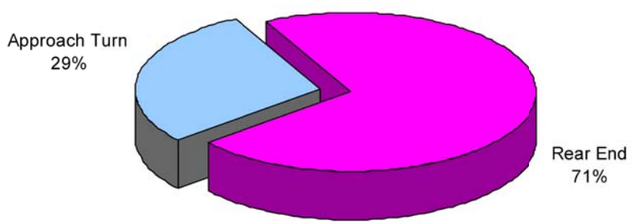
Accident Types at the North Ramp Intersection of the Wadsworth Interchange



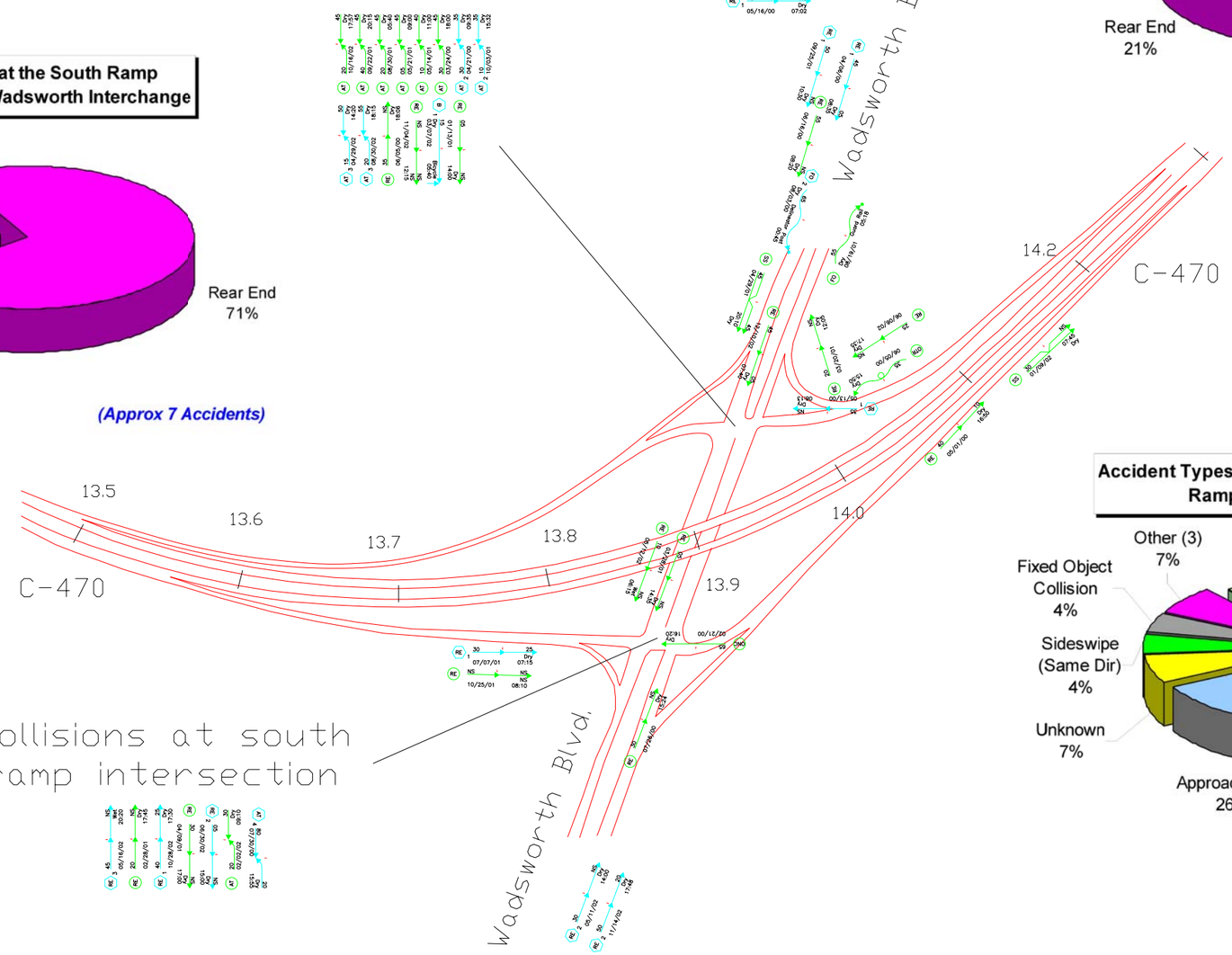
(Approx 14 Accidents)

Collisions at north ramp intersection

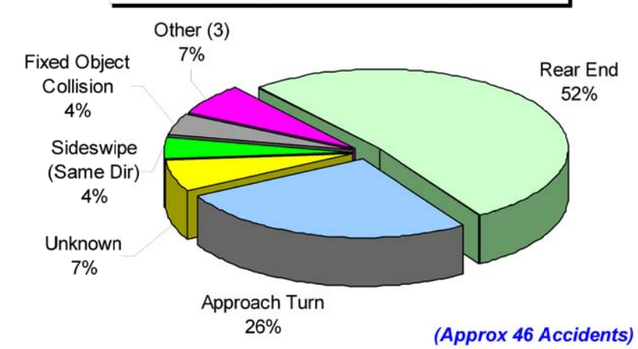
Accident Types at the South Ramp Intersection of the Wadsworth Interchange



(Approx 7 Accidents)



Accident Types at the Wadsworth Interchange Ramps & Crossroad Only



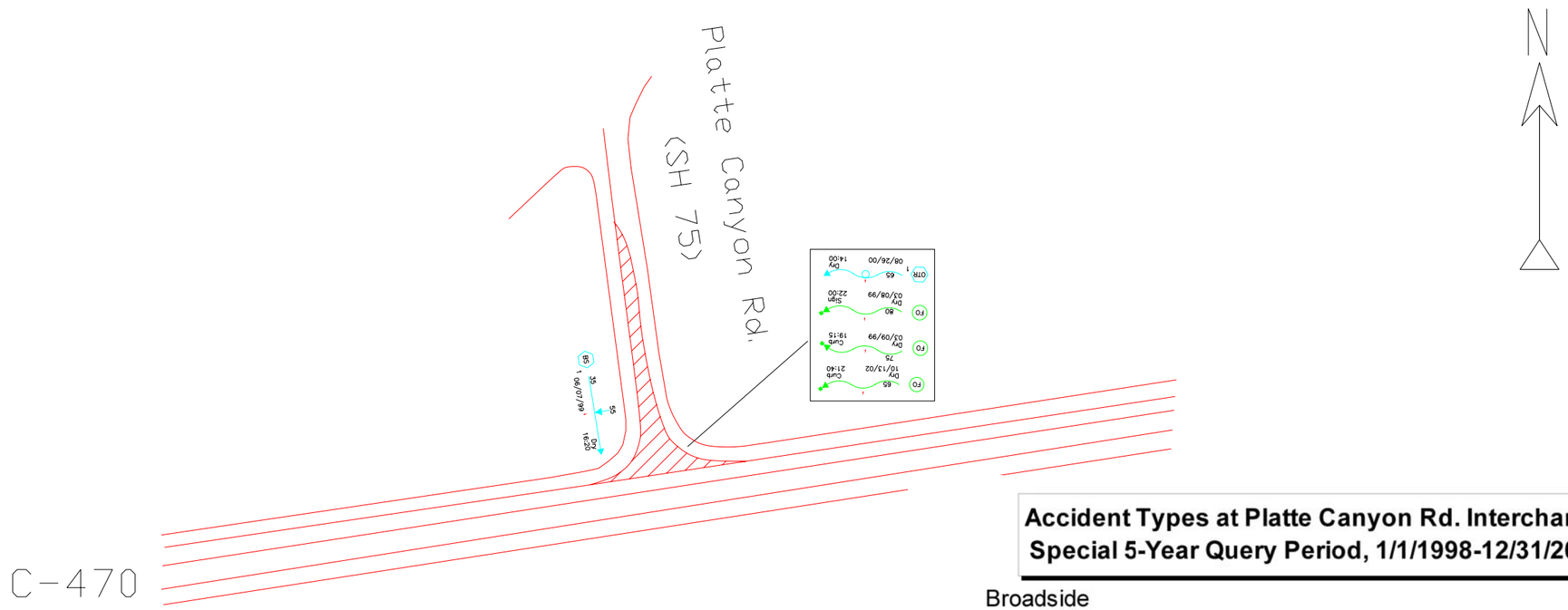
(Approx 46 Accidents)

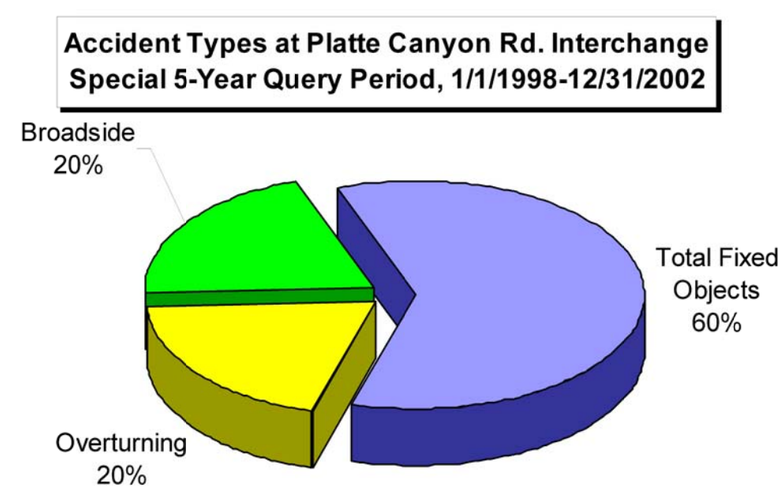
C-470 and Platte Canyon Rd. Interchange

An accident diagram and accident type distribution profile for this minor intersection is shown on the following page.

