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EVALUATION OF AN ACTIVE WILDLIFE-SENSING AND DRIVER WARNING SYSTEM AT TRAPPER'S POINT

By:

Department of Civil and Architectural Engineering
University of Wyoming
1000 E. University Way
Laramie, Wyoming 82071

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WYDOT Technical Contact: Matt Carlson, Highway Safety Program; R. Vince Garcia, ITS Program

Abstract
Collisions with wildlife are a serious concern on American highways. In Wyoming, the concern has prompted the Wyoming Department of Transportation to construct an experimental wildlife detection and driver warning system at Trapper's Point, north of the town of Pinedale on US Highway 191. The focus of this thesis is two-fold: to develop a framework to determine whether the driver warning system is effective at modifying driver behavior and to develop a framework to determine whether the wildlife detection system reliably detects the presence wildlife on the roadside. Transportation agencies have attempted to solve the deer-vehicle collision problem with a wide variety of solutions. Published literature was reviewed to analyze the effectiveness of these solutions with a spotlight on other active, wildlife-detecting driver warning systems. The system at Trapper's Point utilizes the Eagle Intrusion Detection System (EIDS), originally developed by Telonics, Inc for military applications. Seismic and passive infrared sensors are designed to detect the presence of wildlife and trigger the flashing lights atop six signs that read "DEER ON ROAD WHEN FLASHING". Many difficulties with the wildlife detection system and data collection equipment were experienced during this study. This report describes these problems in detail and analyzes the system using three measures of effectiveness: accurate detection of wildlife, changes in driver behavior, and crash reduction.

Key Words Animal-Vehicle Crashes, Safety, Wildlife, Wyoming, WYDOT	Distribution Statement Unlimited

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SI* (Modern Metric) Conversion Factors

Approximate Conversions from SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
Area				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
Volume				
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
Mass				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lbs)	T
Temperature (exact)				
°C	Centigrade temperature	1.8 C + 32	Fahrenheit temperature	°F
Illumination				
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
Force and Pressure or Stress				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

Approximate Conversions to SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
Area				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
Volume				
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
Mass				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
Temperature (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
Illumination				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
Force and Pressure or Stress				
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

EXECUTIVE SUMMARY

Animal detection and traveler warning systems are relatively new technology being used by transportation agencies to address safety concerns related to vehicle-wildlife crashes. These systems go beyond the static wildlife warning signs that drivers quickly become accustomed to and also avoid the habitat separation issue of wildlife fencing methods. Detection and warning systems typically consist of two parts: the animal detection system component that is configured to detect animals in the vicinity of the roadway and the warning system that activates drivers warning signs. Since these signs are not static, the belief is that they elicit greater response from the drivers than the passive, traditional signage.

Issues with the effectiveness of the systems are typically divided into two categories: technology and system maintenance issues and driver response issues. The first is typically discussed with regard to false positives, false negatives, and system maintenance problems. The second issue is related to whether the systems affect driver behaviors and ultimately lead to reduction in animal-vehicles crashes.

The subject of this research is a system installed by the Wyoming Department of Transportation (WYDOT) outside of Pinedale. The system is well-tested in military and security applications, including the detection of animals, but the installation at Trapper's Point is the system's first deployment for a wildlife roadway crossing application.

In order to investigate the effectiveness of the Trapper's Point Animal Detection System the following major research tasks are proposed:

- Document the modifications and maintenance performed on the system throughout the research effort.
- Document data issues and systems problems encountered during this research.

- Determine the success of the system to detect large game in the roadway vicinity.
- Determine the effect of the warning signs with flashing beacons on driver behavior.
- Determine the impact of the system on reducing vehicle-wildlife crashes.

Trapper's Point Animal Detection System

The animal detection system at Trapper's Point is located approximately six miles north of the town of Pinedale on US Highway 191 and begins at the intersection of US 191 and Wyoming Highway 352 (WY 352) at milepost 105.54 and extends 1.36 miles to milepost 106.90.

