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 effecting 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.

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. In order to meet this requirement we employed a recently developed concept of the Level of Service of Safety[2] (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.

The study area includes: Interstate 25 (I-25) from Logan St. (MP 206.62) through State Highway (SH) 40 (MP 210.33) and on SH 6 from I-25 (MP 284.48) to Federal (MP 283.68). The scope of the safety chapter of the Environmental Impact Statement (EIS) is as follows:

- Assess the magnitude and nature of the safety problem within the project 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 EIS will prepare a framework for the evaluation of alternatives from a safety standpoint.

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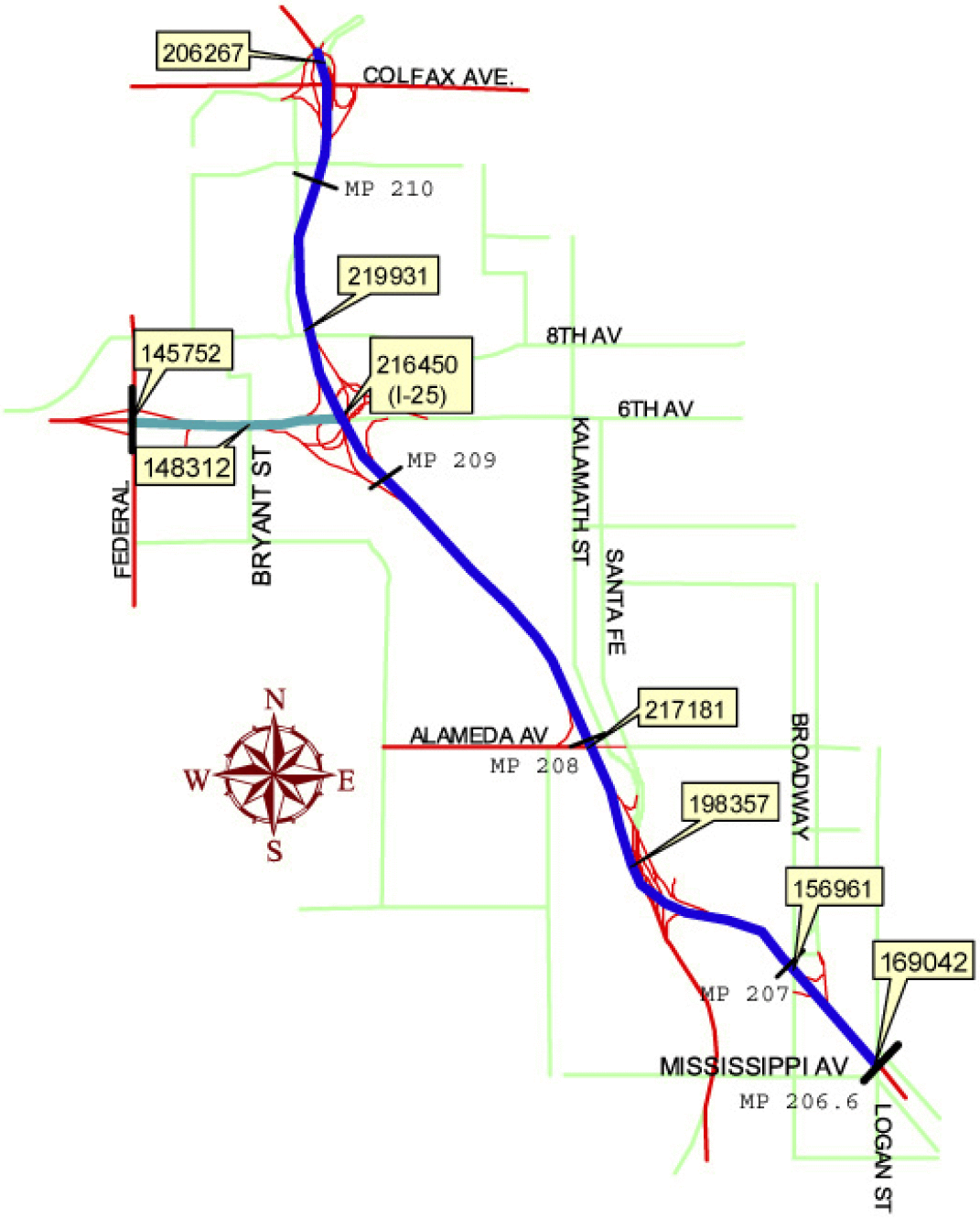
[1] Hauer, E. (1999) *Safety Review of Highway 407: Confronting Two Myths*. TRB

[2] Kononov, J. & Allery, B. (2003) *Level of Service of Safety-Conceptual Blueprint and Analytical Framework*. Presented at the TRB Annual Meeting, Washington D.C. (January 2003)

SITE LOCATION AND CONDITIONS

This study examines I-25 from the Logan St. bridge to the SH 40 interchange and SH 6 from the I-25 interchange to the SH 88 (Federal Blvd.) interchange. I-25 is classified as a Federal-Aid Interstate (FAI) urban highway and SH 6 is classified as a National Highway System (NHS) urban, 6-lane freeway in this area. The study area can be described as an urban environment in rolling terrain typical of metro Denver. The 1999 average daily traffic counts for both highways can be seen in **figure 1** below. Approximately 3% truck traffic was reported on the SH 6 portion and about 7% truck traffic travels on this section of I-25. The posted speed limit is 55 mph through the study section on both highways.

Figure 1: Year 2000 ADT Counts



ACCIDENT HISTORY AND PROBLEM ANALYSIS

The accident history for the period of January 1, 1999 through December 31, 2001 was examined to identify the accident distribution profile. A total of three thousand four hundred fifteen (3415) accidents were reported in the three year period and eight of them were fatal.

Figure 2

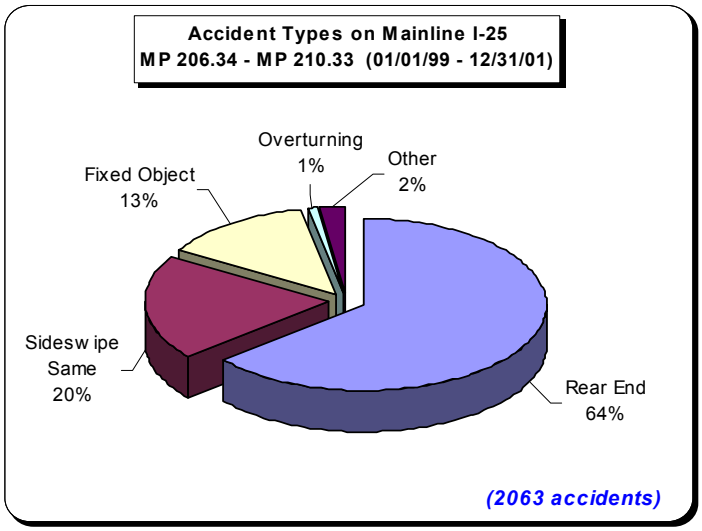
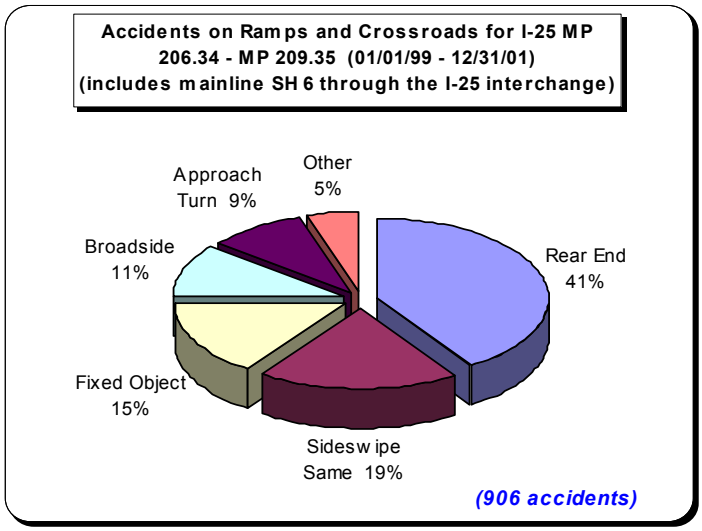


Figure 3



Figures 2 and **3** show accident types and proportions that have occurred over the 3 year study period on the I-25 portion. *Rear end* and *sideswipe same* collisions are the predominant accident types on both the mainline and interchange locations of I-25.

Figure 4

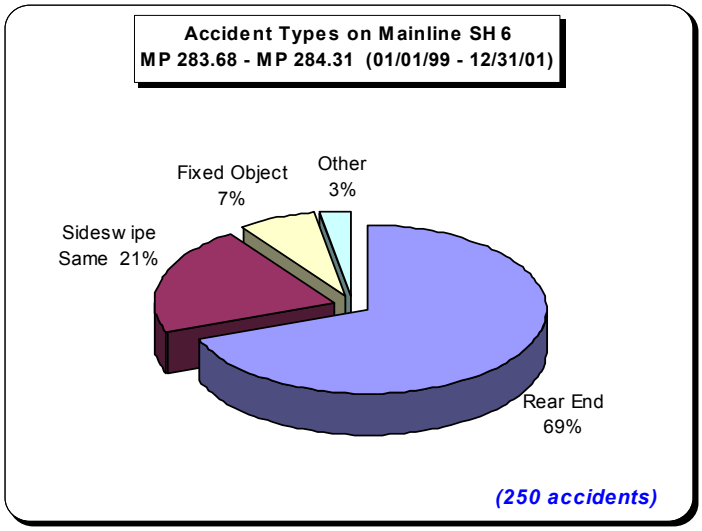
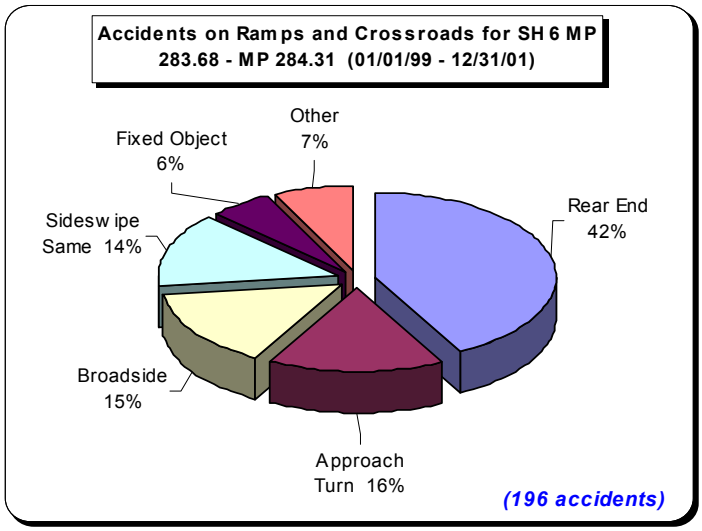


Figure 5



Accidents that have occurred over the 3 year study period on the SH 6 portion are shown in **figures 4** and **5**. *Rear end* and *sideswipe same* collisions are the predominant accident types on this section of mainline SH 6. *Rear end* and *approach turn* accidents are the most common accident types at the 2 interchanges on this section of SH 6.

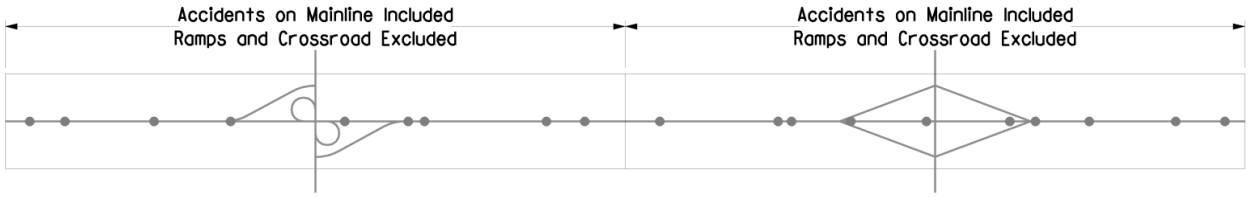
This study will separately examine freeway segments and interchange related safety problems.

We have refined the assessment of the magnitude of safety problems on highway 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 accidents involving an injury or fatality. It allows us to assess the magnitude of the safety problem from the frequency and severity standpoint.

All of the dataset preparation was performed using the Colorado Department of Transportation (CDOT) accident databases. Accident history for each facility was prepared over the 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 6** illustrates how the dataset was prepared for urban freeway facilities.

Figure 6

6–Lane Urban Freeway



Development of the SPF lends itself well to the conceptual formulation of the Level of Service of Safety (LOSS). The concept of level of service uses qualitative measures that characterize safety of a roadway segment in reference to its 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.