The junction of Platte Canyon Rd. and C-470 does not exhibit a high number of accidents. Non-crossing traffic streams, lower access volume and generous auxiliary lanes help maintain the low number of collisions. Of the estimated 5 accidents detected during an extended study period of 5 years, 3 involved vehicles colliding with the raised channelizing island at the intersection. This type of accident results when vehicles exit C-470 at excessive speed or fail to decelerate sufficiently prior to attempting the turn onto Platte Canyon Rd. Improvement options for consideration can include enlarging existing advisory exit speed signs, installing closely-spaced (~20'), approved, post-mounted delineators along the exit median edge or increasing curve radius to bring in line with higher design exit speeds.

C–470 & Platte Canyon Rd. Interchange





(5 Accidents)

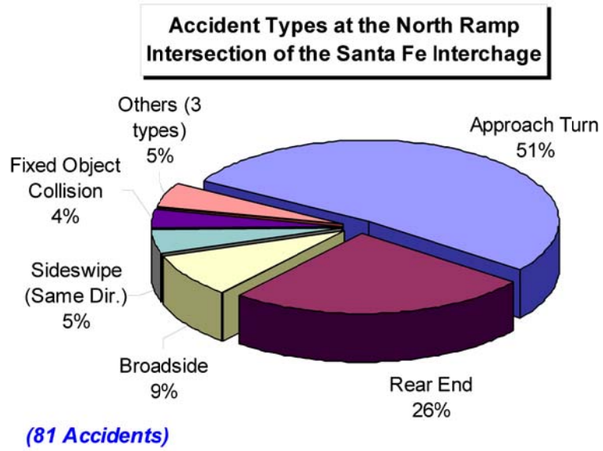
C-470 and Santa Fe Drive Interchange

An accident diagram as well as charts showing the accident type distribution profile for the interchange intersections as well as the ramps and cross road is shown on the following page.

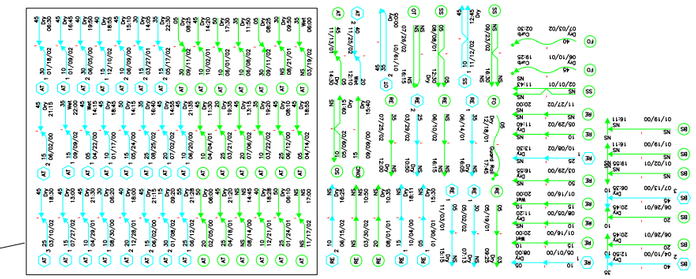
Approximately 158 accidents were detected in the immediate interchange vicinity on Santa Fe Dr. and on the entrance/exit ramps to C-470. Rear-end and approach turn collisions together made up nearly 75% of these crashes. At the signalized ramp intersection on the north side of the bridge structure, over half of the accidents were approach turns. These crashes involved northbound vehicles on Santa Fe turning left onto the westbound C-470 entrance ramp colliding with southbound Santa Fe traffic. The frequency of these accidents is increased by periodic volume congestion and the limited storage capacity of the current northbound to westbound left turn lane configuration. The Region has recently changed from protected-permitted signal phasing to protected-only phasing. This improvement is expected to reduce the incidence of approach-turn crashes significantly, accompanied by a delay and capacity cost however.

The south ramp intersection includes a double left turn lane for vehicles making the southbound to eastbound turn movement. This movement requires drivers to execute a turn through more than 90 degrees due to interchange skew. Approximately eleven same direction sideswipe accidents are noted in these lanes. Ensuring that durable pavement markings are used and maintained for the turn lane stripe extensions into the intersection can help mitigate this type of accident.

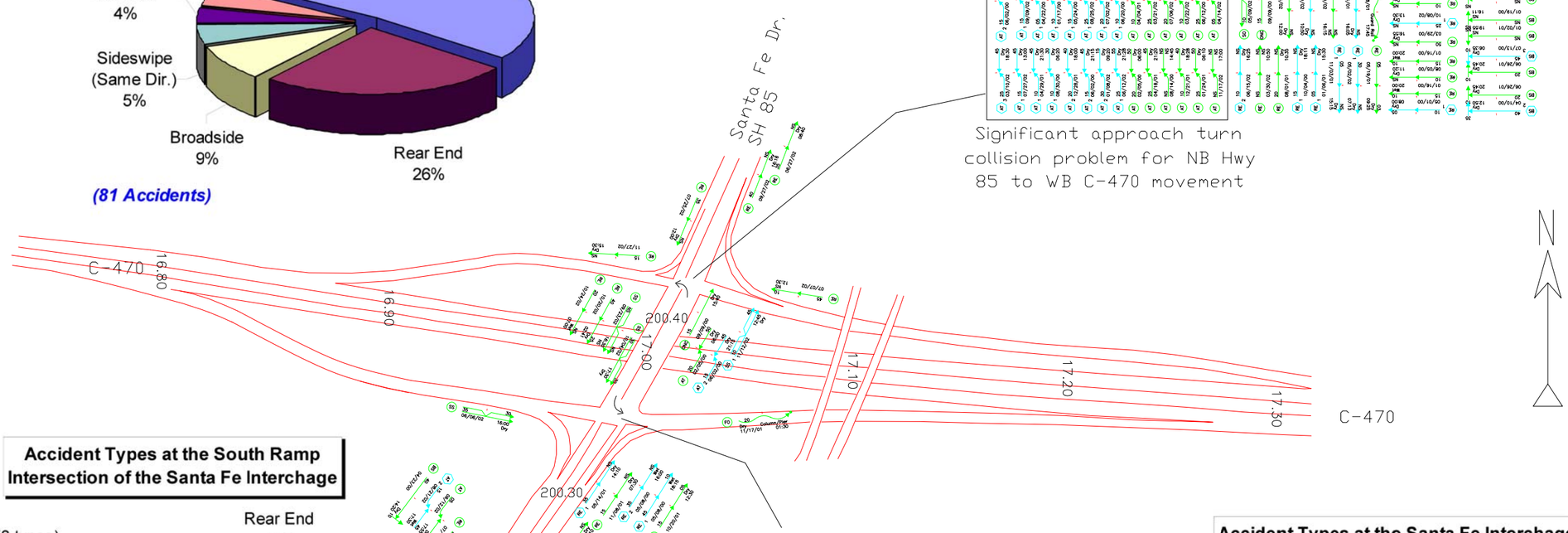
C–470 & Santa Fe Interchange

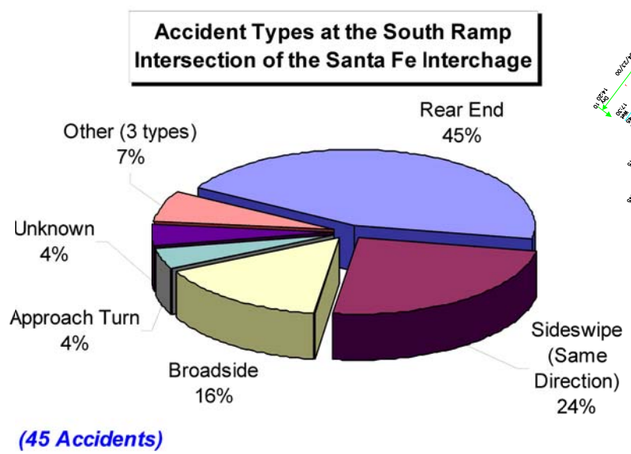


Collisions occurring at north ramp intersection

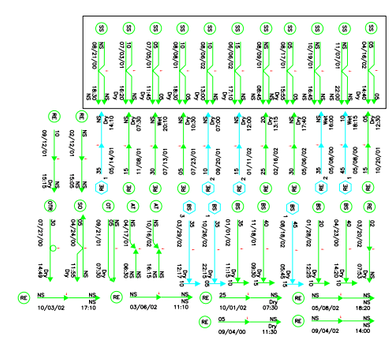


Significant approach turn collision problem for NB Hwy 85 to WB C-470 movement

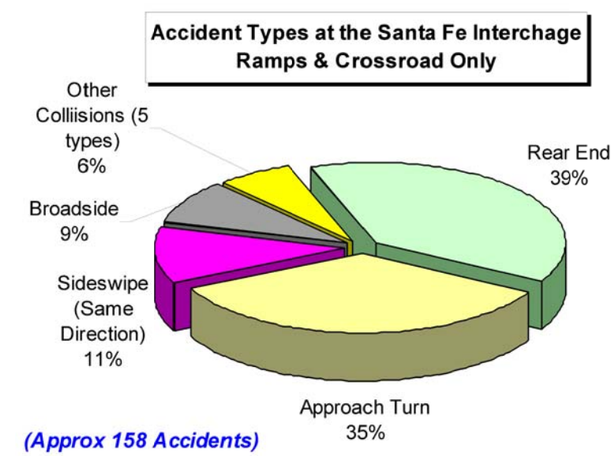




Collisions occurring at the south ramp intersection



Moderate frequency same direction sideswipe accidents in double left turn lanes, SB Santa Fe Drive to EB C-470