US 191 is a two-lane, undivided highway with twelve-foot lanes and four-foot shoulders except between mileposts 105.54 and 106.52, where there is an additional twelve-foot climbing lane in the southbound direction. The posted speed limit in this area is 65 miles per hour. The 1.36-mile-long segment contains two horizontal curves but neither curve is posted with a curve warning speed. The average annual daily traffic (AADT) of US 191 near the project location in 2007 was 2,578 vehicles per day.

The animal detection system at Trapper's Point uses the Eagle Intrusion Detection System (EIDS), developed by Telonics, Inc. The Trapper's Point system was installed in October, 2005 at a cost of approximately $1,000,000, including the cost of contract administration and inspection work. The system uses geophone (seismic) sensors and passive infrared sensors, which are spread along the side of the road at regular intervals along the entire length of the project. Each group of sensors feeds into a transmitter that communicates with a receiver / repeater installed at each "DEER ON ROAD WHEN FLASHING" road sign. The flashing lights on the road signs are activated whenever a signal is received from one of the 34 transmitters.

The driver warning component of the system is comprised of six road signs that were erected in the project area that read “DEER ON ROAD WHEN FLASHING”. Each sign also has two yellow, 12” diameter, flashing lights fixed to the top.

Post-Installation System Modifications

Many technical challenges have been encountered since the Trapper’s Point wildlife-sensing driver warning system was installed. From the Fall of 2005 through the Spring of 2007 extensive modifications and adjustments were made to get the system in best working order. From the Fall 2007 through the Spring 2008 only minor modifications for routine maintenance were made in order to see how the system performed under more these more “typical” maintenance conditions. The modifications to the system over the entire research effort were extensive and are documented fully in Chapter 5.

Data Analyses on System Effectiveness

The effectiveness of an active, wildlife-sensing driver warning system at modifying driver behavior is dependent on how reliably the system can detect the presence of wildlife. A successful, active wildlife-sensing driver warning system will have few false detections and will therefore demand respect from drivers.

A false negative occurs when the system fails to detect large wildlife. A random sample of DVR data were reviewed and a time period was tagged as having a false negative if an animal was viewed within the detection area but the system was not activated. For spring 2007 and fall 2007 periods, the number of false negatives found in the reviewed data was zero. For spring 2008 period, the false negative percentage was slightly less than 20%. There is no set standard for an acceptable level of false negatives but the results appear to indicate that the system has a low occurrence of false negatives.

False positives were analyzed by comparing the detection data to the DVR data to determine if a detection was the result of animal activity. Using random selection methodology, a subset of the remaining detections were identified and a tagged for review. The results indicate that false positives are a problem with the Trapper's Point system with the percentage of periods with false positives being 95% or greater. There is no set standard for an acceptable level of false positives but the results indicate that the system has a very high occurrence of false positives.

The ultimate goal of the wildlife-sensing driver warning systems is to make drivers more aware when wildlife is present on the road. Ideally, greater awareness will cause the driver to slow down, which in turn will allow the driver more time to react to the presence of wildlife, and potentially reduce the likelihood of a deer-vehicle collision. Determining whether there was an effect on driver behavior was accomplished by comparing the average speed during each half hour period for a particular sensor to the number of times that the flashing lights were activated during that half hour.

The results indicate that the system had a greater effect on driver speeds during the earlier data collection periods. This could be due both to the fact that the system was newer to the drivers, although by spring of 2007 the system had been in place for almost a year and a half. In general, the results indicate some correlation between the number of system detections and average speeds in the project area, although the relationship is not as strong as is likely desirable.

The ultimate goal of the wildlife detection and driver warning systems is to reduce the number of total and vehicle-wildlife crashes on this stretch of roadway. This requires two to three years of crash data with the system in place to make statistically significant statements about the effectiveness of the system. This report took an interim look at crash rates on the corridor to see if the effect of the system on crash rates is discernable at this time.

The number of animal-vehicle crashes appears to be fluctuating between one and three crashes per year. When considering total reported crash frequency instead of just animal-vehicle crashes, the three-year moving average appears to be a flatter trend in the total crash frequency.