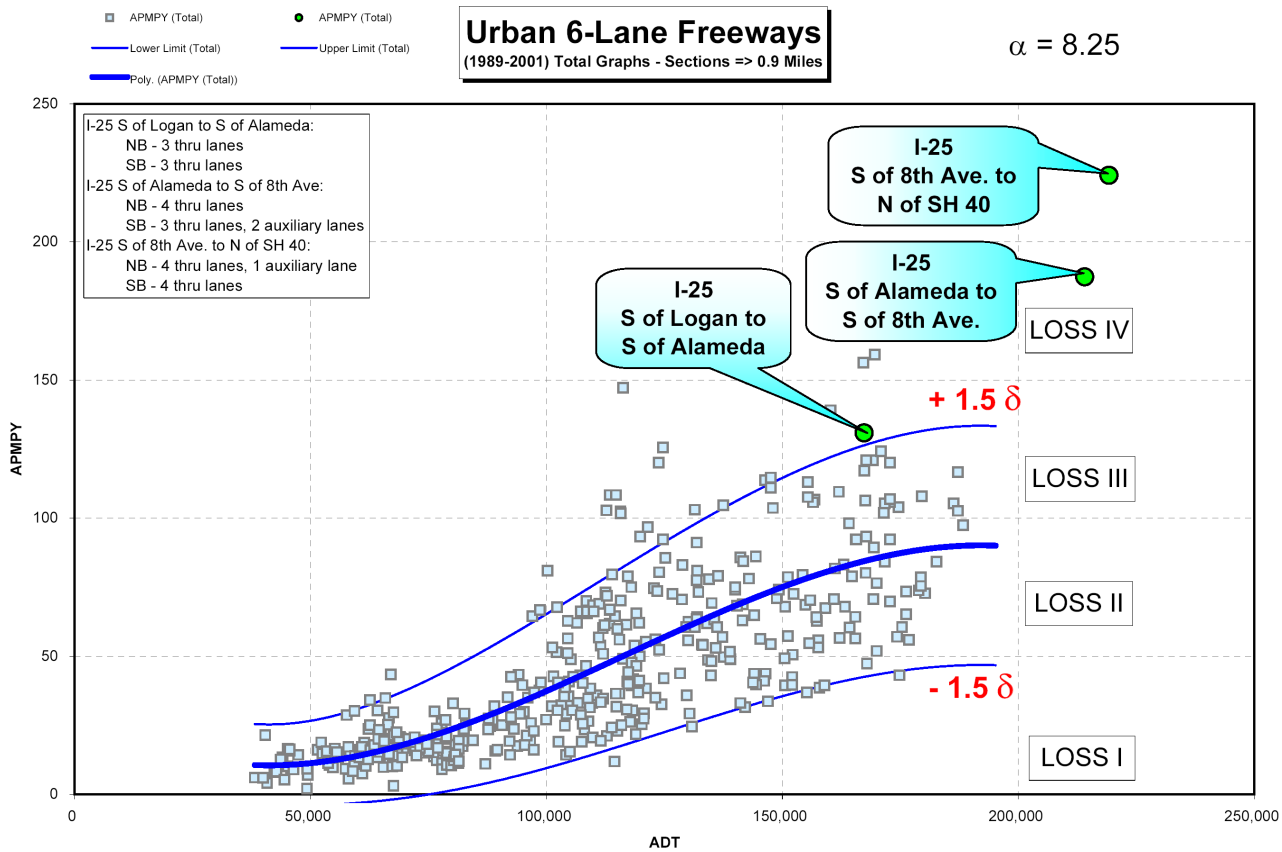
LOSS-I - Indicates low potential for accident reduction
LOSS-II- Indicates better than expected safety performance
LOSS-III - Indicates less than expected safety performance
LOSS-IV - Indicates high potential for accident reduction

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 the safety problem is present, LOSS will only describes its magnitude from the frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostics and pattern recognition techniques.

Because of the close interchange spacing of the I-25, Bryant St. and Federal Blvd. interchanges on the SH 6 highway study section, it was not included on the SPF frequency and severity graphs. Rather, the SH 6 mainline section from I-25 to Federal will be examined later in this report in concert with the Bryant and Federal interchanges.

Figure 7 depicts the SPF calibrated specifically for urban six-lane freeways. Data for three years of accident history (averaged together) on I-25 has been split into separate segments and plotted for evaluation. SPF total and SPF inj+fat analysis describes the magnitude of the safety problem from a severity and frequency standpoint.

Figure 7



From figure 7, it can be observed that all three I-25 sections are LOSS IV (high potential for accident reduction). Since we have so few segments of urban 6-lane freeway with continuous auxiliary lanes in Colorado carrying in excess of 200,000 cars per day, it is difficult to predict the expected safety performance with confidence. Even when this uncertainty is taken into consideration, in our opinion accident frequency in excess of 180 accidents per mile per year suggests a high potential for accident reduction.

It seems that safety performance is heavily influenced by the interchange spacing, even though ramp accidents are deleted from the model. The presence of ramps and the spacing of interchanges on the I-25 study sections are more frequent than at other urban locations. This is a partial explanation for the elevated I-25 accident frequencies.

Generally 8-lane freeway facilities are expected to have fewer accidents than 6-lane facilities carrying the same amount of traffic. This can possibly be explained by increased gap availability for weaving, merging and diverging. A similar improvement in safety is observed when an urban 4-lane freeway is upgraded to a 6-lane facility.

Figure 8

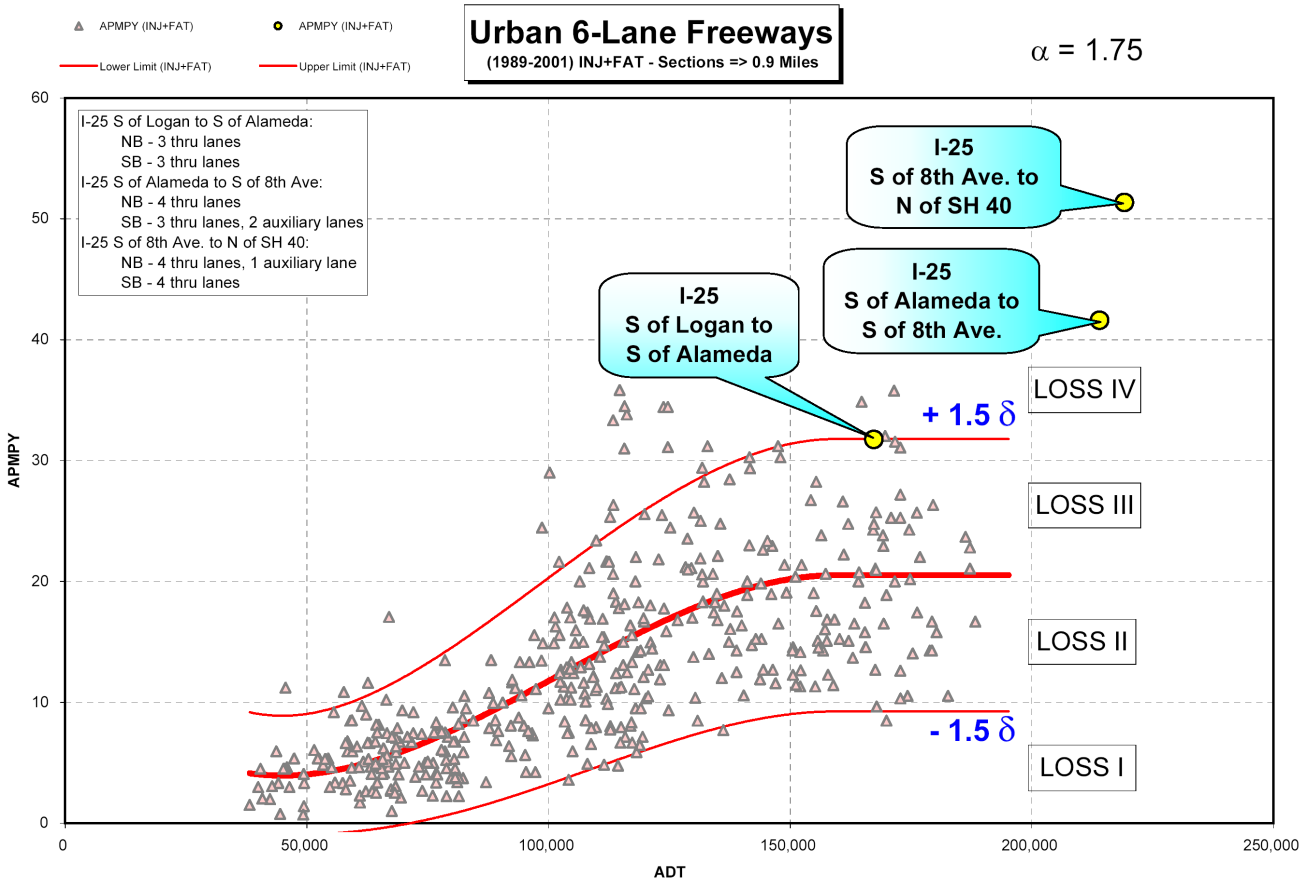


Figure 8 depicts the SPF graph calibrated for injury and fatal accidents only. Figure 8 appears to roughly mirror the total accident SPF shown in figure 7. This increased accident frequency is congestion related, which is reflected by the injury percentage being somewhat lower than typical of similar facilities. Nevertheless, **the overall number of injury accidents is much higher than is expected. This points to a need to provide additional capacity from the safety as well as mobility standpoint.**

We have further examined roadway segments for accident concentrations and patterns. The roadways within project limits were 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 normative percentages for diagnostics of safety problems in the urban, 6-lane 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** on the following page.

Table 1
Diagnostic Norms for Urban 6-Lane Freeways

Urban 6-Lane Freeways					
Description	**Percent**	**Description**	**Percent**	**Description**	**Percent**
PDO	71.14%	Daylight	68.75%	Wild Animal	0.44%
INJ	28.49%	Dawn or Dusk	3.79%	Light or Utility Pole	1.40%
FAT	0.36%	Dark - Lighted	19.58%	Traffic Signal Pole	0.04%
Single Vehicle Accidents	21.23%	Dark - Unlighted	5.91%	Sign	0.87%
Two Vehicle Accidents	59.61%	Unknown Lighting	1.97%	Bridge Rail	0.36%
Three or more Vehicle Accident	19.00%	No Adverse Weather	81.12%	Guard Rail	3.85%
Unknown Number of Vehicles	0.16%	Rain	6.61%	Median Barrier	8.61%
On Road	77.55%	Snow or Sleet or Hail	9.72%	Bridge Abutment	0.11%
Off Road	21.63%	Fog	0.21%	Column or Pier	0.06%
Off Road Left	11.02%	Dust	0.01%	Culvert or Headwall	0.07%
Off Road Right	10.45%	Wind	0.32%	Embankment	0.36%
Off Road at Tee	0.04%	Unknown Weather	2.00%	Curb	0.47%
Off Road in Median	0.12%	Overturning	2.74%	Delineator Post	0.47%
Unknown Road Location	0.82%	Other Non Collision	1.48%	Fence	0.83%
Dry Road	75.53%	School Age Pedestrians	0.05%	Tree	0.21%
Wet Road	10.24%	All Other Pedestrians	0.17%	Large Boulder	0.03%
Muddy Road	0.07%	Broadside	1.29%	Rocks in Roadway	0.05%
Snowy Road	2.83%	Head On	0.23%	Barricade	0.17%
Icy Road	6.37%	Rear End	50.27%	Wall or Building	0.19%
Slushy Road	1.82%	Sideswipe (Same Direction)	18.78%	Crash Cushion	0.30%
Foreign Material Road	0.13%	Sideswipe (Opposite Direction)	0.20%	Mailbox	0.01%
With Road Treatment	0.20%	Approach Turn	1.10%	Other Fixed Object	0.26%
Dry with Icy Road Treatment	0.04%	Overtaking Turn	0.35%	Involving Other Object	1.79%
Wet with Icy Road Treatment	0.05%	Parked Motor Vehicle	1.47%	Road Maintenance Equipment	0.10%
Snowy with Icy Road Treatment	0.05%	Railway Vehicle	0.00%	Unknown Accident Type	0.75%
Icy with Icy Road Treatment	0.09%	Bicycle	0.03%	Total Fixed Objects	18.68%
Slushy with Icy Road Treatment	0.02%	Motorized Bicycle	0.00%	Total Other Objects	1.93%
Unknown Road Condition	2.55%	Domestic Animal	0.03%	**Total Accidents**	**23,849**

Figure 9

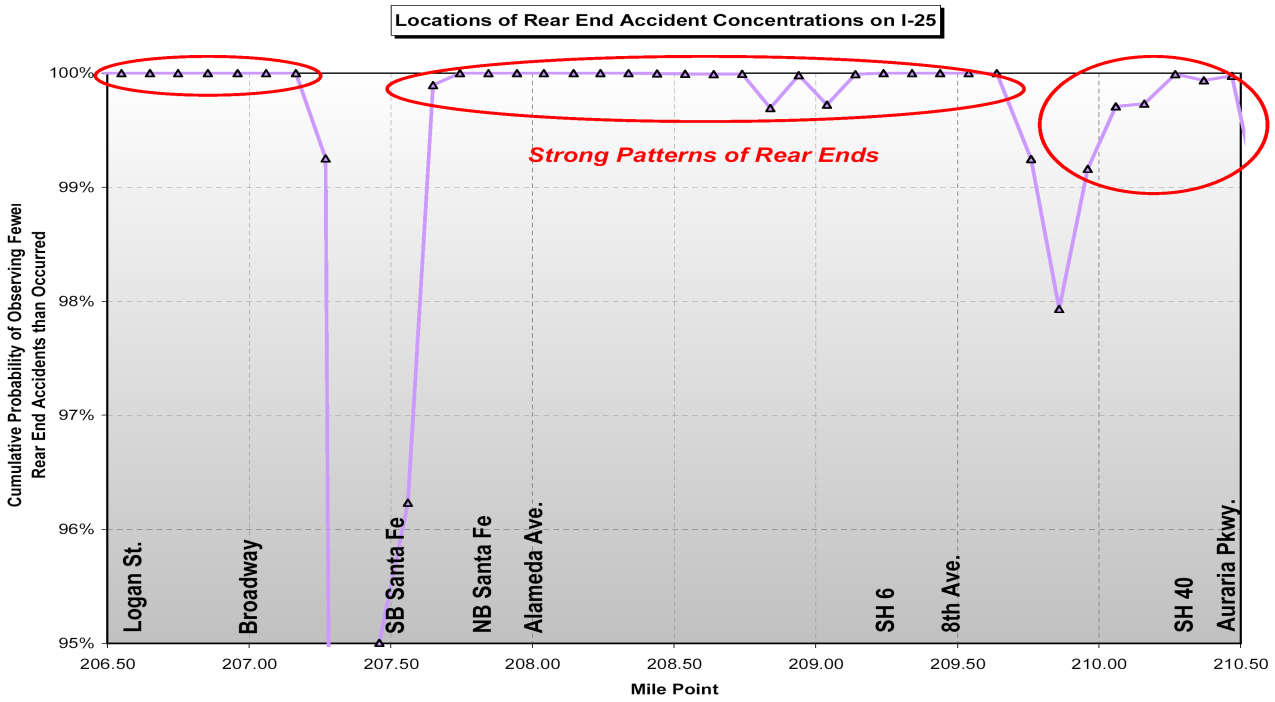
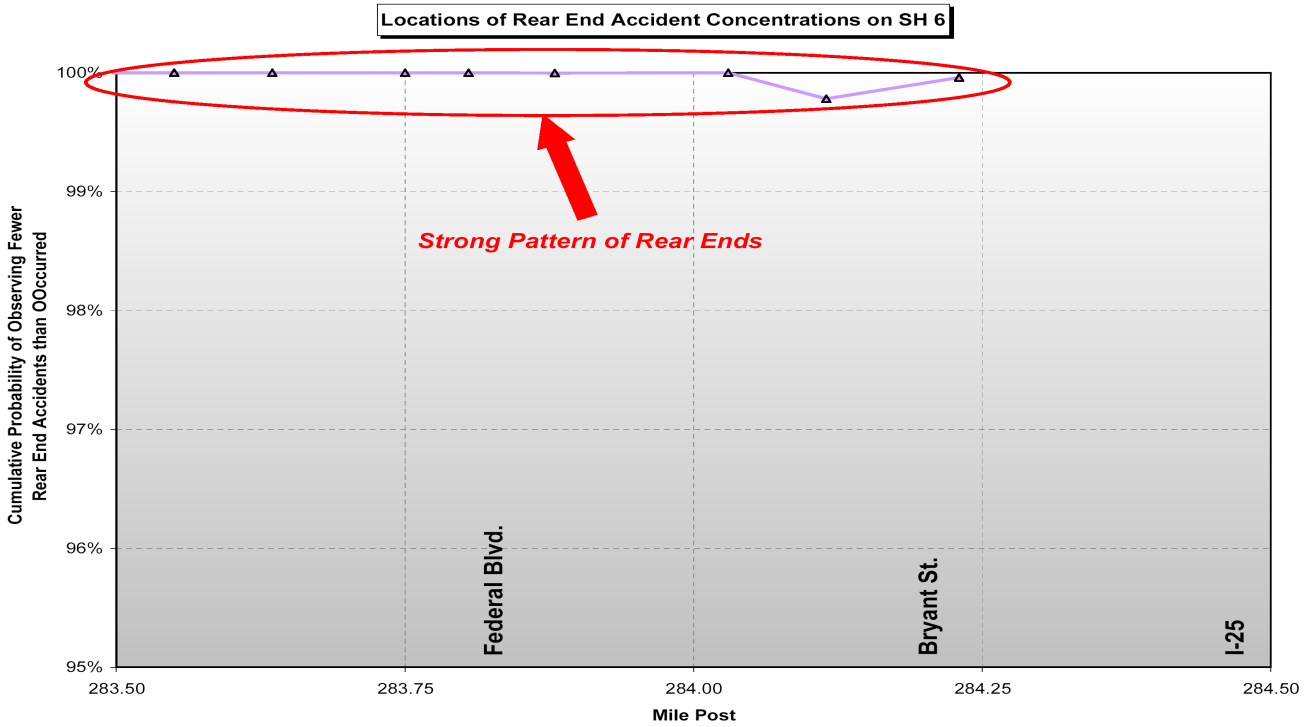