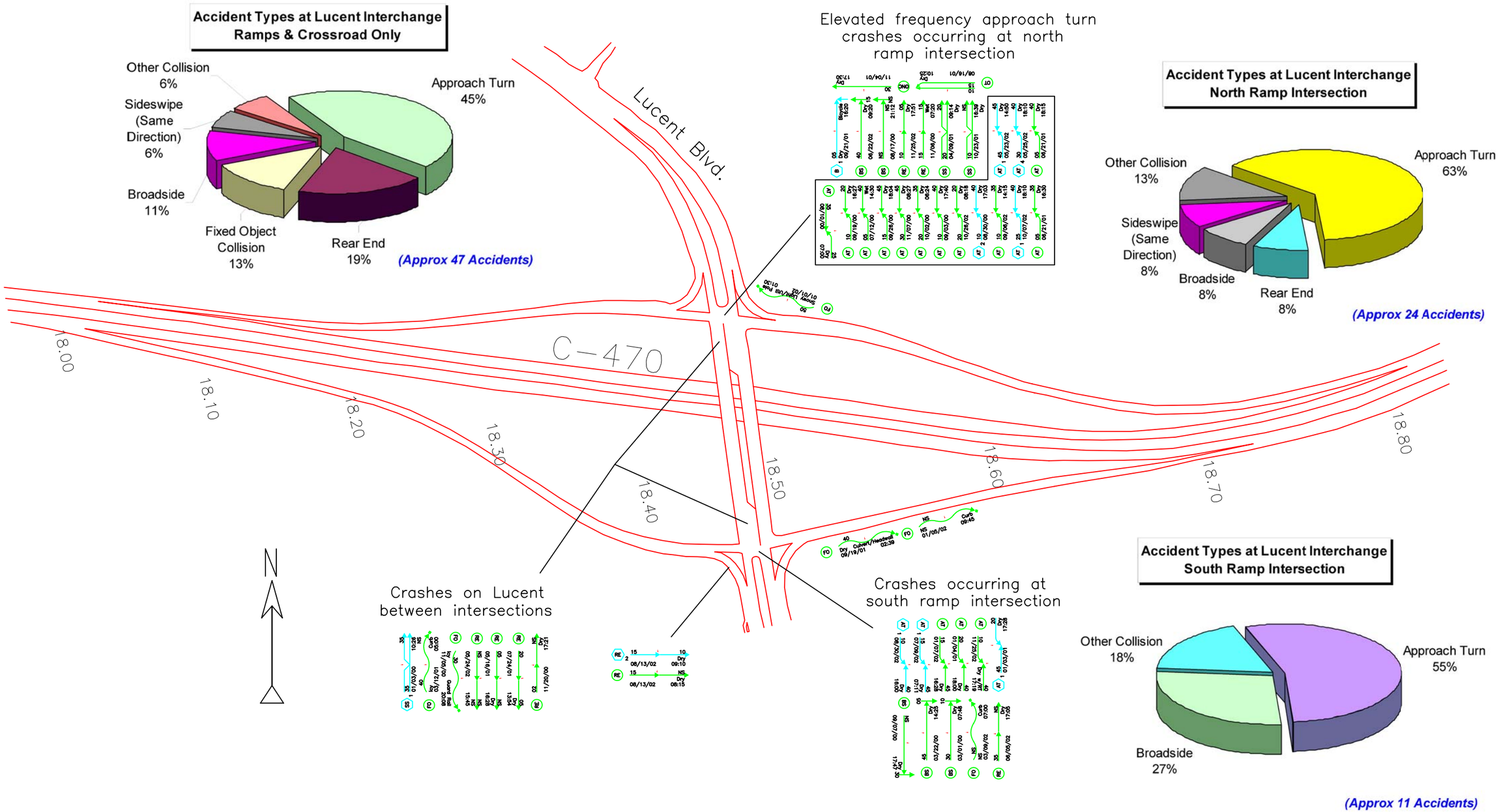


C-470 and Lucent Blvd. Interchange

An accident diagram as well as charts showing the accident type distribution profile for the interchange intersections as well as the ramps and cross road is shown on the following page.

During the 3-year study period 47 crashes were detected on Lucent Blvd. and the ramps at this interchange. An elevated frequency of approach turn collisions was noted at the north ramp intersection. These accidents involve southbound through vehicles on Lucent colliding with vehicles turning left from northbound Lucent to westbound C-470. Consideration may be given to implementing a protected only left turn signal interval for the double left turn onto the westbound C-470 on-ramp if not already installed.

C–470 & Lucent Blvd. Interchange

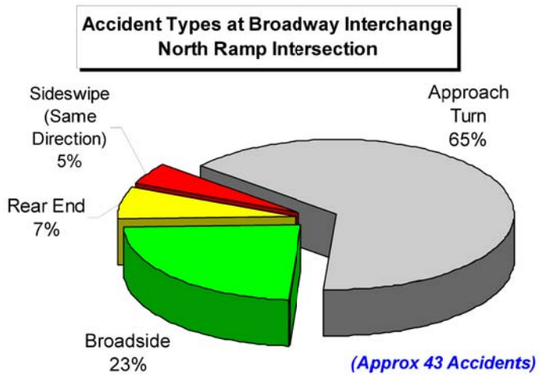


C-470 and Broadway Interchange

An accident diagram as well as charts showing the accident type distribution profile for the interchange intersections as well as the ramps and cross road is shown on the following page.

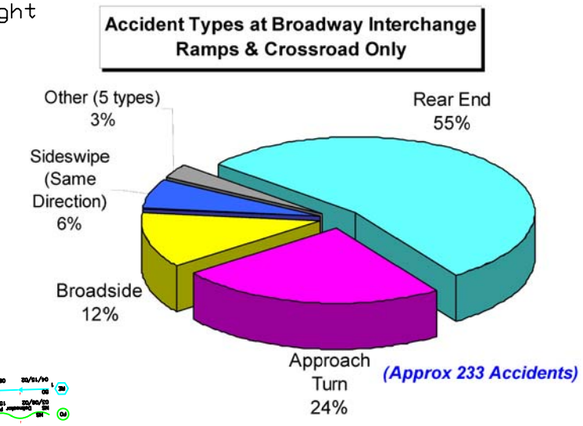
Approach turn type collisions were prevalent at the Broadway interchange. Both north and south ramp intersections exhibited these collisions during the study period. If not already implemented, fully protected left turn intervals for the north and southbound Broadway to C-470 left turn movements should be considered at both ramp intersection signals. Additionally, we note rear-end collisions occurring with moderate frequency in the channelized right turn lanes from the freeway off ramps to north & southbound Broadway. Again, these are generally congestion related typically occurring during peak volume hours. Provision of extended right turn acceleration lanes on Broadway, if practical, may be considered to eliminate some of these rear-end collisions. An occasional north or southbound vehicle on Broadway does not observe or disregards a red signal indication at the ramp intersection which generates a broadside collision potential. Improving the conspicuity of the traffic signal indications or minor extension of the signal change interval may be considered as an accident countermeasure for this accident type. This interchange currently carries relatively high traffic volume. This is acknowledged in the present double left turn lane configuration. Increasing the traffic capacity throughout this interchange may be considered in conjunction with improvement planning for mainline C-470.

C–470 & Broadway Interchange



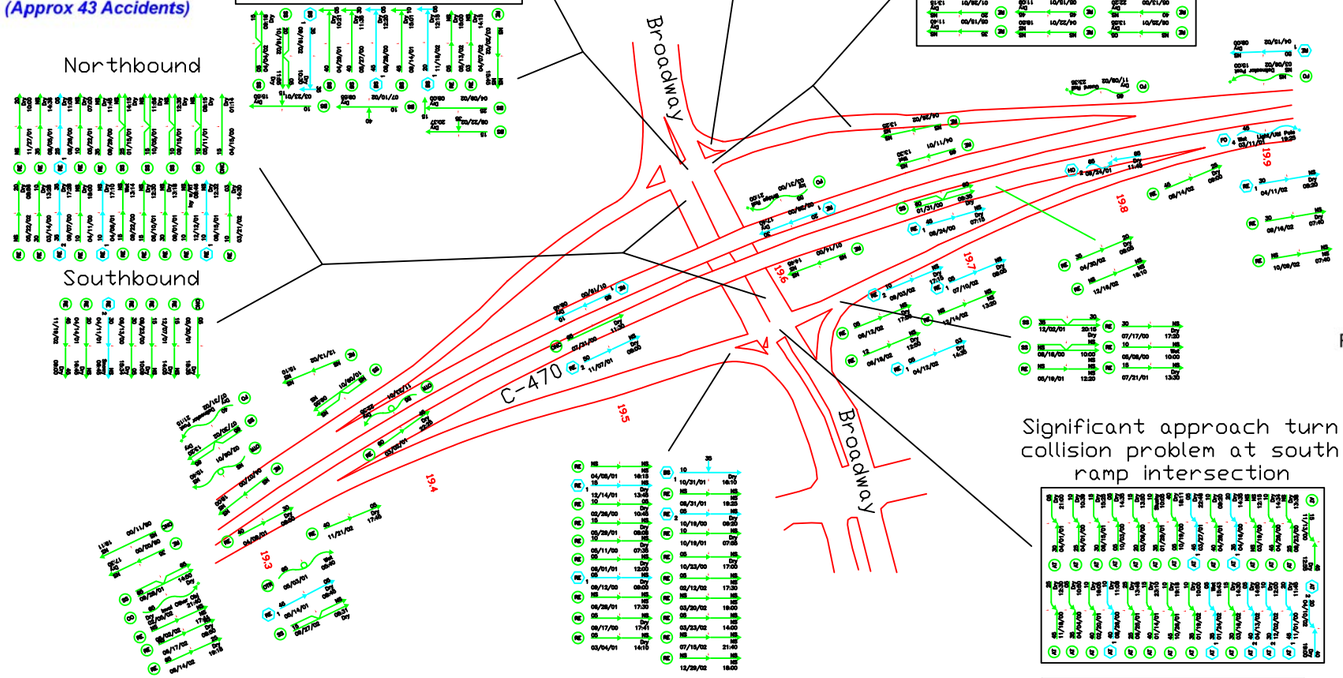
Significant approach turn collision problem at north ramp intersection

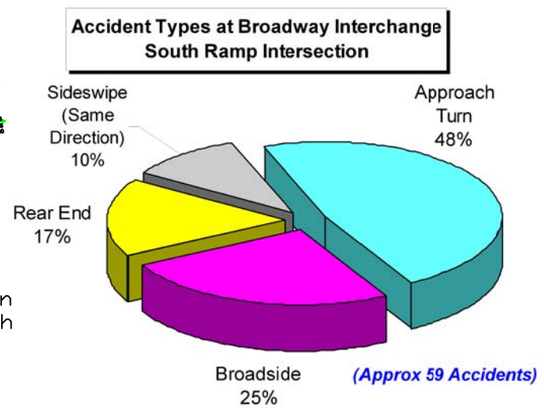
Moderate frequency rear-end collisions on off-ramp & right turn lane to northbound