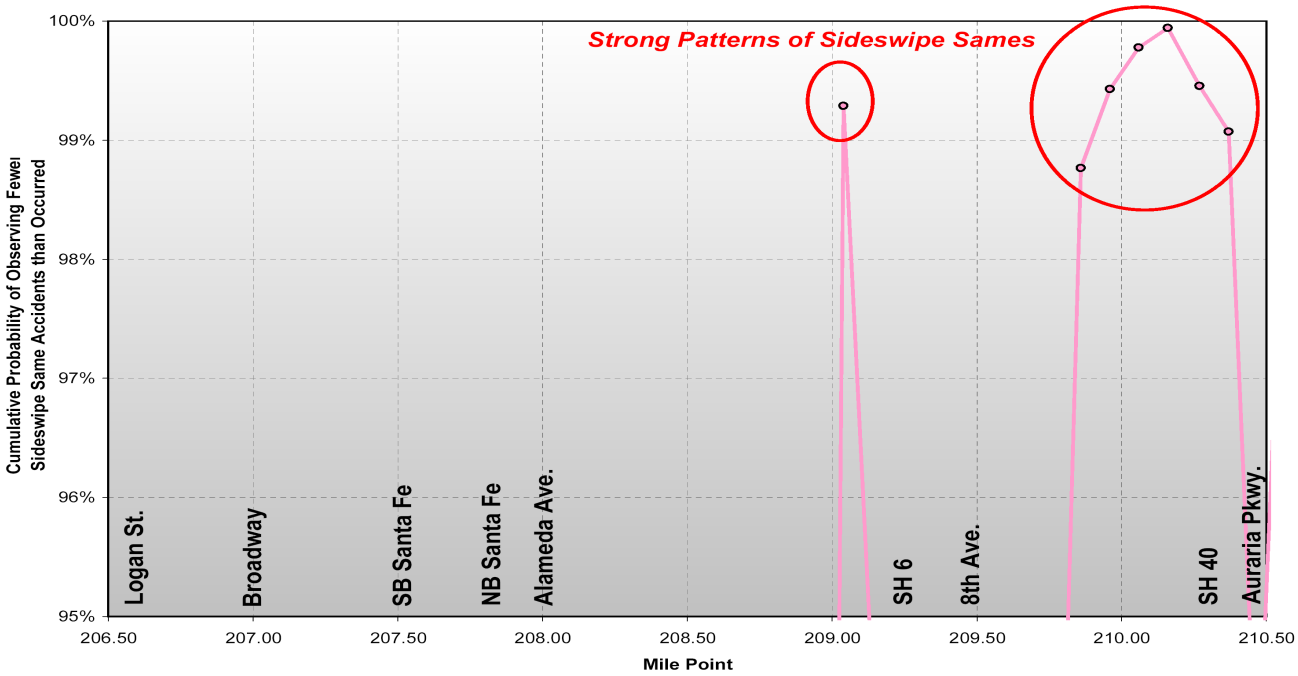
Figure 10



Figures 9 and **10** show locations with high frequencies of rear end type accidents on I-25 and SH 6. Well defined patterns of rear-end accidents reflects congestion related safety problems, which is consistent with the SPF analysis presented in this report.

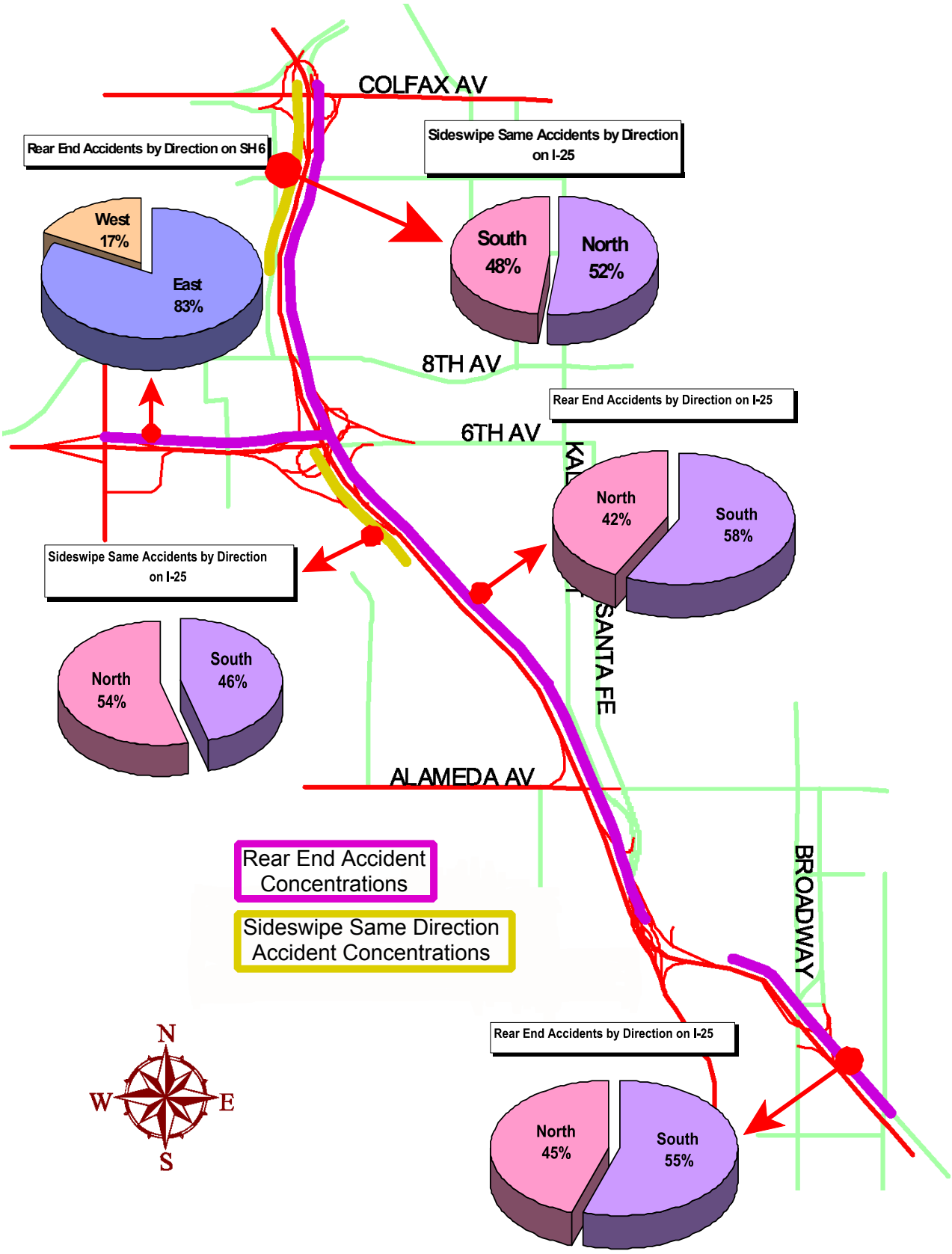
Figure 11

Locations of Sideswipe Same Accident Concentrations on I-25



Locations of statistically high frequencies of sideswipe same accidents on I-25 are shown in **figure 11**. While a strong pattern of rear end collisions is present at the 2 locations of left side merges within the Santa Fe interchange, it is of interest to note that there are no sideswipe same patterns in these areas.

Figure 12
Locations Exhibiting Strong Patterns of Rear End and Sideswipe Same Accidents



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. The following sections of this study will address safety problems at specific interchanges.

I-25 and Broadway/Lincoln Interchange

An accident diagram, as well as figures showing the accident type distribution profiles for each of the interchange related intersections is shown on the following page, and will be referred to throughout this section.

Figure 13 shows the accident type distribution profile at the SB I-25 off ramp and Broadway signalized intersection. A significant broadside problem is present at this location. Thirty-two accidents occurred at this location in the 3 year study period and 22 of them were broadsides in the SB direction. This suggests a signal head visibility problem. During the reconstruction of this intersection, signal heads need to be placed for maximum visibility of traffic.

Accidents that occurred during the 3 year study period at the Broadway and I-25 south bound on ramp intersection (also the intersection of Broadway and Kentucky) are shown in **figure 14**. Approach turns are a significant problem at this location, and constitute 63% of the total number of accidents. Sideswipe same accidents also appear to be occurring at a somewhat higher than expected rate.

The most effective way of preventing approach turn accidents is to use protected-only phasing for left turn movements. Sideswipe same accidents can be prevented by wider lanes, longer storage lanes for turning movement and correct use of striping and pavement markings.

Figure 15 presents a pie chart showing the accident types that occurred at the NB I-25 on and off ramps and Lincoln intersection. A total of 8 accidents occurred here in the 3 year period. A low frequency sideswipe pattern is present at this location.

Features that can reduce the frequency of sideswipe same accidents include widened lanes, longer storage lanes for turning movement and correct use of striping and pavement markings.

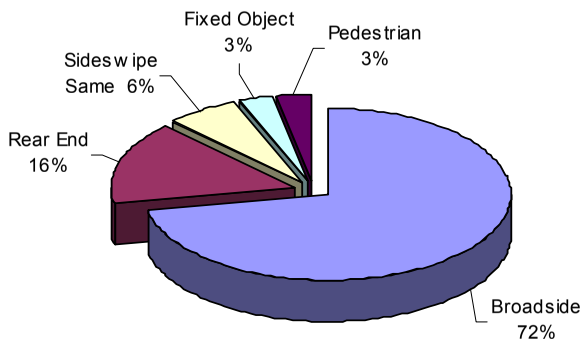
Accidents that occurred on the ramp sections of the I-25 and Broadway/Lincoln interchange are shown in **figure 16**. A low frequency pattern of single vehicle accidents has occurred on the NB I-25 off ramp. While only 5 single vehicle accidents occurred in this area, the severity of these fixed object and overturning accidents is high, with 4 of the 5 accidents resulting in injuries.

Providing appropriate warning signs and clear pavement markings can help motorists judge the ramp curvature and geometry. These measures can assist in reducing the number of single vehicle, run off the road type accidents. Future interchange design alternatives will need to consider the high severity of accidents on this ramp.

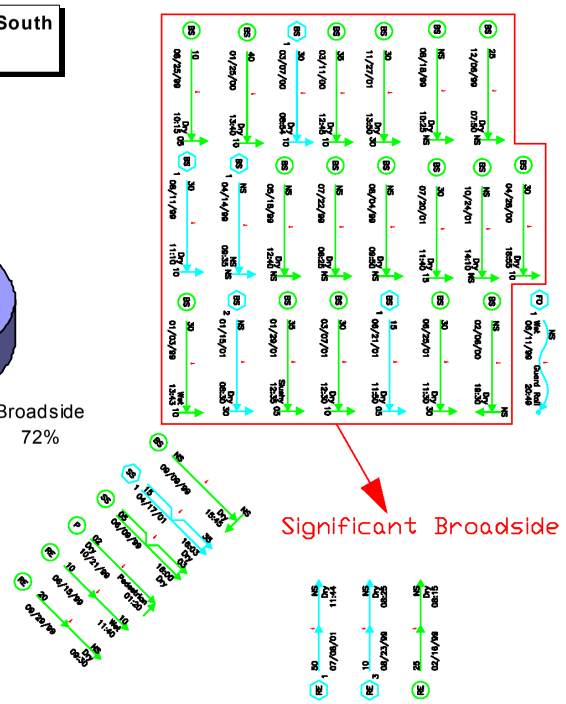
I–25 & BROADWAY/LINCOLN AVE. INTERCHANGE

Figure 13

Accident Types at the I-25 and Broadway South Bound Off Ramp Intersection



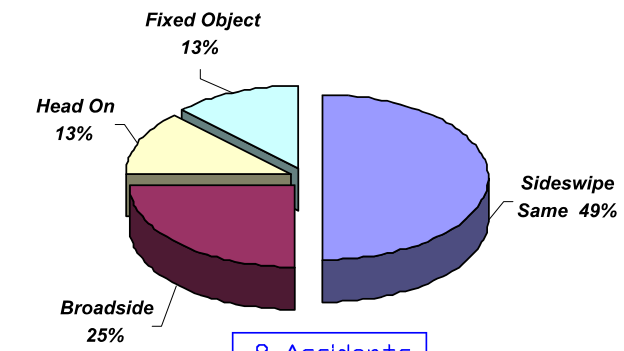
32 Accidents



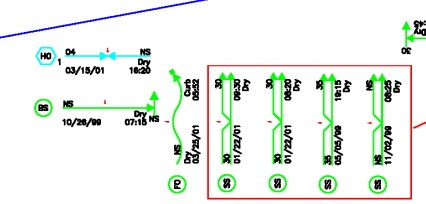
Significant Broadside Problem

Figure 15

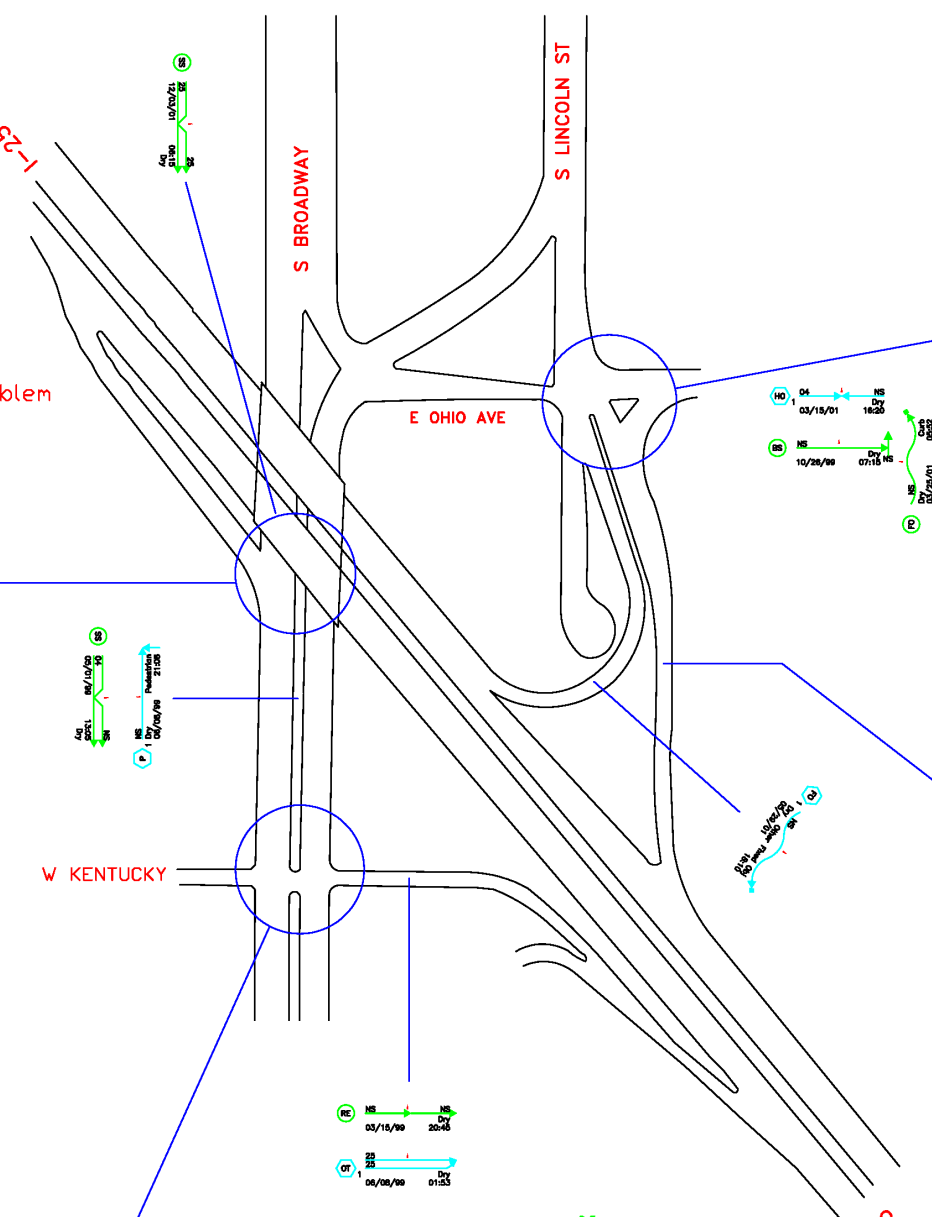
Accident Types at the I-25 and Broadway North Bound On and Off Ramp Intersection



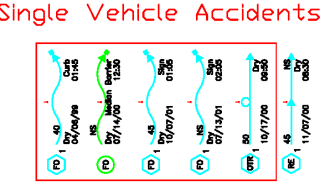
8 Accidents



Low Frequency Pattern of Sideswipe Same Accidents



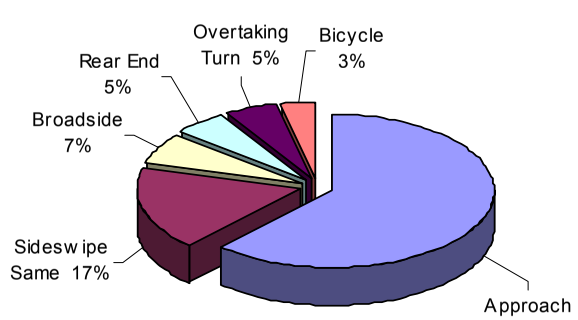
Low Frequency Pattern of Single Vehicle Accidents



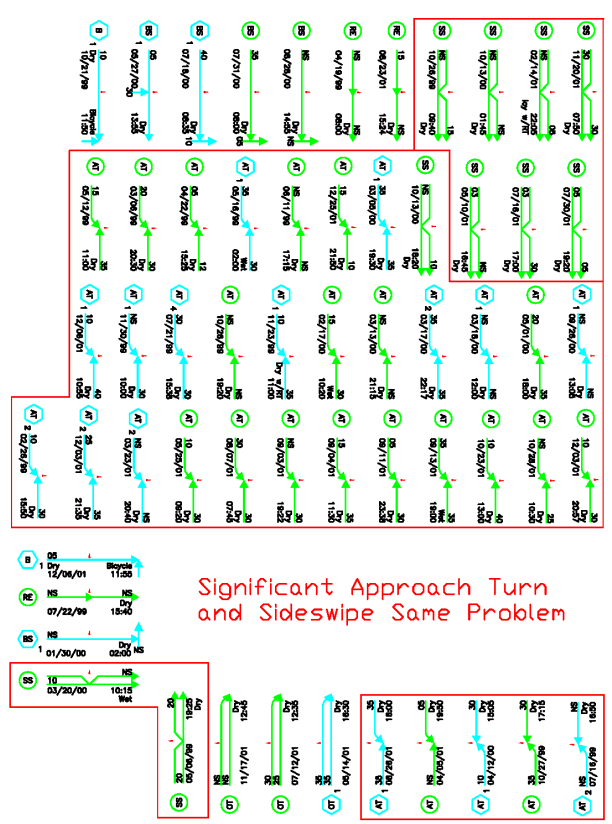
8 Accidents

Figure 14

Accident Types at the I-25 and Broadway South Bound Ramp Intersection



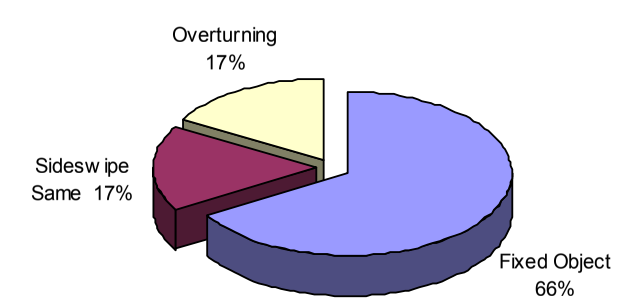
58 Accidents



Significant Approach Turn and Sideswipe Same Problem

Figure 16

Accident Types on the I-25 and Broadway Interchange Ramp and Crossroad Sections



I-25 and Santa Fe Interchange

An accident diagram, as well as figures for accident type distribution profiles for the interchange related intersection, the ramp sections and the crossroad sections is shown on the following page.

Accidents that occurred at the I-25 NB on and off ramp and Santa Fe signalized intersection is shown in **figure 17**. Of the 70 accidents that occurred at this location in the 3 year study period, 61% of them were approach turns. This frequency of approach turns is higher than expected.

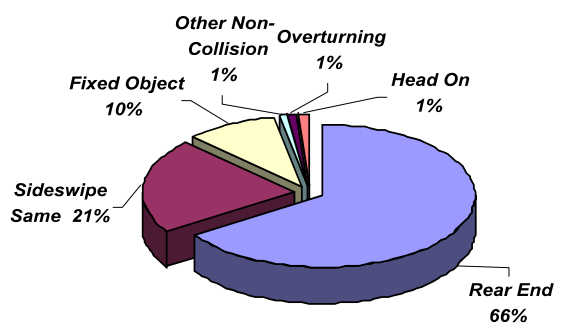
Thirty-seven of the 43 approach turns that occurred at this location were in the NB direction and six occurred in the SB direction. This tells us that protected only left turns should be implemented for NB, left turning vehicles on Santa Fe.

Figures 18 and **19** show accident profiles for the ramp sections and cross road sections, respectively. Rear end and sideswipe same accidents account for over 80% of the accidents in both charts. These accident types can be related to frequent traffic backups and high congestion conditions. Highway widening, lane widening, signal visibility and effective use of warning signs and high visibility lane markings can help reduce the frequency of these accident types.

I–25 & SANTA FE DR INTERCHANGE

Figure 19

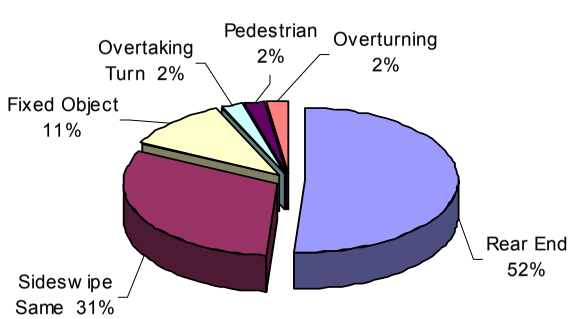
Accident Types on Santa Fe in the Interchange Area



(94 accidents)

Figure 18

Accident Types on the I-25 and Santa Fe Interchange Ramp Sections



(45 accidents)

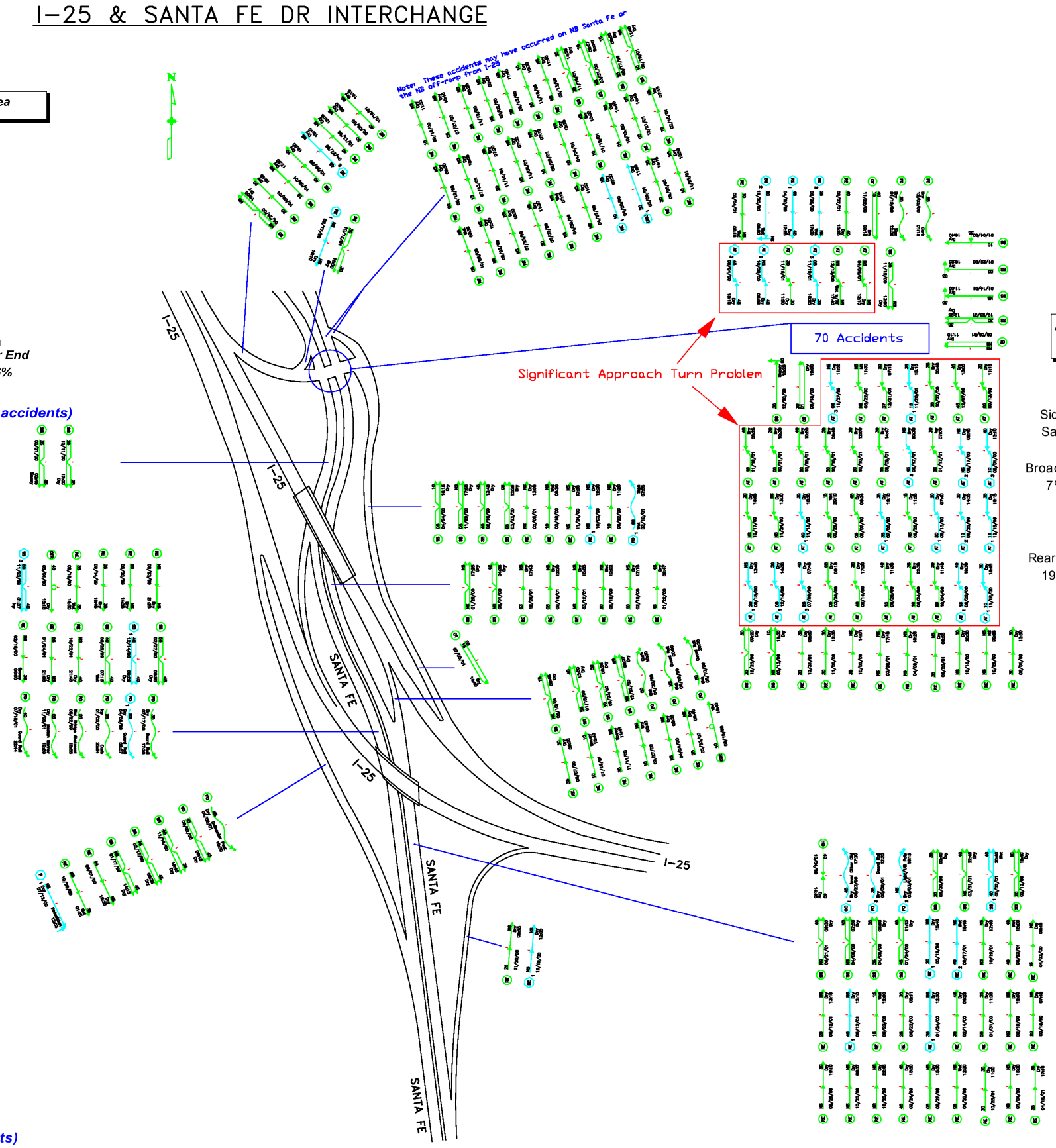
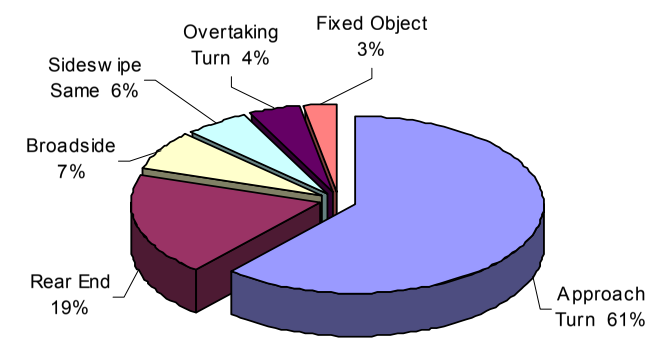


Figure 17

Accident Types at the I-25 and Santa Fe North Bound On and Off Ramp Intersection



I-25 and Alameda Interchange

An accident diagram, as well as accident type distribution profiles for each of the interchange related intersections is shown on the following page.