Northbound

Southbound





Significant approach turn collision problem at south ramp intersection

Moderate Frequency Broadside collisions at south ramp intersection

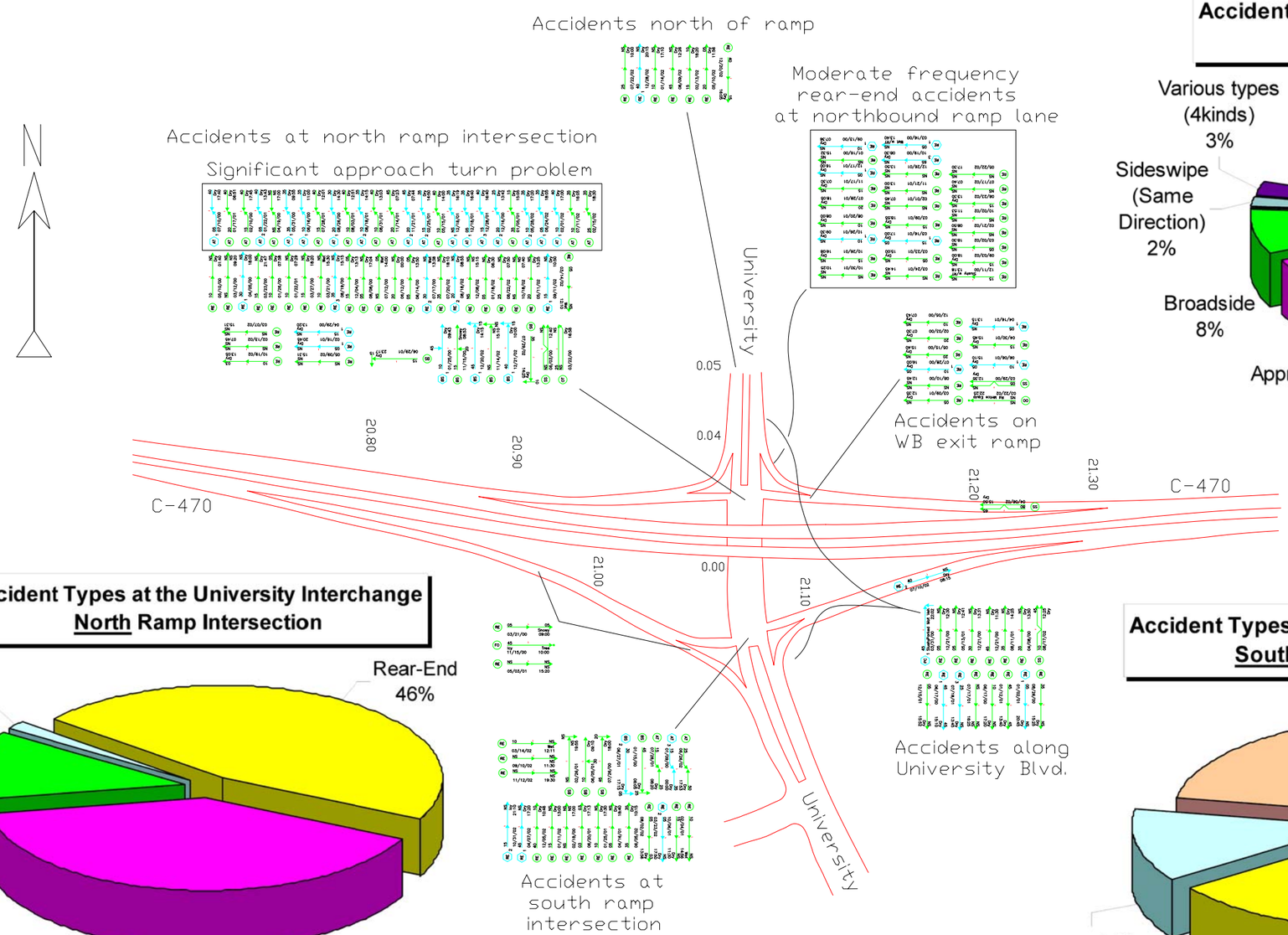
C-470 and University Blvd. Interchange

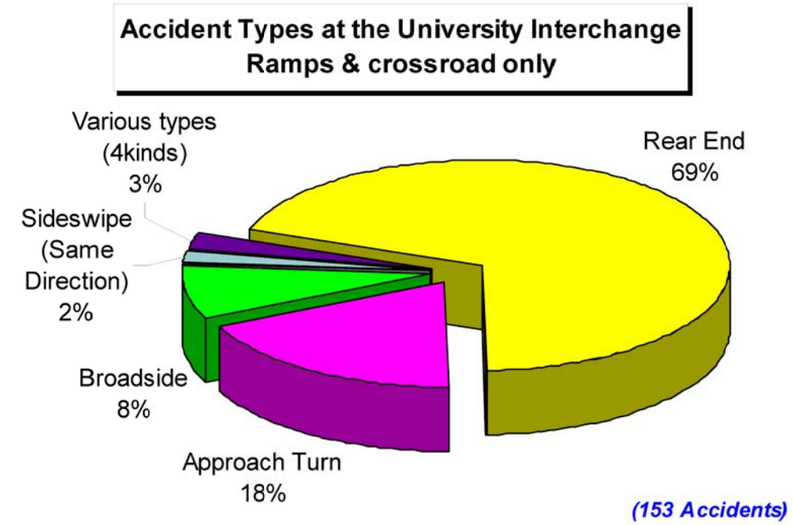
An accident diagram as well as charts showing the accident type distribution profile for the interchange intersections as well as the ramps and cross road is shown on the following page.

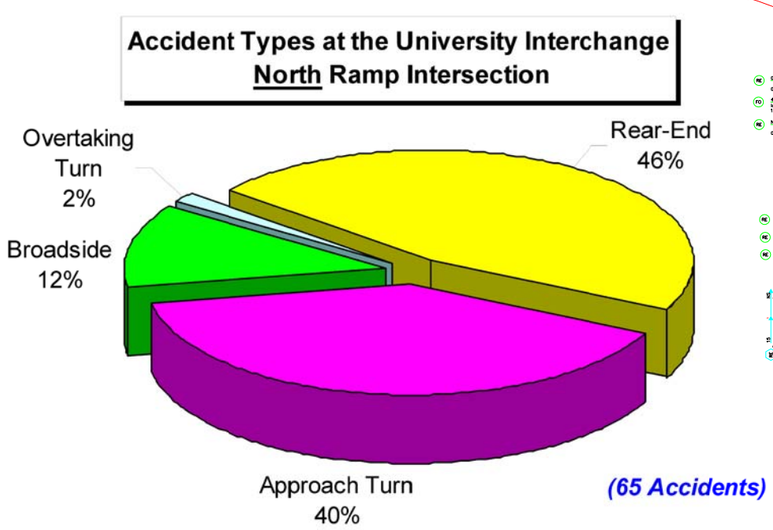
Over 150 accidents were detected in the University Blvd. interchange area during the 3 year study period. We note an approach-turn collision history at the north ramp intersection. These crashes involve vehicles turning left from northbound University to the westbound C-470 on-ramp colliding with southbound vehicles on University. Protected only left turn phasing has been implemented recently at both north and south ramp intersections. This change has moderated the incidence of the approach-turn type collisions.

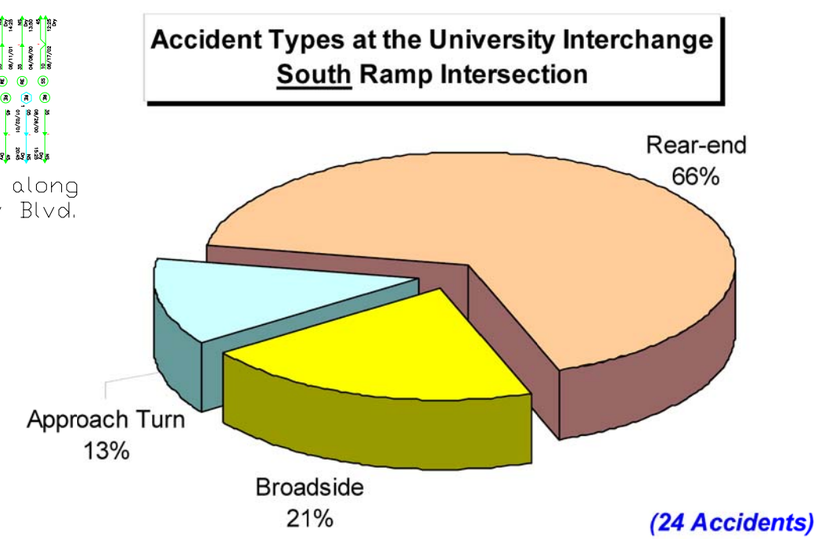
As with the Broadway interchange, rear-end collisions are noted in the channelized right turn lanes from the westbound freeway off ramps to northbound University. Extension of the right turn acceleration lanes on northbound University, if practical, may be considered to mitigate rear-end collision occurrence here.

C–470 & University Blvd. Interchange









C-470 and Quebec St. Interchange

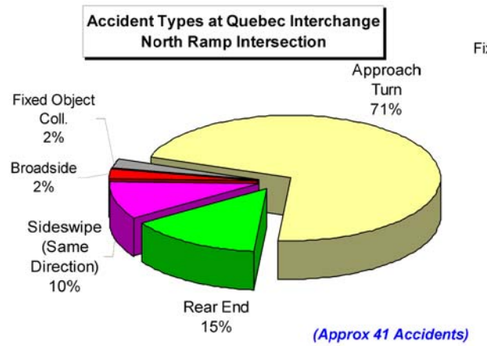
An accident diagram and charts showing the accident type distribution profile for the interchange intersections as well as the ramps and cross road is shown on the following page.