Figure 20 presents a graphical representation of the accident profile at the west I-25 and Alameda interchange intersection. Sixteen of the 37 accidents in the 3 year study period were broadsides. Broadsides represent a significant pattern at this location.

Measures to address broadside accidents include ensuring signal head visibility and optimizing signal progression through the interchange and adjacent signalized intersections.

A breakdown of accident types for the east I-25 and Alameda interchange intersection is shown in **figure 21**. Thirty-two accidents occurred at this location in the 3 years. A minor pattern of sideswipe same accidents is present at this signalized intersection.

Four sideswipe same accidents occurred in the EB direction. This suggests that lane widening on the overpass bridge may be considered as part of the reconstruction project.

I-25 & ALAMEDA AVE. INTERCHANGE

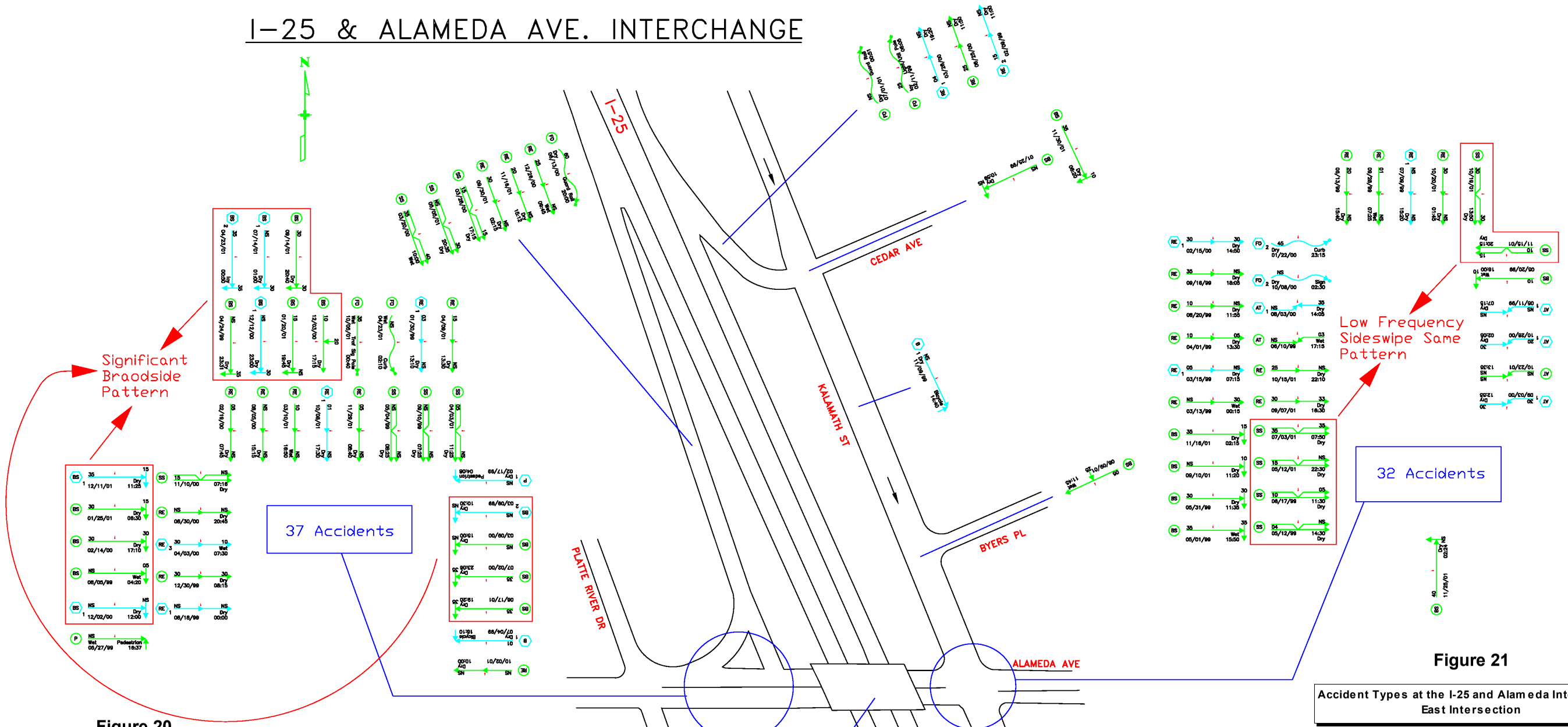
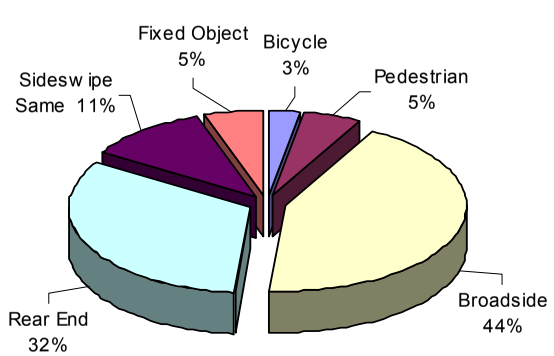


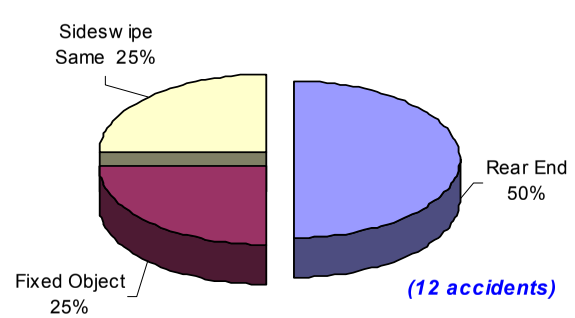
Figure 20

Figure 21

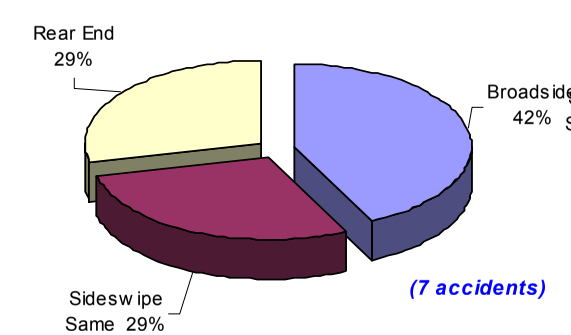
Accident Types at the I-25 and Alameda Interchange West Intersection



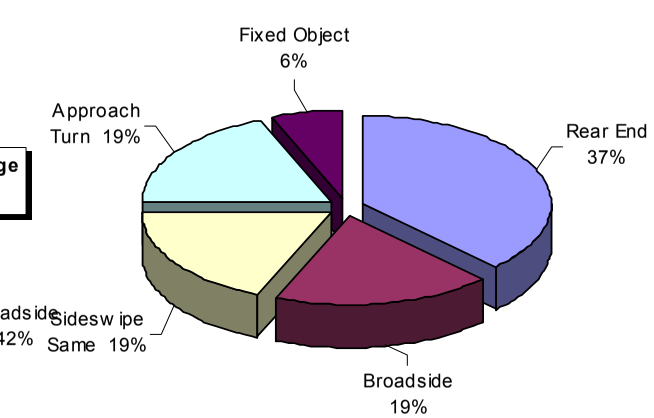
Accident Types on the I-25 and Santa Fe Interchange Crossroad Sections



Accident Types on the I-25 and Santa Fe Interchange Ramp Sections



Accident Types at the I-25 and Alameda Interchange East Intersection



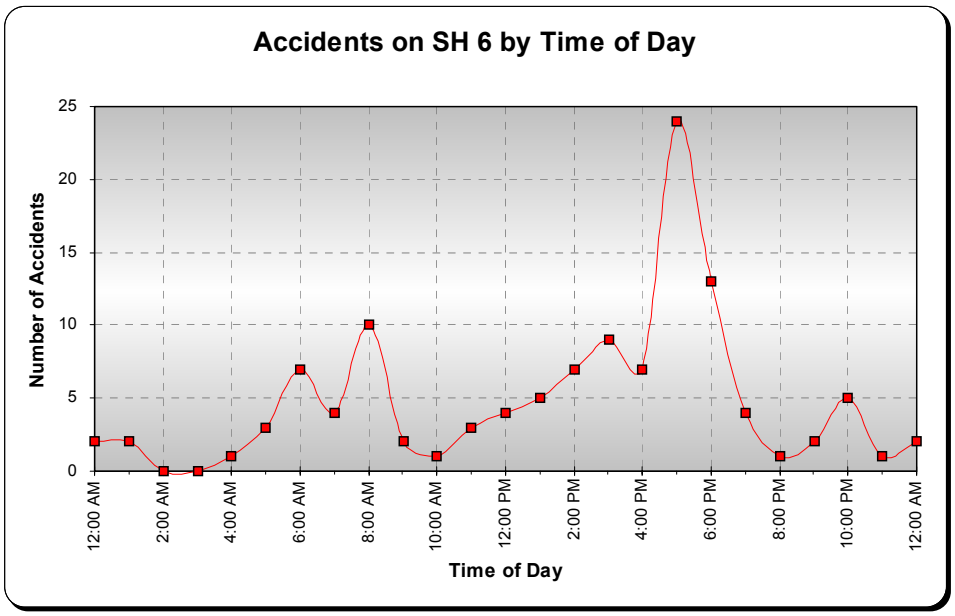
I-25 and SH 6 Interchange

An accident diagram, as well as accident type distribution profiles for selected areas is shown on the following page.

Figures 22 and **23** show accident type distribution profiles for EB and WB SH 6 through the I-25 interchange. The most prominent accident types are rear end and sideswipe same. This suggests a congestion problem on SH 6.

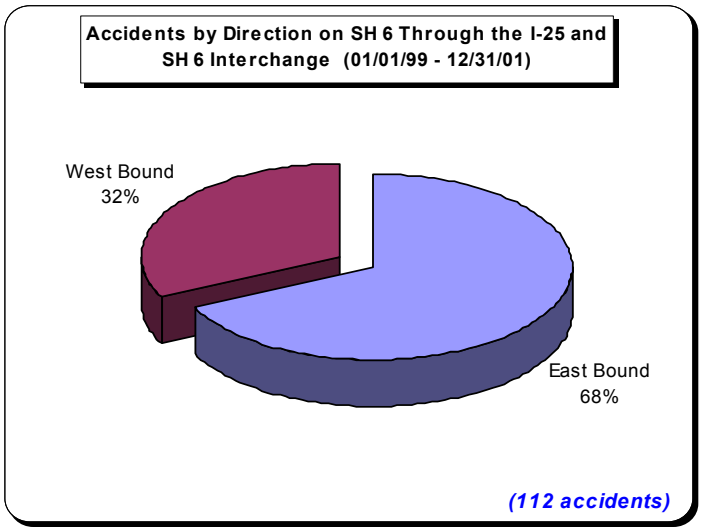
The times at which accidents are occurring on SH 6 is shown in **figure 24**. Significantly more accidents occur during the PM peak than the AM peak.

Figure 24



A graph showing the directional split of accidents on mainline SH 6 through the I-25 interchange is shown in **figure 25**. East bound accidents occurred at over double the rate of WB accidents during the study period. This can be related to the highly constrained weaving section present for vehicles entering EB SH 6 from I-25 and vehicles exiting EB SH 6 for Bryant and Federal.