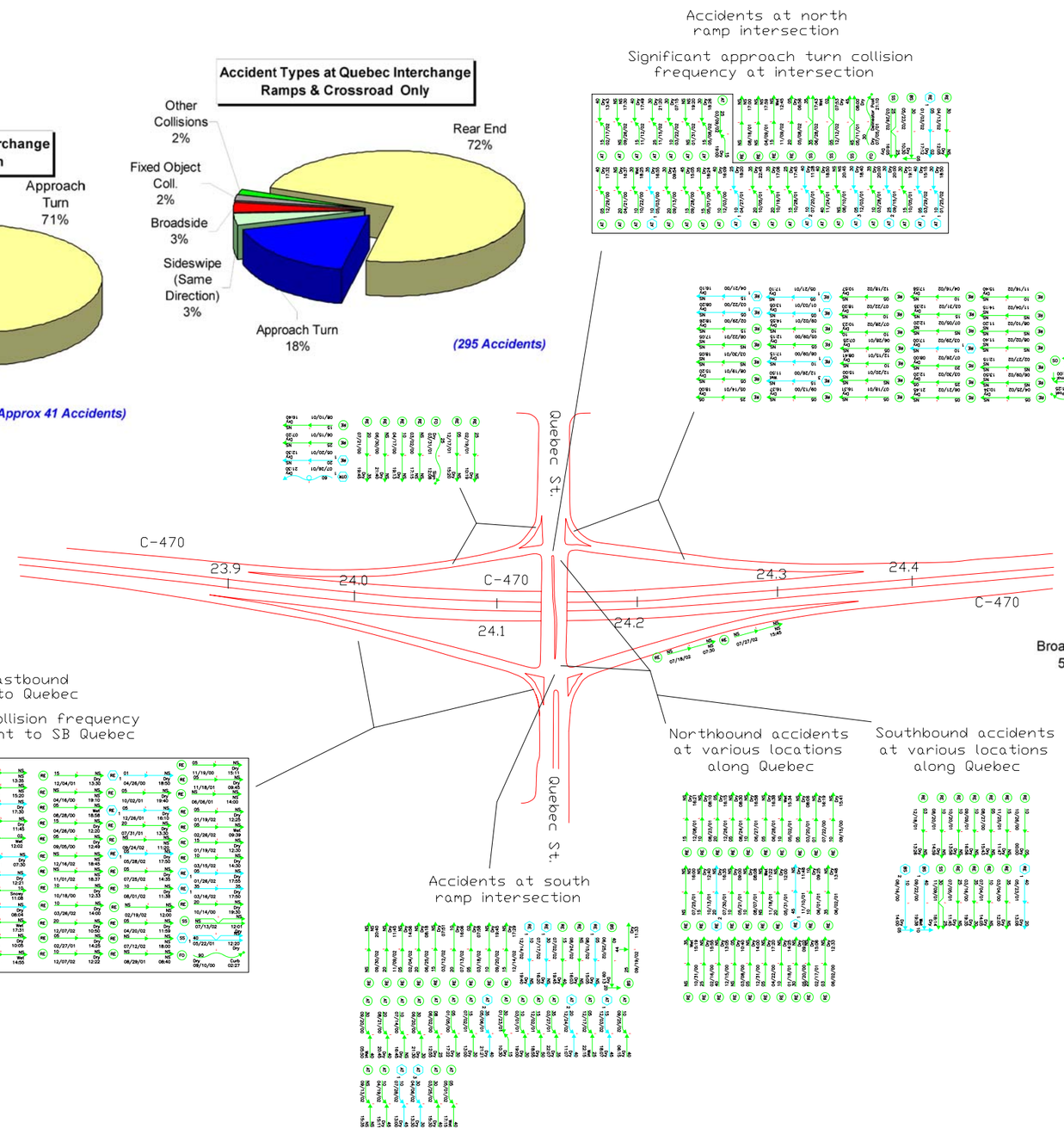
The north ramp intersection at this interchange was experiencing significant approach-turn collision frequency involving northbound vehicles on Quebec St. turning left in front of southbound through vehicles on Quebec. Presently, this left turn movement includes double left turn lanes and protected/permitted signal intervals. Consideration may be given to implementing a fully protected left turn scheme at this intersection.

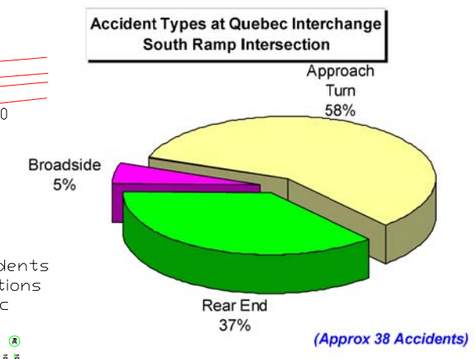
At both north and south ramp intersections we note rear-end collisions occurring in the channelized right turn lanes. Extension of the right turn acceleration lanes, particularly the eastbound to southbound movement at the south intersection, may help moderate this type of collision.

This interchange also experiences a fairly high number of rear-end crashes along Quebec St. itself. Again, periodic congestion may be a contributing factor to this condition. Options for capacity improvement and peak hour delay mitigation at this interchange should be investigated in concert with other potential major improvement construction.

C–470 & Quebec St. Interchange





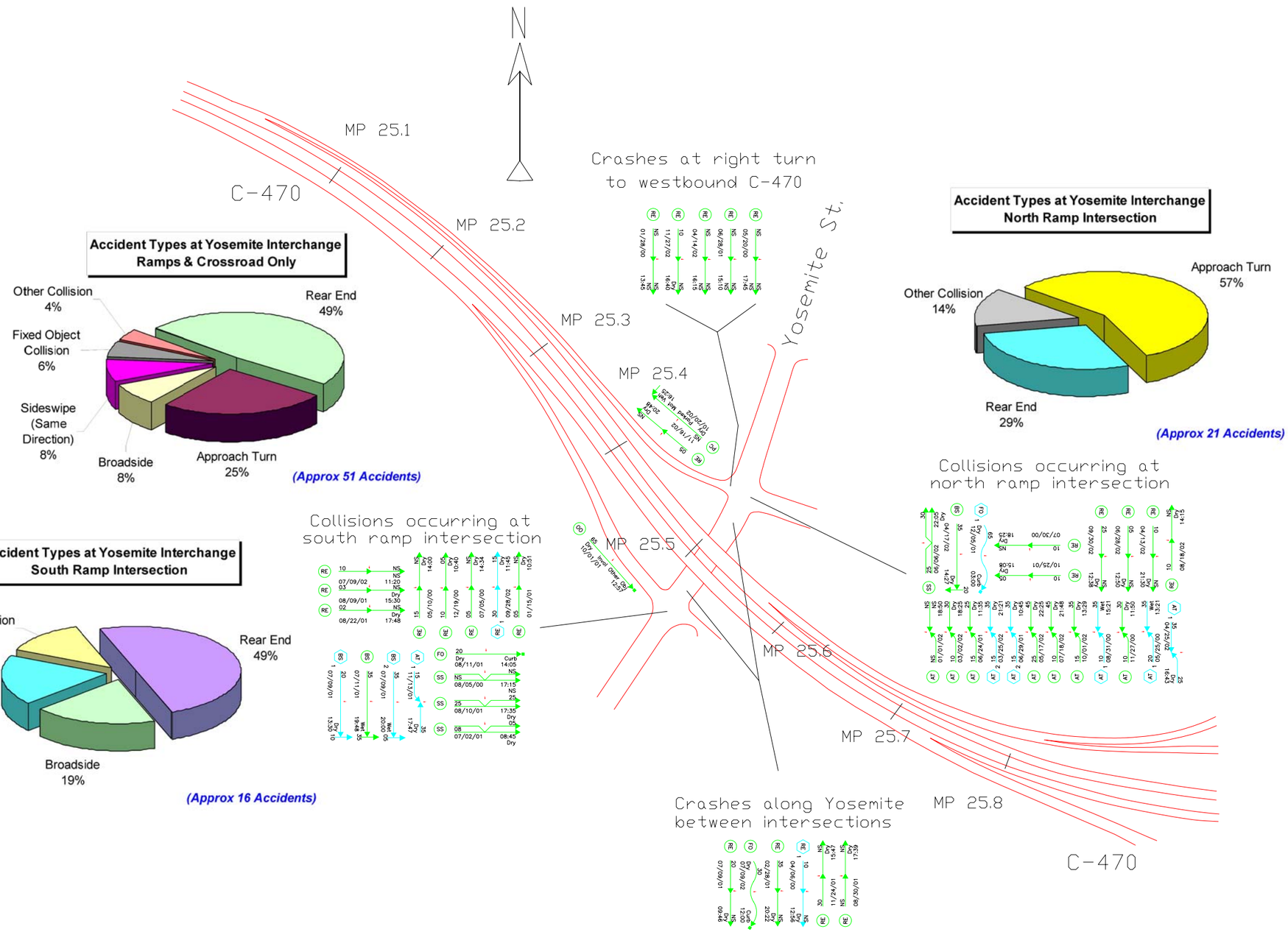


C-470 and Yosemite St. Interchange

An accident diagram as well as charts showing the accident type distribution profile for the interchange intersections and the ramps and cross road is shown on the following page.

The Yosemite St. interchange did not exhibit unusual accident frequency during the study period, recording approximately 51 collisions. Rear-end crashes were most common accounting for 50% of the total followed by approach turn crashes at 25% of the total. Most of the approach turn collisions take place at the north ramp intersection as occasional northbound vehicles turning left to enter the westbound C-470 on-ramp are struck by southbound through traffic on Yosemite. At present crash frequencies, countermeasures addressing this accident type may not be are not strongly recommended. The safety performance of this interchange, however, should be monitored for unusual increases in accident occurrence as traffic volume increases.