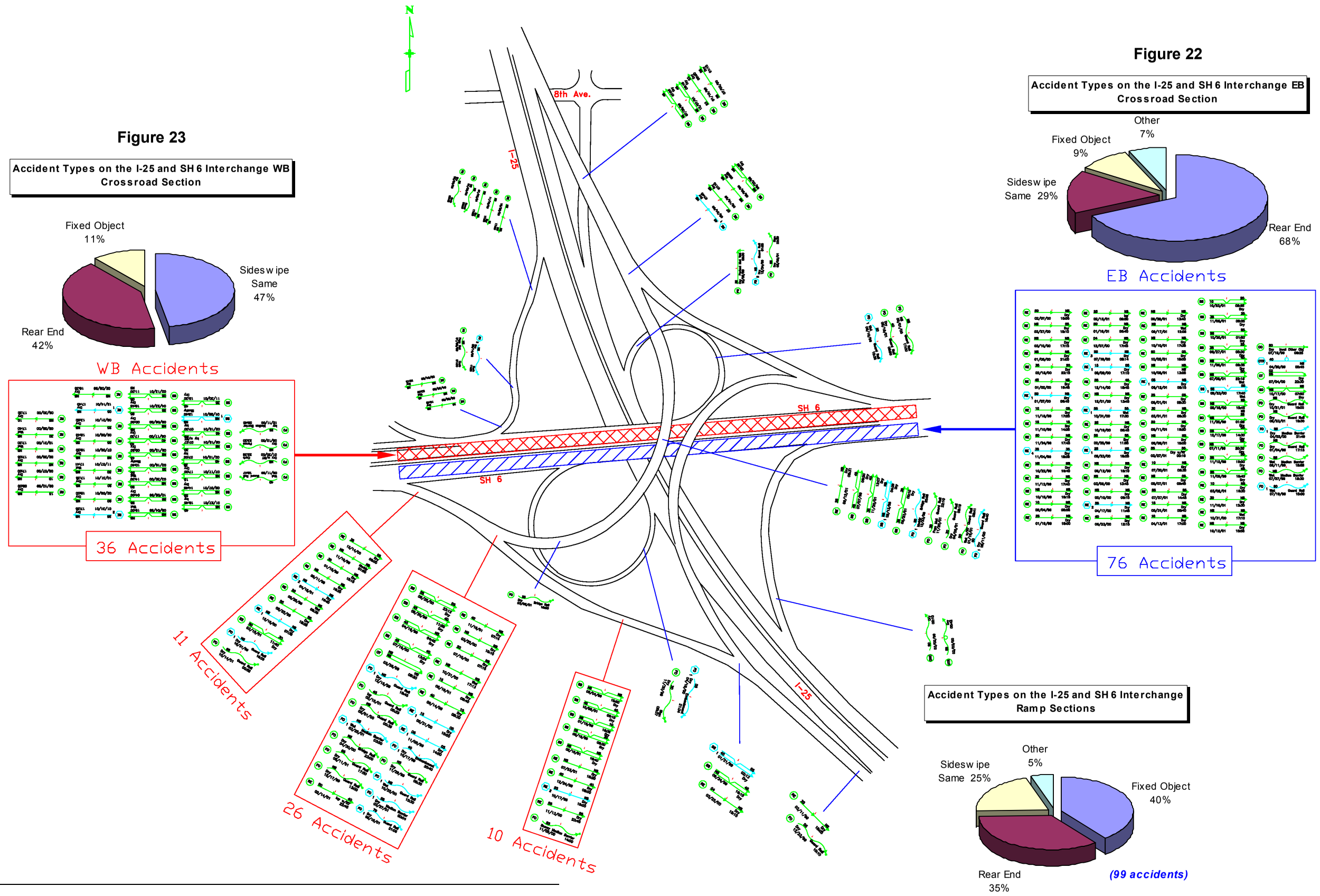
Figure 25



Most of the interchange related problems are congestion related. While a SH 6 segment containing this interchange performs at a level of service of safety of III (LOSS III), in relative terms it is safer than other segments in the study area. In other words, accident frequency and severity are closer to the expected mean than other segments. Nevertheless, this area is susceptible to safety improvements by providing additional capacity through the interchange.

The most significant ramp related accident cluster is observed on the EB SH 6 off ramp, which splits into separate ramps for NB and SB I-25. A short and constrained weaving section, compounded by queuing from SB I-25, result in rear end, sideswipe same and fixed object collisions. A lane drop on the ramp downstream of the ramp split is reflected by an increased frequency of sideswipe same and rear end collisions.

I–25 & SH 6 INTERCHANGE



I-25 and 8th Ave. Interchange

An accident diagram, as well as accident type distribution profile for the west interchange intersection is shown on the following page.

Figure 26 shows that 8 accidents occurred at the west interchange related intersection. The accident profile shown is within the expected range when compared to other urban, 3-leg intersections. Additionally, accidents at this intersection are generally of low severity, as no injuries occurred at this site during the 3 year study period.

I-25 & 8TH AVE. INTERCHANGE

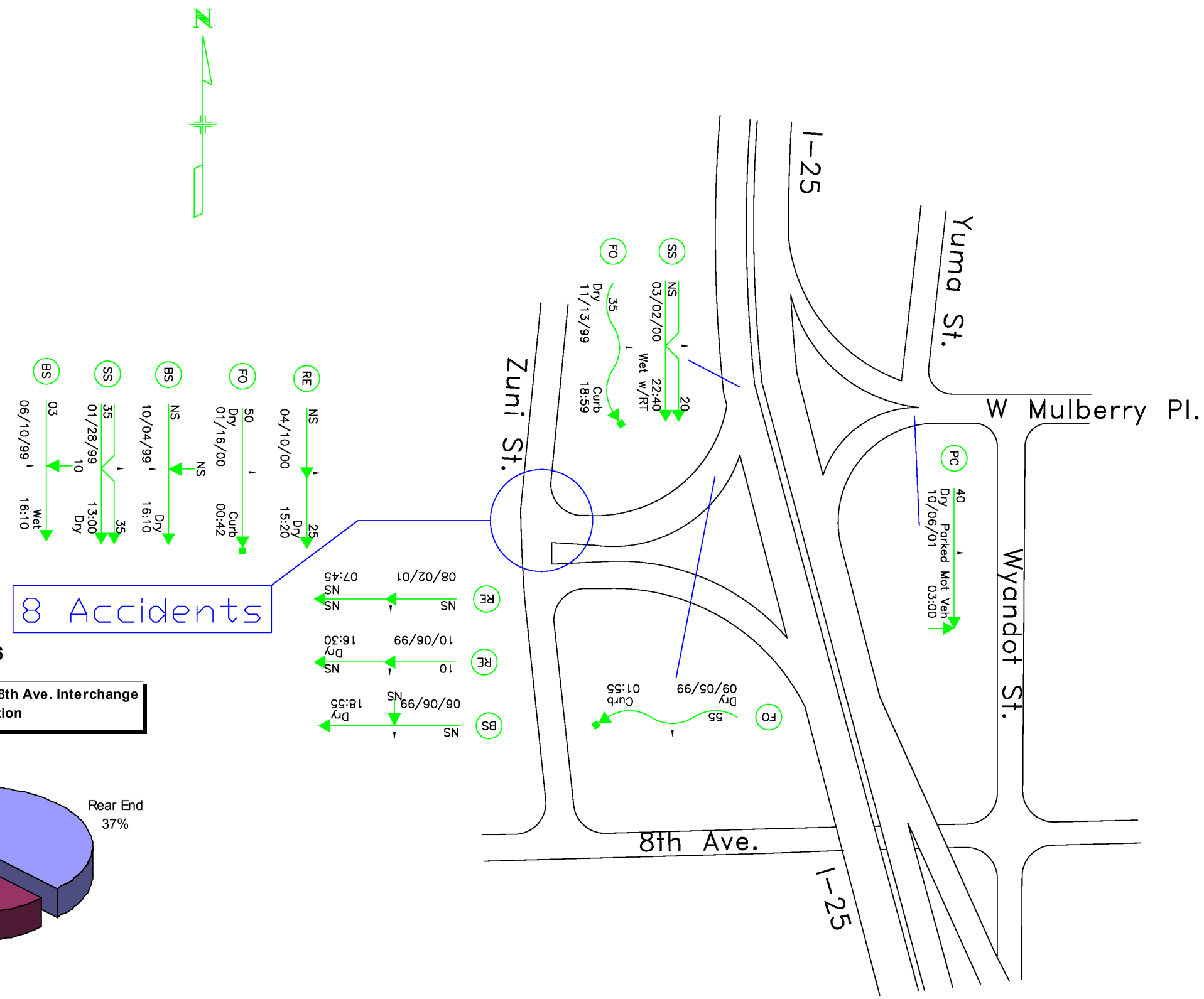
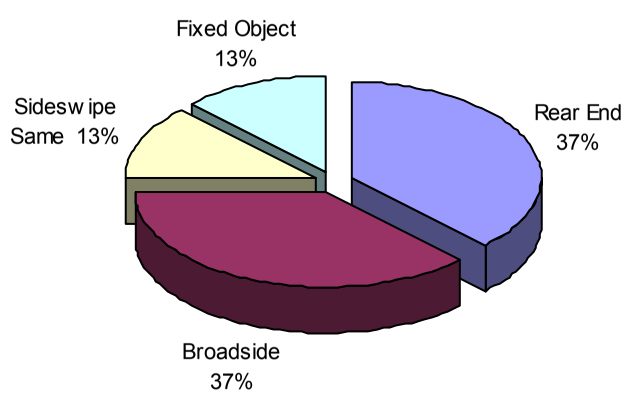


Figure 26

Accident Types on the I-25 and 8th Ave. Interchange West Intersection



I-25 and SH 40/Auraria Pkwy. Interchange

An accident diagram for SH 40, as well as accident type distribution profiles for the east and west interchange intersections are shown on the following page. Additionally, an accident diagram showing accidents which occurred on ramp sections is presented on page 24.

Figure 27 is an accident distribution profile for the west intersection. Accidents at this signalized intersection are primarily rear ends. Rear ends account for 55% of the accidents at this location while 19% are broadsides. This profile is within the expected range when compared to other similar intersections statewide.

Accidents that occurred at the east ramp intersection are shown in **figure 28**. Forty-four percent of the accidents are rear ends and 41% of the accidents are broadsides. A significant pattern of broadsides exists at this signalized intersection. Methods to assist in reducing the frequency of broadside accidents at this intersection may include installation of a larger mast arm with signal heads placed over each lane. Additionally, installation of a pole mounted signal on the right hand side for vehicles waiting on the I-25 off ramp would increase signal visibility for vehicles waiting behind large vehicles. We also recommend verification of adequate yellow and all-red time in the timing plan at this location.

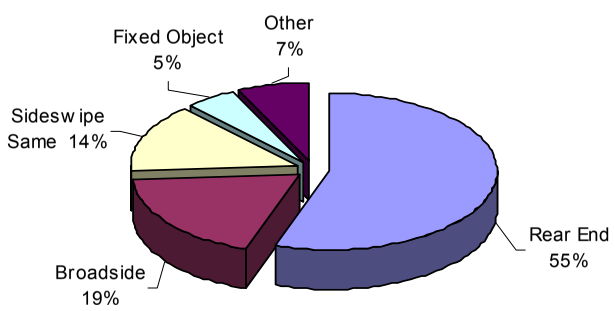
Figure 29 on page 24 shows that 4 of the 7 (57%) of the single vehicle accidents that occurred on the WB SH 40 to SB I-25 on ramp occurred at night. Additionally, **figure 30** shows that all 6 of the single vehicle accidents that occurred during the study period on the WB SH 40 to NB I-25 on ramp also occurred at night. This suggests that the lighting in this area may be obscured in some way. If reconstruction of these ramps is included in the project, improved lighting as well as high definition striping and delineation should be used in these areas. Improved ramp geometrics can also reduce the frequency of single vehicle, fixed object accidents on these ramps. The overall safety performance of ramps at this interchange appears satisfactory.

I-25 and SH 40/AURARIA INTERCHANGE

Accidents on SH 40 Only

Figure 27

Accident Types on the West I-25 and SH 40/Auraria Interchange Intersection



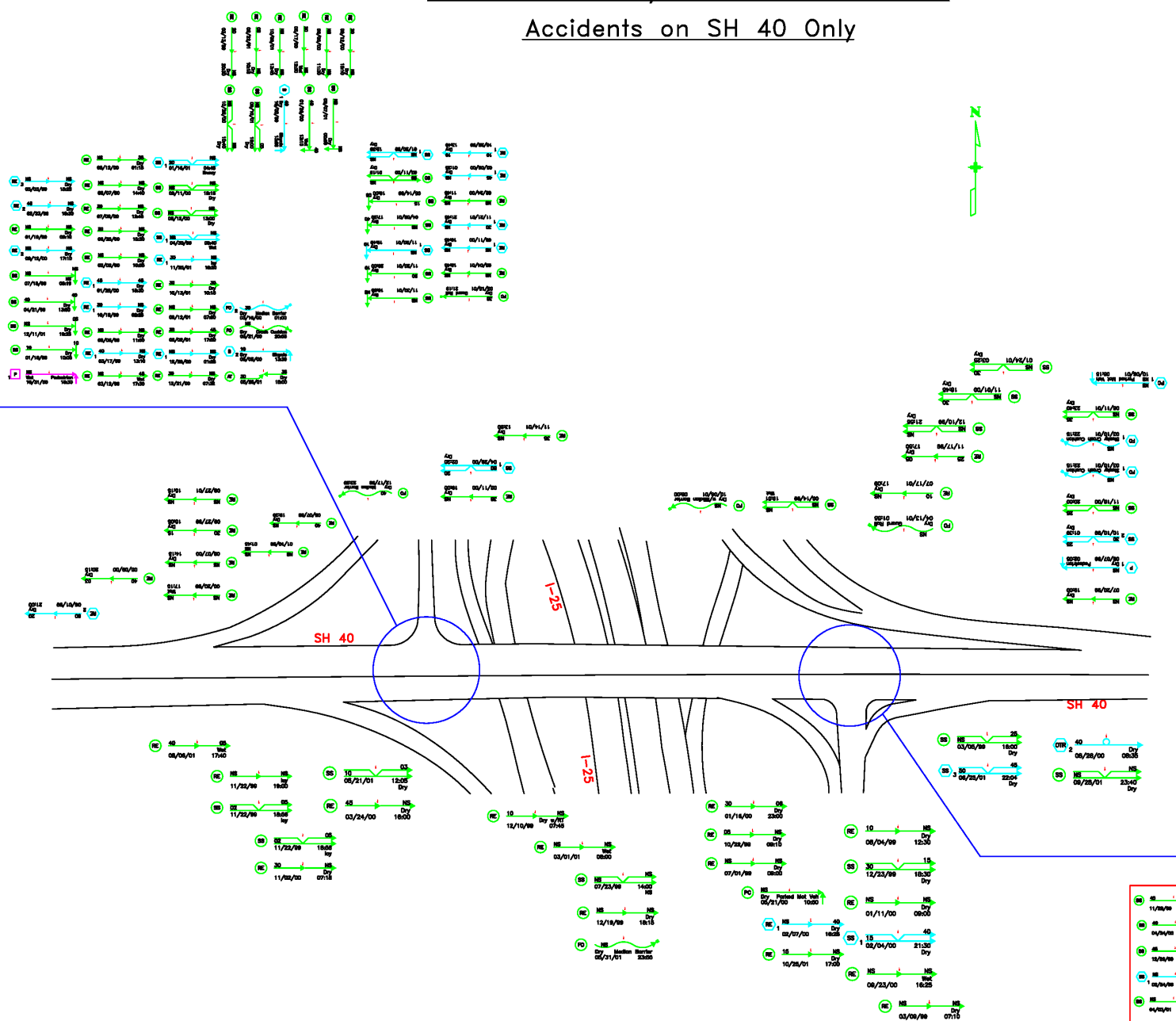
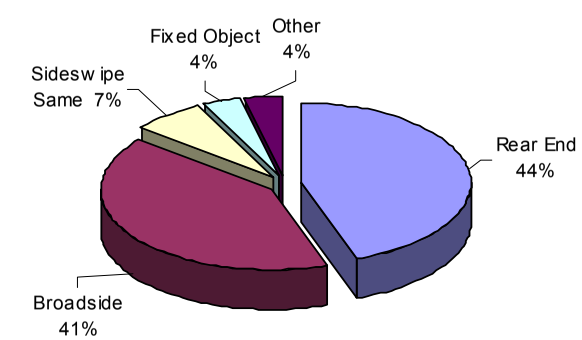
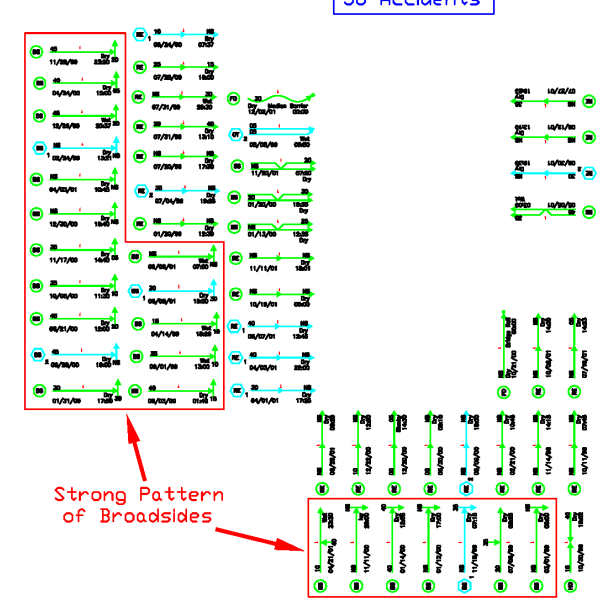