C–470 & Yosemite Interchange

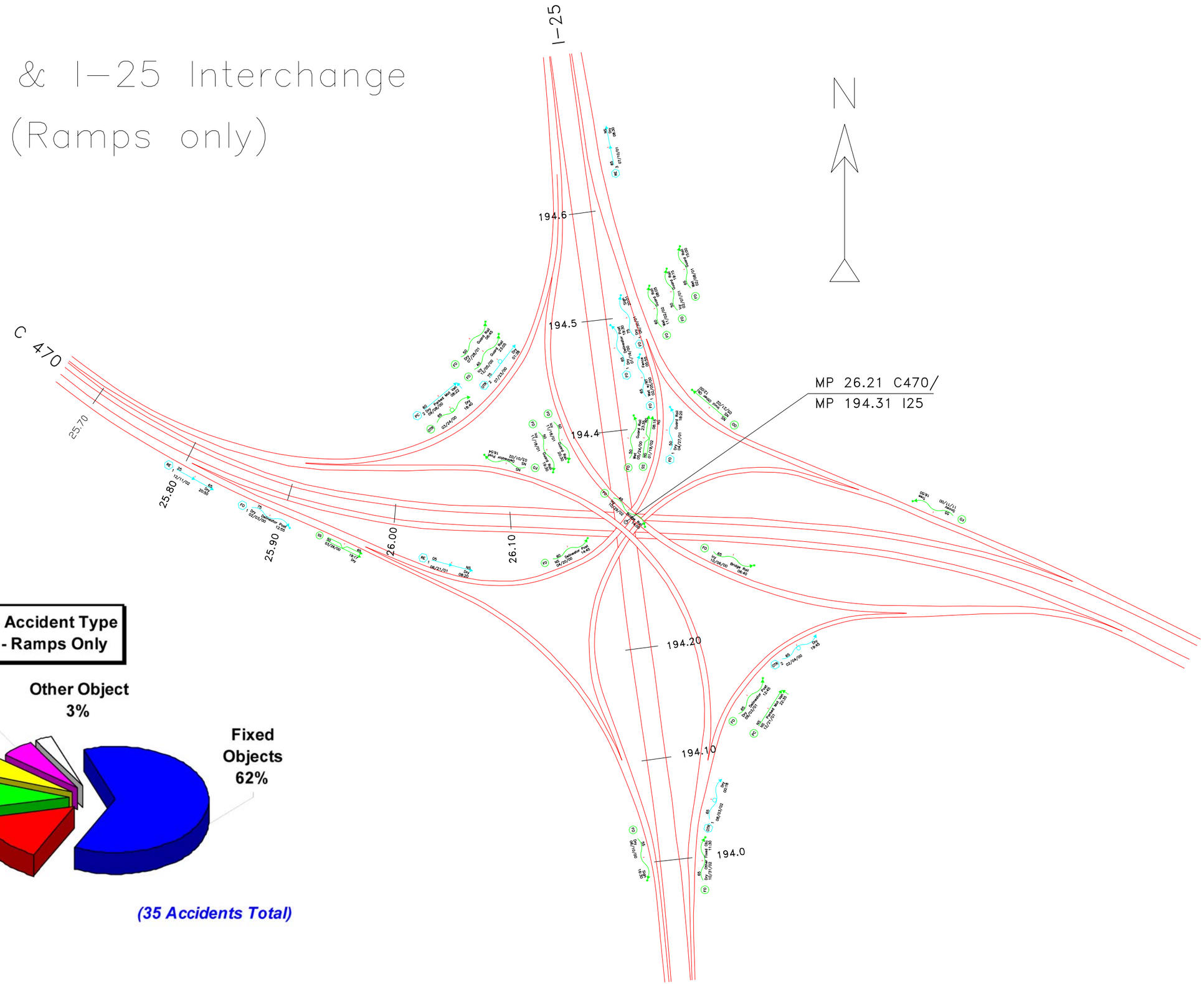


C-470 and I-25 Interchange (interchange ramps only)

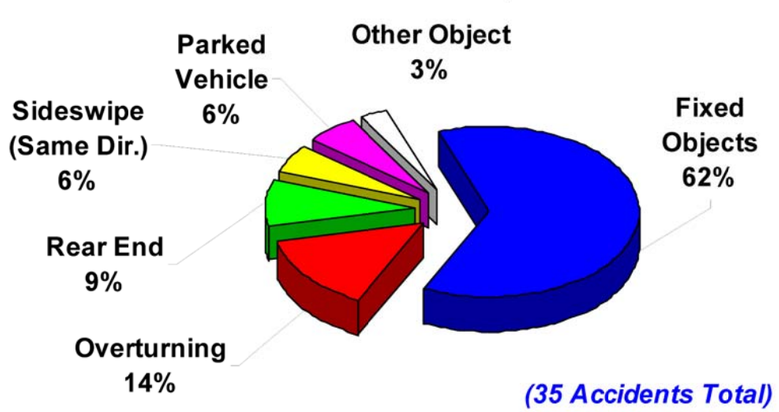
An accident diagram as well as charts showing the accident type distribution profile for the interchange ramps is shown on the following page.

For the purposes of this report, only the ramp accidents were examined for the I-25/C-470 interchange. Overall, the accident frequency during the 3-year study period was low on the included ramps. In contrast to other interchange locations, collisions with various fixed objects such as guardrail, delineator posts, bridge rail etc. were highest in the I-25 interchange zone. The reduced congestion, higher speeds and consistent, predictable driving conditions through this interchange are, most likely, the reason for the lower incidence of rear-end crashes when compared to previous freeway segments. At this location, timely winter maintenance attention, prompt repair of guardrail and bridgerail and maintenance of the pavement surface and pavement markings is recommended to continue the lower accident frequency at this location.

C–470 & I–25 Interchange
(Ramps only)



Accident Distribution by Accident Type
C470/I-25 Interchange - Ramps Only



(35 Accidents Total)

CONCLUSIONS AND RECOMMENDATIONS

The Transportation Equity Act for the 21st Century (TEA-21) of 1998 requires explicit consideration of safety in the transportation planning process. In order to meet this requirement and assist in the C-470 planning process, we have employed various analytical methods to evaluate the safety history on the segment of C-470 between the Ken Caryl Rd. interchange and the I-25 interchange. Primary among these methods is the recently developed concept of the Level of Service of Safety (LOSS). The LOSS concept makes it possible to accomplish the following:

- Qualitatively describe the degree of safety or un-safety of a roadway segment.
- Effectively communicate the magnitude of the safety problem to other professionals or elected officials.
- Bring perception of roadway safety in line with reality of safety performance reflecting a specific facility.
- Provide a frame of reference from a safety perspective for planning major corridor improvements.

Level of Service of Safety (LOSS) analysis shows that most of the C-470 corridor in the study area is performing at the LOSS-II level from an overall crash frequency as well as crash severity perspective. This observation suggests that C-470 is, on average, performing in an expected manner when viewed against freeways of this type statewide. In general, the potential for exceptional accident reduction in the study area is only moderate. This is not a surprising result as this highway is of relatively recent construction and was designed to a high standard. This study, however, has revealed the strong association of elevated accident occurrence with periods of high traffic volume and congested conditions. The higher incidence of the characteristic, congestion-related rear end and same direction sideswipe collisions is noted on the mainline as well as throughout most of the included interchanges. From a safety improvement perspective, any steps taken to increase capacity and improve traffic operations will have an accident reduction benefit. An overall reduction in accidents of 20% - 25% is expected to accompany capacity improvements such as adding an additional lane to the present freeway cross-section.

At the included interchanges, most of the safety problems can similarly be attributed to congestion and backups during periods of high traffic volume. Accident problems at interchange-related ramp intersections can be addressed by congestion mitigation such as adding travel and storage lanes, extending existing auxiliary lanes, using protected only left turn phases where approach turn problems exist and verifying adequate yellow and all-red times where broadside problems are present. In locations such as the Santa Fe and Broadway interchanges, more extensive modifications can provide commensurate operational and safety benefits.

Part II: Evaluation of Proposed Designs from a Safety Standpoint

Introduction

Hauer[4] formulated very clearly just how to measure road safety, "Of two alternative highway designs connecting points A and B and serving the same traffic, that highway design which is likely to have fewer and less severe crashes is the safer one. If so, safety of a road is always a matter of degree. A road can be safer or less safe." This formulation sets out sound principles to follow for the evaluation of design alternatives from a safety standpoint. In Part II we will assess the effect on existing safety of the facility that the proposed design alternative will have. For this analysis, a widened cross section to include four general purpose lanes in each direction is evaluated. An alternative 8-lane design under consideration includes two toll lanes in each direction. The extent to which safety is improved with the proposed design can be quantified by the estimated accident reduction for the design under investigation. These estimates are associated with some inherent degree of uncertainty, yet we believe this approach will allow us to identify the safety improvement potential of the design alternative.

Safety Gains Accompanying Capacity Improvements

Capacity improvement, in the form of additional traffic lanes, through this segment of C-470 is an alternative that would result in significant safety benefits in addition to the targeted operational improvements. Generally, freeway facilities of 6 or more lanes are expected to have fewer accidents than 4 lane facilities carrying the same amount of traffic. This can possibly be explained by increased gap availability for weaving, merging and diverging. Increased capacity, therefore, also yields a safety dividend. Figure 1, on the following page, depicts an SPF comparison calibrated for 4 and 8 lane freeways, showing the safety dividend expected to accompany freeway capacity improvement at an ADT of 100,000. Statewide safety studies indicate that for highway expansions from 4 to 6 lanes , 15%-20% reduction in accidents can be expected. Although data establishing the safety benefits of corridor expansion from 6 to 8 lanes are not readily available in Colorado, a conservative estimate of 10% reduction in accidents may be a reasonable assumption until additional data is obtained. On the basis of the SPF comparison, as shown by Figure 1, in the urban freeway environment, widening from 4 to 8 lanes, therefore, is expected to yield a total reduction in overall, mainline vehicular collisions of approximately 30%.

Figure 2, similarly, indicates a reduction in injury and fatal crashes associated with widening. Again, studies indicate that up to 30% of the fatal and injury producing accidents occurring on the present 4-lane configuration could be prevented after the corridor expansion is implemented.

A design alternative providing capacity improvement by substitution of express toll lanes for general purpose lanes is expected to provide similar safety benefits to those described above. An incremental increase in accident frequency over a non-toll alternative, however, can be expected due to additional turbulence generated in the traffic stream near toll facilities. This analysis, however, indicates that both mainline design alternatives will be significantly safer than the existing C-470 configuration. In addition, both alternatives are expected to address interchange problems identified in Part 1.