Figure 28

Accident Types on the East I-25 and SH 40/Auraria Interchange Intersection





I–25 and SH 40/AURARIA INTERCHANGE

Ramp Section Accidents Only

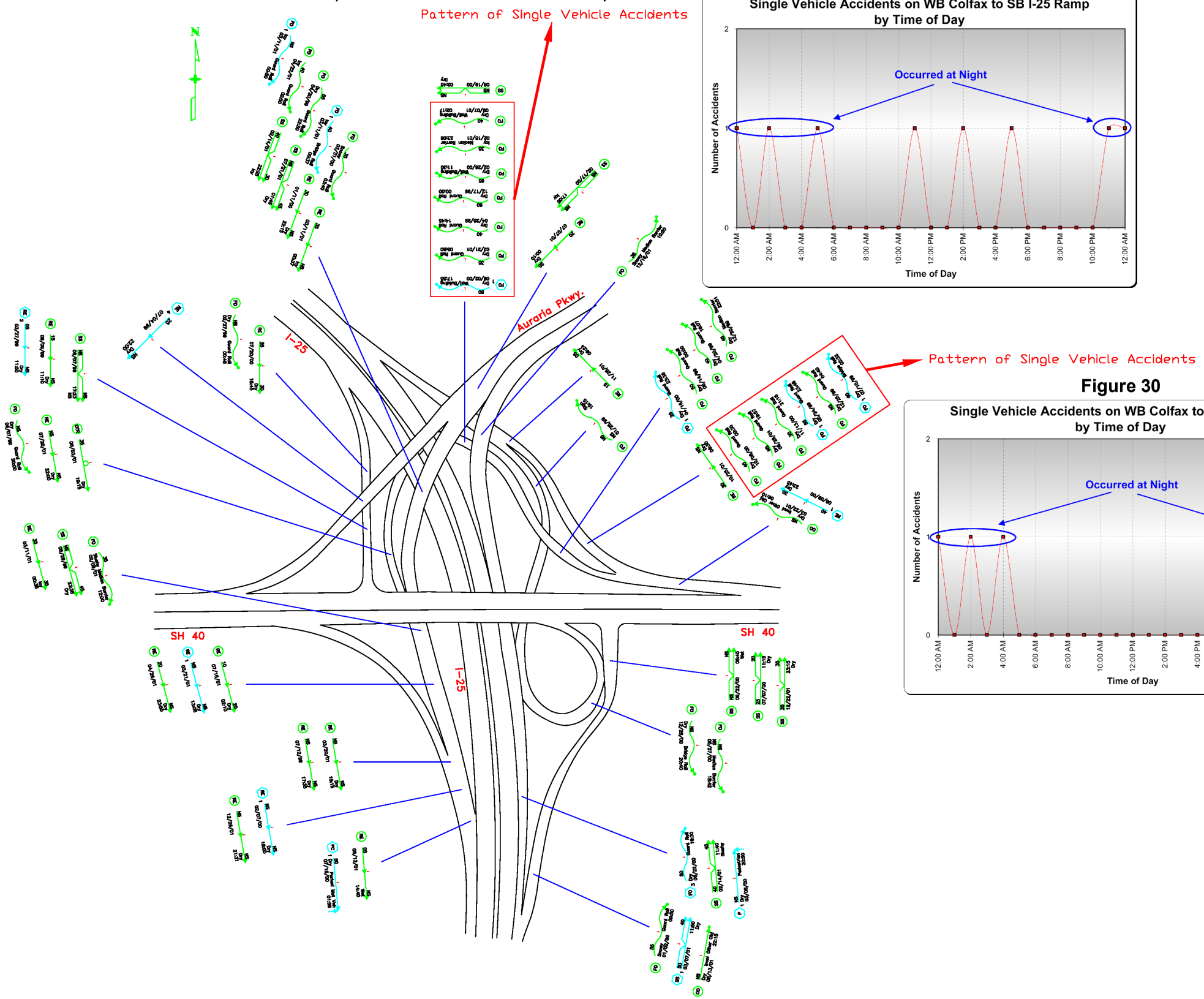
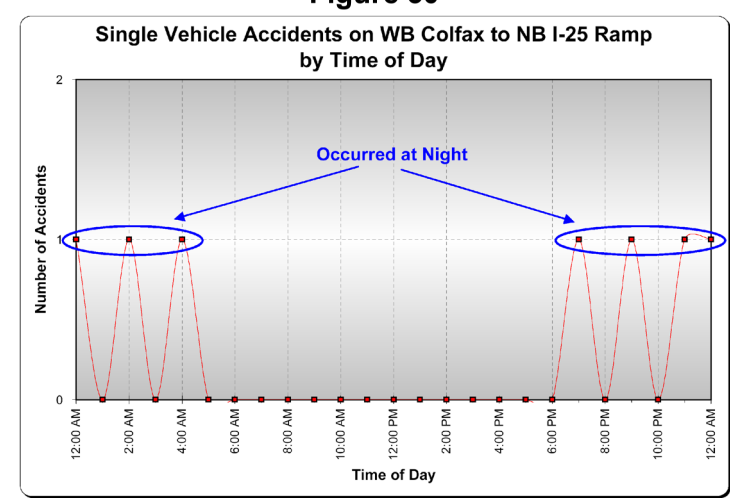


Figure 29

Figure 30



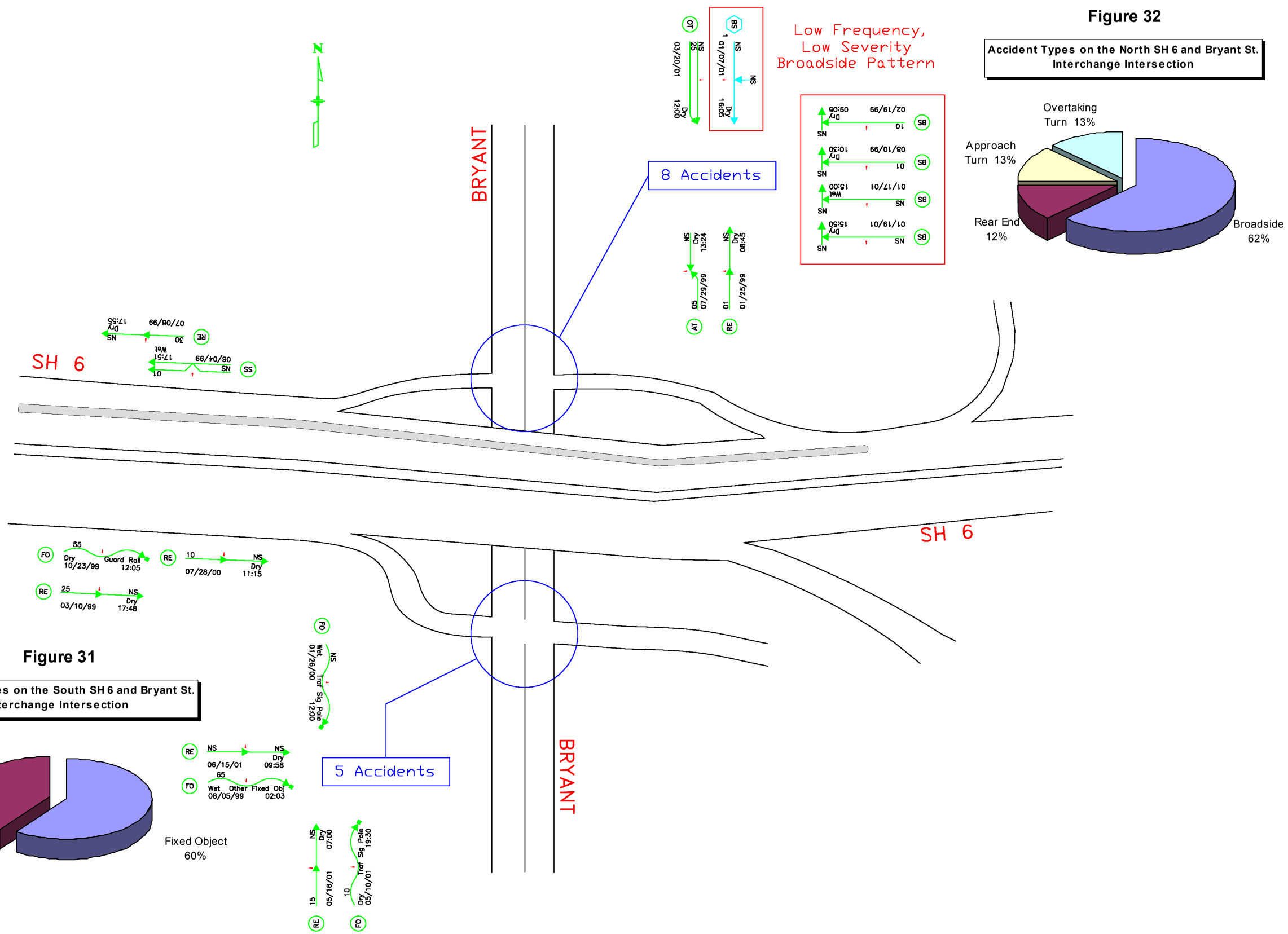
SH 6 and Bryant St. Interchange

An accident diagram for the SH 6 and Bryant St. interchange, as well as accident type distribution profiles for the east and west interchange intersections are shown on the following page.

Figure 31 shows accidents that occurred at the south interchange intersection. Five accidents were reported at this location in the 3 year study period. The accident type distribution as well as the overall accident frequency at this signalized intersection are well below the expected range.

Accidents that occurred at the north interchange intersection are shown in **figure 32**. While accident frequency at this signalized intersection is less than 3 accidents per year, on average, a low frequency, low severity pattern of broadsides is apparent. All 4 WB broadsides in the 3 year study period occurred as a result of a left turning vehicle from the SH 6 off ramp off-tracking its rear axle into a vehicle parked in the NB left turn lane on Bryant St. In 2 of the 4 WB broadside cases, a heavy vehicle was the vehicle at fault. This suggests that the NB stop bar may be too far forward.

SH 6 & BRYANT INTERCHANGE



SH 6 and Federal Interchange

An accident diagram for the SH 6 and Federal interchange, as well as accident type distribution profiles for the three interchange intersections are shown on the following page.

Figure 33 shows the accidents that occurred at the north on and off ramp intersection. Broadsides account for 32% of the accidents and approach turns account for 30%. Additionally, sideswipe same direction accidents account for 18% of the total number of accidents. The percentages of broadside and sideswipe same collisions are significantly higher than expected for these types of signalized intersections.

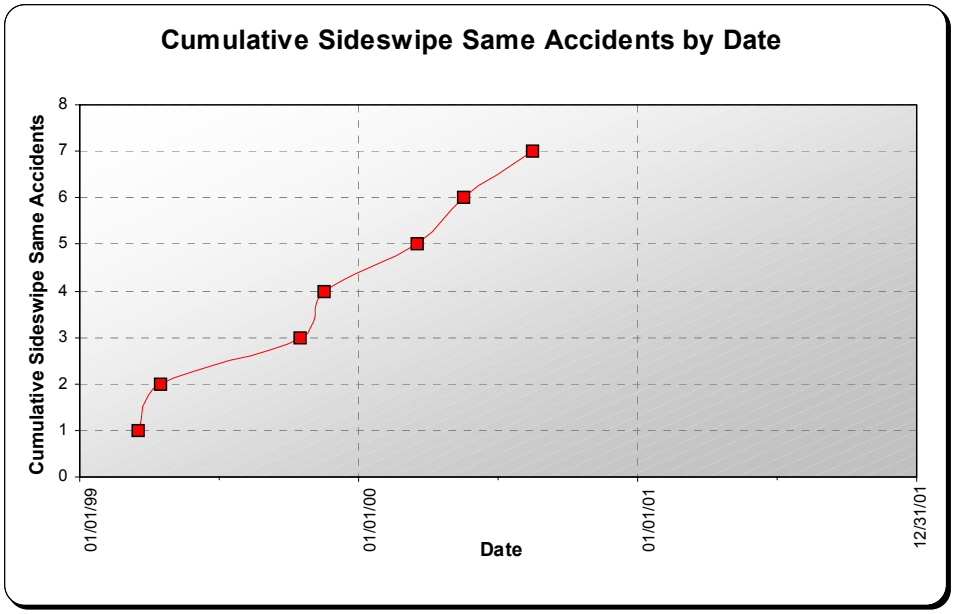
Nine of the 11 sideswipe same accidents occurred in the WB direction on the SH 6 off ramp. The signing, striping, channelization and delineation can be examined at this intersection. Additionally, lane width may be related to the high frequency of sideswipe sames at this location.

To reduce the frequency of broadside collisions at this signalized intersection, installation of LED bulbs and signal head back plates can be considered. We also recommend verification of adequate yellow and all-red time in the timing plan at this location.

A pie chart showing an accident distribution for the EB SH 6 off ramp intersection is shown in **figure 34**. Rear ends account for 54% of the accidents and sideswipe sames account for 18% of the total. The number of sideswipe sames that occurred at this signalized location is slightly higher than expected.

During the 3 year study period, sideswipe sames have occurred approximately equal between the 3 approaches to the intersection. Additionally, **figure 36** shows that the most recent sideswipe same accident at this intersection occurred in August of 2000. This suggests that either a past sideswipe same problem is now solved, or it may mean that sideswipe sames are occurring randomly at this location without a solid causal link to the roadway itself.

Figure 36



The accident profile for the EB SH 6 on ramp intersection is shown in **figure 35**. While rear ends account for 45% of the accidents from the 3 year study period, approach turns account for 41% of the total. The severity of approach turn accidents at this unsignalized intersection is relatively low. The overall frequency of approach turn accidents may be related to a need to cross 3 lanes of traffic when turning left.

US6 & FEDERAL BLVD INTERCHANGE

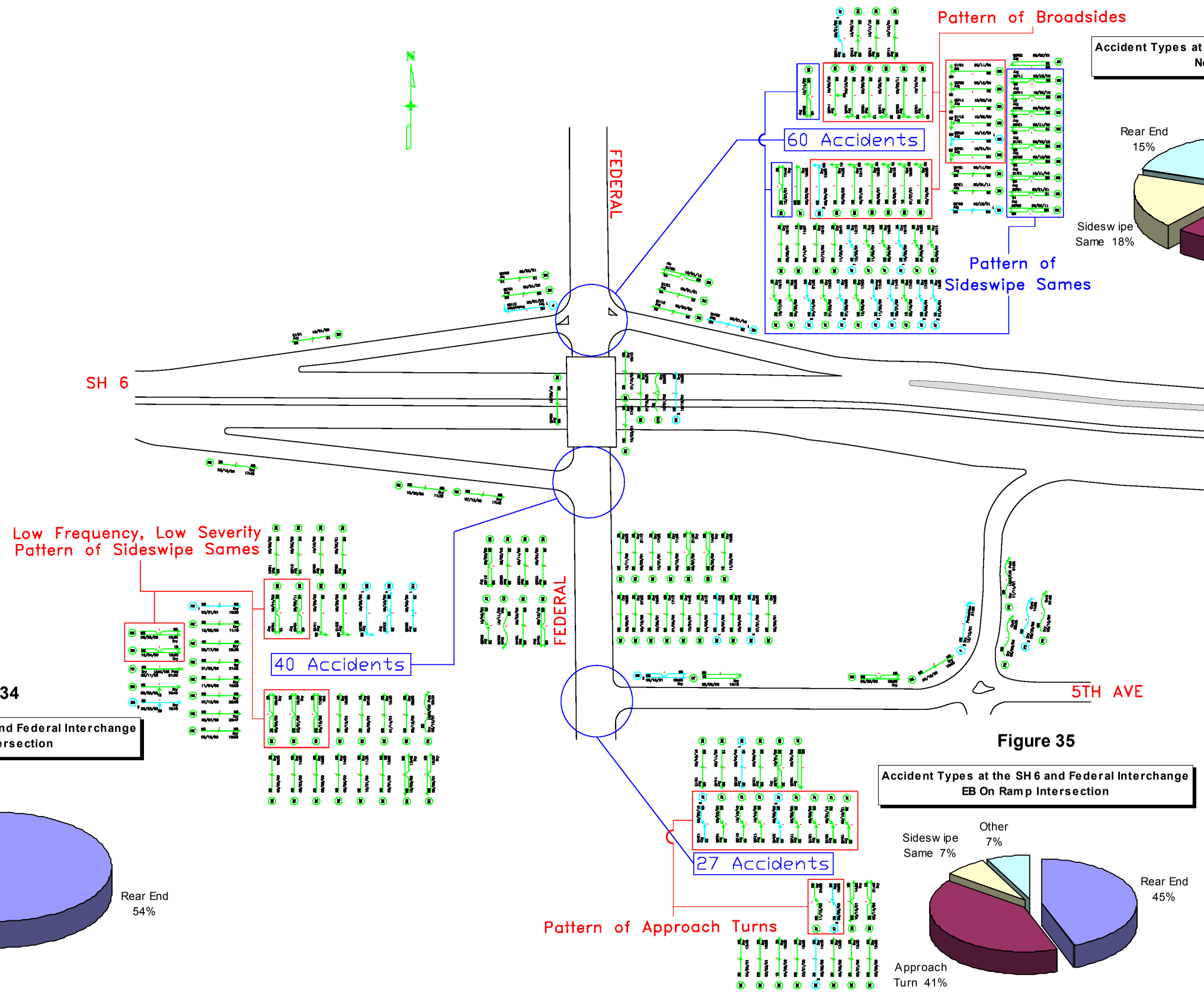


Figure 33

Accident Types at the SH 6 and Federal Interchange North Intersection

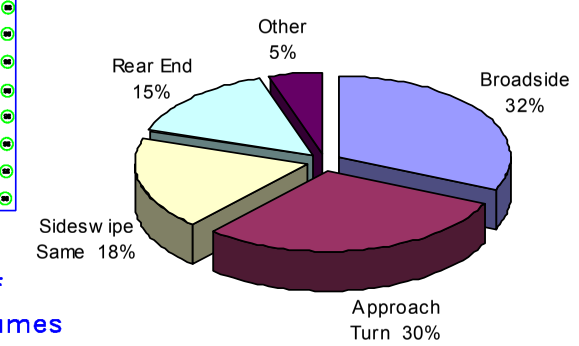


Figure 34

Accidents Types at the SH 6 and Federal Interchange EB Off Ramp Intersection

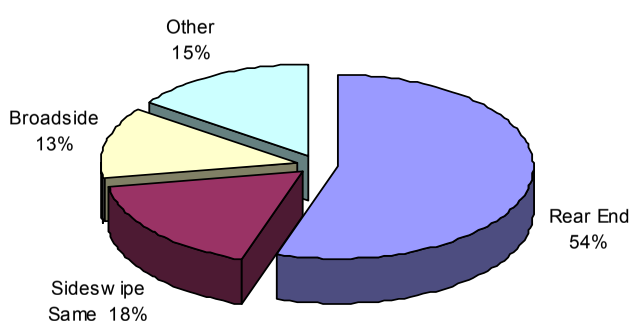


Figure 35

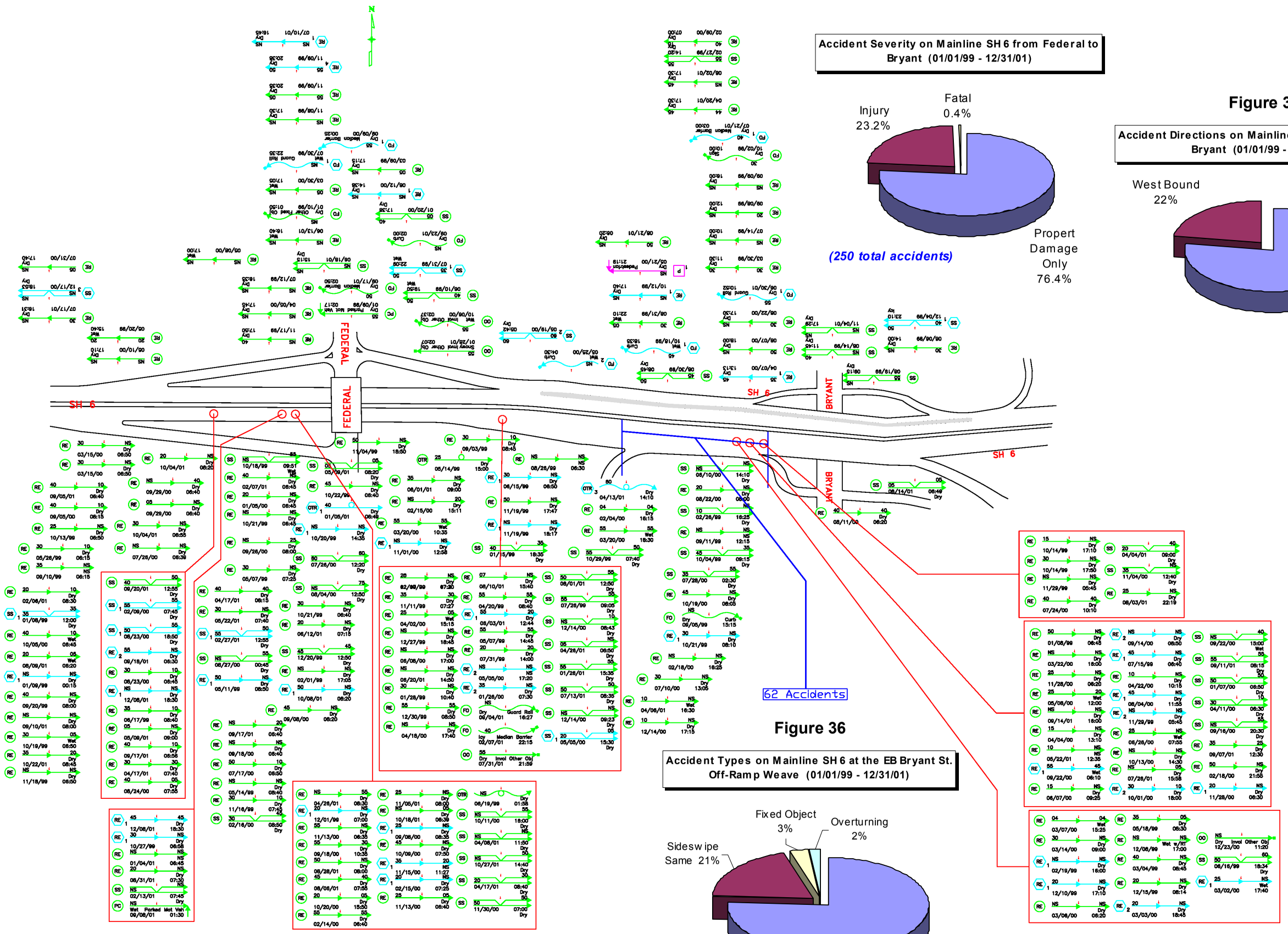
Accident Types at the SH 6 and Federal Interchange EB On Ramp Intersection

Mainline US 6 within Project Limits (Excludes I-25 Interchange)

US 6 mainline does not lend itself to the Safety Performance Function (SPF) analysis because of very tight interchange spacing within a short freeway segment. It is an unusual situation, which should be examined in detail by looking at accident patterns, clusters and related accident characteristics. A severely congested freeway operations environment that is exacerbated by highly constrained weaving is characterized by the high number of rear-end and side-swipe collisions.

The following page provides a detailed accident diagram with additional information about accident frequency, type, severity and direction of travel. Seventy-eight percent (78%) of all accidents on this segment occurred in the eastbound direction, which may be related to constrained weaving and major merging/diverging conflicts. Although the 23% injuries observed in this section is somewhat lower than the 28.5% typical of these facilities, the total number of injury accidents is significant and should be addressed. Most of the safety problems on this segment are related to inadequate interchange spacing as well as lack of through capacity. New design alternatives should address both of these needs.

MAINLINE US 6 IN PROJECT LIMITS



Accident Severity on Mainline SH 6 from Federal to Bryant (01/01/99 - 12/31/01)

Figure 38

Accident Directions on Mainline SH 6 from Federal to Bryant (01/01/99 - 12/31/01)

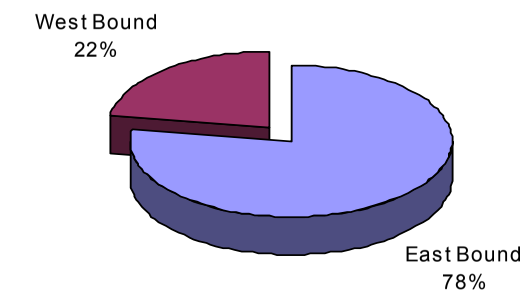
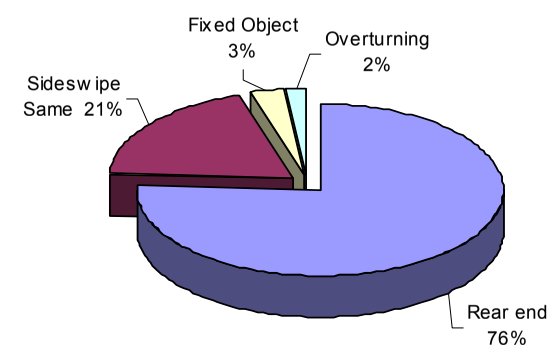


Figure 36

Accident Types on Mainline SH 6 at the EB Bryant St. Off-Ramp Weave (01/01/99 - 12/31/01)



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 we employed a 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 all of I-25 in the study area is performing at LOSS-IV from the frequency as well severity perspective. It suggests a high potential for accident reduction in the study area. US 6 mainline does not lend itself to the Safety Performance Function (SPF) analysis because of very tight interchange spacing within a short freeway segment. The high number of accidents on this section of US 6, both PDO and injury, are significant and should be addressed. Safety problems on I-25 and SH-6 can be related to congestion, recurrent and frequent queuing, close interchange spacing and geometric characteristics of existing alignment of I-25. New alternatives will need to provide higher design speed, additional capacity and increased interchange spacing.

Most of the safety problems on interchange ramps can be attributed to congestion and backups on mainline I-25 that result in rear ends and sideswipe same direction accidents. Accident problems at interchange-related ramp intersections can be addressed by improving signal head visibility, using protected only left turn phases where approach turn problems exist and verifying adequate yellow and all-red times where broadside problems are present.