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[4] Hauer, E., (1999) *Safety Review of Highway 407: Confronting Two Myths*. TRB

Figure 1

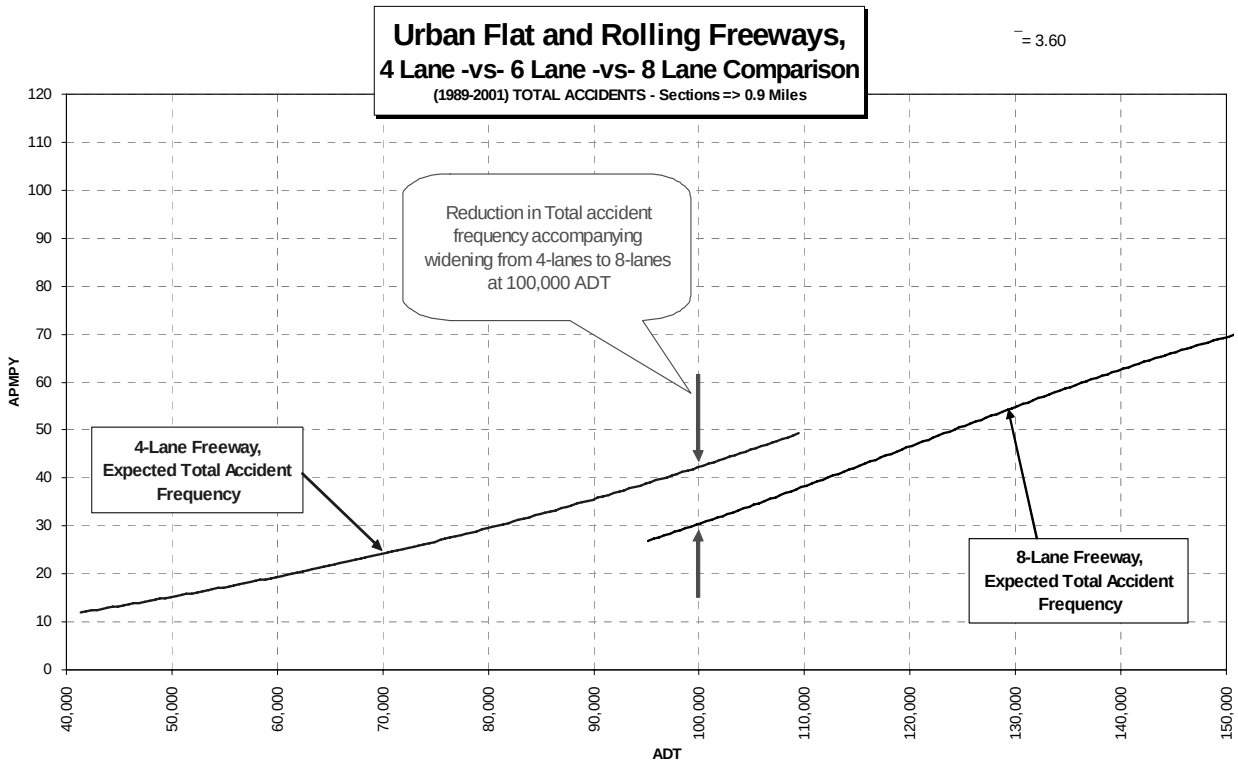
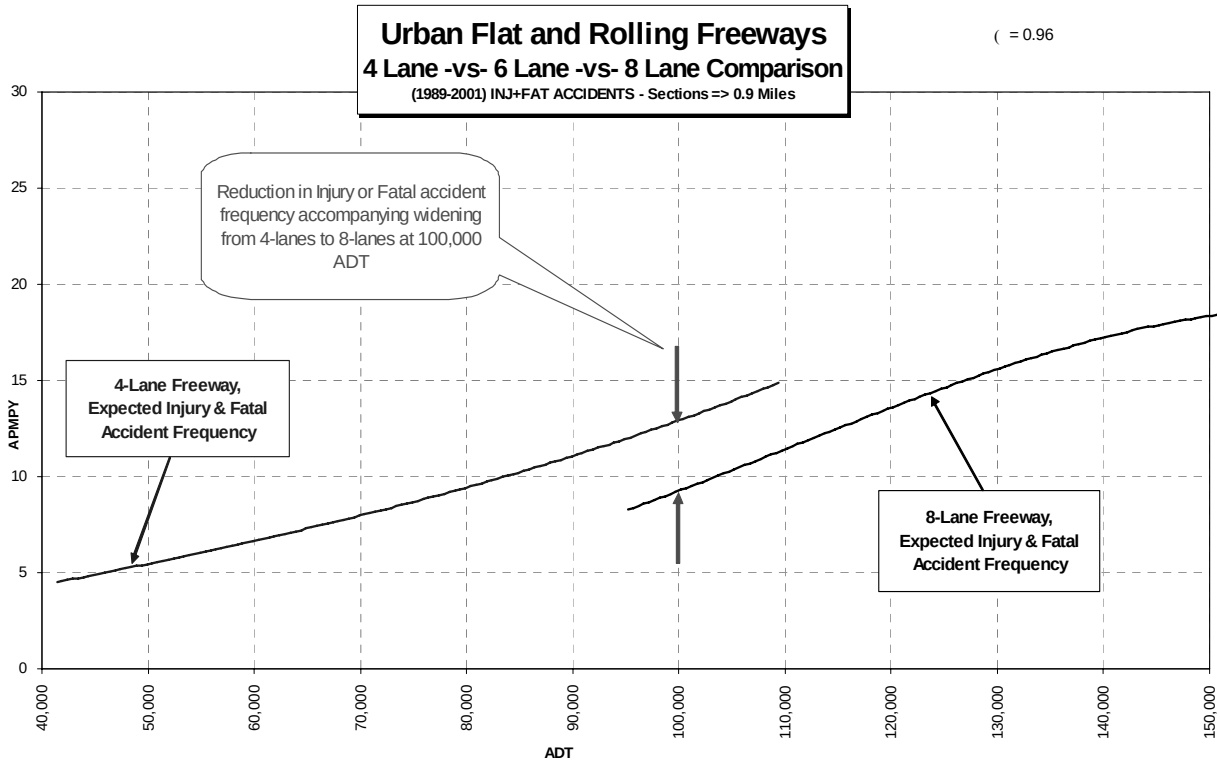


Figure 2



Considering the mainline crash frequency of 850 accidents during the 3-year study period, one can estimate how many accidents can be prevented over the life cycle of the expansion improvement (in this case, 20 years). The total 3-year accident count of 850 included 576 property damage accidents (PDO), 266 injury accidents (INJ) and 8 fatal accidents (FAT). On a yearly average this is approximately 282 PDO, 88 INJ and 2 FAT accidents per year. By assuming a 2% annual growth in the number of accidents caused by increasing traffic over the next 20 years, one can expect to prevent the number of accidents presented in Table 1 if the capacity improvements are constructed.

Appendix

Three Year (1/1/2000 - 12/31/2002) Detailed Summary of Accidents: Mainline, MP 10.00 - 26.21

Three Year (1/1/2000 - 12/31/2002) Detailed Summary of Accidents: Overall (including mainline & interchanges), MP 10.00 - 26.21

Visual FoxPro

Colorado Department of Transportation
Transportation Safety and Traffic Engineering
Detailed Accident Summary Report

09/08/2004

Job #: 20040908170911

Highway: 470A **Begin:** 10.00 **End:** 26.21 **From:** 01/01/2000 **To:** 12/31/2002

Severity

PDO:	576	
INJ:	266	361 :Injured
FAT:	8	9 :Killed
Total:	**850**	

Multi-Vehicle

One Vehicle:	240
Two Vehicles:	480
Three or More:	130
Unknown:	0
Total:	**850**

Location

On Road:	619	Off in Median:	15
Off Road Left:	105	Unknown:	1
Off Road Right:	110		
Off Road at Tee:	0	**Total:**	**850**

Accident Type

Overturning:	46	Domestic Animal:	1	Tree:	2
Other Non Collision:	39	Wild Animal:	13	Large Boulder:	0
School Age Peds:	0	Light/Utility Pole:	4	Rocks in Roadway:	0
Other Pedestrians:	0	Traffic Signal Pole:	0	Barricade:	0
Broadside:	1	Sign:	9	Wall/Building:	2
Head On:	11	Bridge Rail:	7	Crash Cushion:	0
Rear End:	414	Guard Rail:	37	Mailbox:	0
Sideswipe (Same):	99	Median Barrier:	15	Other Fixed Object:	3
Sideswipe (Opposite):	4	Bridge Abutment:	0	Involving Other Object:	44
Approach Turn:	3	Column/Pier:	0	Road Maintenance Equipment:	1
Overtaking Turn:	2	Culvert/Headwall:	0	Unknown:	1
Parked Motor Vehicle:	12	Embankment:	14	**Total:**	**850**
Railway Vehicle:	0	Curb:	1		
Bicycle:	0	Delineator Post:	40	Total Fixed Objects:	159
Motorized Bicycle:	0	Fence:	25	Total Other Objects:	45

Lighting Conditions

Daylight:	462
Dawn or Dusk:	28
Dark - Lighted:	56
Dark - Unlighted:	114
Unknown:	190
Total:	**850**

Weather Conditions

None:	570	Dust:	0
Rain:	33	Wind:	1
Snow/Sleet/Hail:	55	Unknown:	190
Fog:	1	**Total:**	**850**

Road Description

At Intersection:	9
At Driveway Access:	0
Intersection Related:	3
Non Intersection Urban:	462
In Alley:	0
Non Intersection Rural:	187
Highway Interchange:	188
Unknown:	1
Total:	**850**

Road Conditions

Dry:	547
Wet:	56
Muddy:	0
Snowy:	17
Icy:	25
Slushy:	8
Foreign Material:	0
With Road Treatment:	0
Dry w/Icy Road Treatment:	2
Wet w/Icy Road Treatment:	2
Snowy w/Icy Road Treatment:	1
Icy w/Icy Road Treatment:	1
Slushy w/Icy Road Treatment:	0
Unknown:	191
Total:	**850**

Mainline/Ramps/Frontage Rds

Mainline:	850
Crossroad (Ramp A):	0
Frontage Rd:	0

Ramps

B:	0	H:	0
C:	0	I:	0
D:	0	J:	0
E:	0	K:	0
F:	0	T:	0
G:	0		

Intsx Frontage/Ramps

M:	0	N:	0
O:	0	P:	0

HOV Lanes:	0		
Uknwn:	0	**Total:**	**850**

Accident Rates

PDO:	0.47	MVMT	Total:	0.70 MVMT
Injury:	0.22	MVMT		
Fatal:	0.66	100 MVMT		

ADT: 68494 **WHI:** -6.09 **Length:** 16.22 **Coris File:** tcoris2003.dbf

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Highway: 470A **Begin:** 10.00 **End:** 26.21 **From:** 01/01/2000 **To:** 12/31/2002

Vehicle Type	Veh 1	Veh 2	Veh 3
Passenger Car/Van:	503	364	85
Passenger Car/Van w/Trl:	2	1	1
Pickup Truck/Utility Van:	117	77	22
Pickup Truck/Utility Van w/Trl:	16	3	0
Truck 10k lbs or Less:	7	4	0
Trucks > 10k lbs/Bus > 15 People:	23	15	1
School Bus < 15 People:	0	0	0
Non School Bus < 15 People:	0	0	0
Motorhome:	1	1	0
Motorcycle:	4	1	1
Bicycle:	0	0	0
Motorized Bicycle:	0	0	0
Farm Equipment:	0	0	0
Hit and Run - Unknown:	7	2	1
Other:	0	0	0
Unknown:	170	142	19
Total:	**850**	**610**	**130**

Vehicle Movement	Veh 1	Veh 2	Veh 3
Going Straight:	654	212	26
Slowing:	22	176	18
Stopped in Traffic:	1	186	64
Making Right Turn:	1	0	0
Making Left Turn:	3	0	0
Making U-Turn:	1	0	0
Passing:	11	1	0
Backing:	2	1	0
Enter/Leave Parked Position:	1	0	0
Starting in Traffic:	4	0	1
Parked:	1	10	1
Changing Lanes:	88	2	2
Avoiding Object in Road:	16	8	0
Weaving:	4	0	0
Other:	11	4	0
Unknown:	30	10	18
Total:	**850**	**610**	**130**

Contributing Factor	Veh 1	Veh 2	Veh 3
No Apparent Contributing Factor:	333	444	105
Asleep at the Wheel:	21	0	0
Illness:	3	0	0
Distracted by Passenger:	7	0	0
Driver Inexperience:	61	3	1
Driver Fatigue:	4	0	0
Driver Preoccupied:	221	6	3
Driver Unfamilar with Area:	1	0	1
Driver Emotionally Upset:	5	0	0
Evading Law Enforcement Officier:	0	0	0
Physical Disability:	1	0	0
Unknown:	193	157	20
Total:	**850**	**610**	**130**

Direction	Veh 1	Veh 2	Veh 3
North:	9	4	2
Northeast:	0	0	0
East:	378	271	46
Southeast:	0	0	0
South:	1	5	0
Southwest:	0	0	0
West:	432	319	61
Northwest:	0	0	0
Unknown:	30	11	21
Total:	**850**	**610**	**130**

Condition of Driver	Veh 1	Veh 2	Veh 3
No Impairment Suspected:	758	579	123
Alcohol Involved:	44	2	0
RX Drugs or Medication Involved:	0	0	0
Illegal Drugs Involved:	0	0	0
Alcohol and Drugs Involved:	2	0	0
Driver/Pedestrian not Observed:	39	15	5
Unknown:	7	14	2
Total:	**850**	**610**	**130**

ADT: 68494 **WHI:** -6.09 **Length:** 16.22 **Coris File:** tcoris2003.dbf

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Visual FoxPro

Colorado Department of Transportation
Transportation Safety and Traffic Engineering
Detailed Accident Summary Report

09/08/2004

Job #: 20040908170352

Highway: 470A **Begin:** 10.00 **End:** 26.21 **From:** 01/01/2000 **To:** 12/31/2002

Severity

PDO:	1140	
INJ:	417	579 :Injured
FAT:	8	9 :Killed
Total:	**1565**	

Multi-Vehicle

One Vehicle:	269
Two Vehicles:	1129
Three or More:	165
Unknown:	2
Total:	**1565**

Location

On Road:	1313	Off in Median:	15
Off Road Left:	114	Unknown:	1
Off Road Right:	121		
Off Road at Tee:	1	**Total:**	**1565**

Accident Type

Overturning:	50	Domestic Animal:	1	Tree:	3
Other Non Collision:	42	Wild Animal:	14	Large Boulder:	0
School Age Peds:	0	Light/Utility Pole:	5	Rocks in Roadway:	0
Other Pedestrians:	1	Traffic Signal Pole:	0	Barricade:	0
Broadside:	55	Sign:	12	Wall/Building:	2
Head On:	11	Bridge Rail:	7	Crash Cushion:	0
Rear End:	851	Guard Rail:	38	Mailbox:	0
Sideswipe (Same):	141	Median Barrier:	15	Other Fixed Object:	3
Sideswipe (Opposite):	5	Bridge Abutment:	1	Involving Other Object:	45
Approach Turn:	147	Column/Pier:	1	Road Maintenance Equipment:	2
Overtaking Turn:	4	Culvert/Headwall:	1	Unknown:	1
Parked Motor Vehicle:	14	Embankment:	15	**Total:**	**1565**
Railway Vehicle:	0	Curb:	9		
Bicycle:	2	Delineator Post:	42	Total Fixed Objects:	179
Motorized Bicycle:	0	Fence:	25	Total Other Objects:	47

Lighting Conditions

Daylight:	935
Dawn or Dusk:	44
Dark - Lighted:	151
Dark - Unlighted:	127
Unknown:	308
Total:	**1565**

Weather Conditions

None:	1129	Dust:	0
Rain:	58	Wind:	1
Snow/Sleet/Hail:	65	Unknown:	310
Fog:	2	**Total:**	**1565**

Road Description

At Intersection:	10
At Driveway Access:	0
Intersection Related:	3
Non Intersection Urban:	462
In Alley:	0
Non Intersection Rural:	187
Highway Interchange:	902
Unknown:	1
Total:	**1565**

Road Conditions

Dry:	1084
Wet:	100
Muddy:	0
Snowy:	20
Icy:	31
Slushy:	9
Foreign Material:	0
With Road Treatment:	0
Dry w/Icy Road Treatment:	4
Wet w/Icy Road Treatment:	4
Snowy w/Icy Road Treatment:	1
Icy w/Icy Road Treatment:	2
Slushy w/Icy Road Treatment:	0
Unknown:	310
Total:	**1565**

Mainline/Ramps/Frontage Rds

Mainline:	850
Crossroad (Ramp A):	397
Frontage Rd:	0

Ramps

B:	19	H:	0
C:	21	I:	0
D:	28	J:	0
E:	10	K:	0
F:	0	T:	0
G:	0		

Intsx Frontage/Ramps

M:	0	N:	119
O:	121	P:	0

HOV Lanes:	0		
Uknwn:	0	**Total:**	**1565**

Accident Rates

PDO:	0.94	MVMT	Total:	1.28 MVMT
Injury:	0.34	MVMT		
Fatal:	0.66	100 MVMT		

ADT: 68494 **WHI:** -5.01 **Length:** 16.22 **Coris File:** tcoris2003.dbf

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Highway: 470A **Begin:** 10.00 **End:** 26.21 **From:** 01/01/2000 **To:** 12/31/2002

Vehicle Type	Veh 1	Veh 2	Veh 3
Passenger Car/Van:	976	850	109
Passenger Car/Van w/Trl:	3	4	1
Pickup Truck/Utility Van:	213	146	29
Pickup Truck/Utility Van w/Trl:	18	3	0
Truck 10k lbs or Less:	13	7	0
Trucks > 10k lbs/Bus > 15 People:	36	19	4
School Bus < 15 People:	0	1	0
Non School Bus < 15 People:	0	0	0
Motorhome:	1	1	0
Motorcycle:	9	4	1
Bicycle:	1	1	0
Motorized Bicycle:	0	0	0
Farm Equipment:	0	0	0
Hit and Run - Unknown:	10	3	1
Other:	0	0	0
Unknown:	285	257	22
Total:	**1565**	**1296**	**167**

Vehicle Movement	Veh 1	Veh 2	Veh 3
Going Straight:	954	367	33
Slowing:	44	208	19
Stopped in Traffic:	7	545	84
Making Right Turn:	167	34	0
Making Left Turn:	148	91	6
Making U-Turn:	1	1	0
Passing:	16	1	0
Backing:	8	1	0
Enter/Leave Parked Position:	1	1	0
Starting in Traffic:	47	6	1
Parked:	1	11	1
Changing Lanes:	104	5	2
Avoiding Object in Road:	17	8	0
Weaving:	4	0	0
Other:	13	5	0
Unknown:	33	12	21
Total:	**1565**	**1296**	**167**

Contributing Factor	Veh 1	Veh 2	Veh 3
No Apparent Contributing Factor:	671	1001	137
Asleep at the Wheel:	23	1	0
Illness:	4	0	0
Distracted by Passenger:	11	0	0
Driver Inexperience:	107	5	1
Driver Fatigue:	4	0	0
Driver Preoccupied:	404	8	5
Driver Unfamilar with Area:	16	0	1
Driver Emotionally Upset:	5	0	0
Evading Law Enforcement Officier:	1	0	0
Physical Disability:	1	0	0
Unknown:	318	281	23
Total:	**1565**	**1296**	**167**

Direction	Veh 1	Veh 2	Veh 3
North:	232	151	14
Northeast:	0	0	0
East:	576	471	55
Southeast:	2	3	0
South:	133	190	6
Southwest:	0	0	0
West:	591	469	64
Northwest:	0	0	0
Unknown:	31	12	28
Total:	**1565**	**1296**	**167**

Condition of Driver	Veh 1	Veh 2	Veh 3
No Impairment Suspected:	1440	1250	157
Alcohol Involved:	55	2	0
RX Drugs or Medication Involved:	0	0	0
Illegal Drugs Involved:	0	0	0
Alcohol and Drugs Involved:	2	0	0
Driver/Pedestrian not Observed:	51	21	5
Unknown:	17	23	5
Total:	**1565**	**1296**	**167**

ADT: 68494 **WHI:** -5.01 **Length:** 16.22 **Coris File:** tcoris2003.dbf

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