Crash rates (i.e. number of crashes per million vehicle miles traveled) instead of crash frequencies (i.e. number of crashes) accounts for changes in traffic volumes over the study period. The results for animal-vehicle crash rates shows slightly more pronounced downward trend in last four years for the animal-vehicle crashes. For the total crashes, the flat trend seen in the frequency analysis over the last seven years is shown as a downward trend in the total crash rate analysis, which makes sense given that the number of crashes is holding relatively steady during this period even though the traffic volumes are increasing.

There is likely to be higher animal-vehicle crashes if there are increases in the animal populations. To account for changes in the animal populations, herd population estimates provided by the Wyoming Game and Fish were used. The results showed that even after accounting for herd population changes, the trends in the shown in the other analyses remain.

A before and after analysis was used to determine whether the number of crashes per Million VMT before 2005 is significantly different from the true mean of the number of crashes per Million VMT after 2005. The results indicate that there is not a statistically significant difference between the before and after period.

Recommendations

The potential future actions for Trapper's Point are summarized in the six options listed below:

1. Keep system in its current state and operate year round with dedicated maintenance staff.
2. Keep system in its current state and operate only during spring and fall migration periods.
3. Reduce the scale of the system and use fencing to funnel the animals to the detection zones.
4. Remove the geophones and use only the infrared sensors for wildlife detection.
5. Use of other animal detection technology such as "break the beam" systems.
6. Use of a wildlife underpass or overpass.

The choice of future action should be made carefully and will most likely require additional study. The choice should be based on the resources of the Department and in consultation with local authorities and the Wyoming Game and Fish. One recommendation from this research is clear in that the existing system should not be left in its current state without the required maintenance commitment. The system will continue to decline in effectiveness without this maintenance commitment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Animal detection and traveler warning systems are relatively new technology being used by transportation agencies to address safety concerns related to vehicle-wildlife crashes. These systems go beyond the static wildlife warning signs that drivers quickly become accustomed to and also avoid the habitat separation issue of wildlife fencing methods. Detection and warning systems typically consist of two parts: the animal detection system component that is configured to detect animals in the vicinity of the roadway and the warning system that activates drivers warning signs. Since these signs are not static, the belief is that they elicit greater response from the drivers than the passive, traditional signage.

Research into the effectiveness of these various systems is limited, and to date, somewhat inconclusive (K. K. Knapp, et al. 2004). Issues with the effectiveness of the systems are typically divided into two categories: technology and system maintenance issues and driver response issues. Regarding the first issue, the existing literature discusses the effectiveness of the system with regard to false positives, false negatives, and system maintenance problems. The second issue has the least amount of available research and is related to whether the systems affect driver behaviors and ultimately lead to reduction in animal-vehicles crashes.

The subject of this research is a system installed by the Wyoming Department of Transportation (WYDOT) that is well-tested in military and security applications, including the detection of animals, but the installation at Trapper’s Point is the system’s first deployment for a wildlife roadway crossing application (Cox, 2005). Therefore, research is necessary to determine the effectiveness of the system in detecting wildlife, warning travelers, and ultimately in reducing vehicle-wildlife crashes in this area. If proven effective, this system could then be used by WYDOT and other transportation agencies in areas with high vehicle-wildlife crash occurrences.

1.1 Research Objectives

The main objective of the overall research project is to investigate the effectiveness of the Trapper's Point Animal Detection System. To meet this objective the following major research tasks are proposed:

- Document the modifications and maintenance performed on the system throughout the research effort.
- Document data issues and systems problems encountered during this research.
- Determine the success of the system to detect large game in the roadway vicinity.
- Determine the effect of the warning signs with flashing beacons on driver behavior.
- Determine the impact of the system on reducing vehicle-wildlife crashes.

1.2 Research Tasks

The study methodology for the overall project is divided into the tasks listed in the previous section and described in detail in this section. Because of the extended timeline of the entire project and the need to meet Federal Highway Administration reporting requirements for the experimental feature, two interim reports were prepared in July of 2007 and September of 2008 (Vander Giessen and Young 2007, Dai and Young 2008). This final report compiles information from both of these reports as well as drawing additional conclusions and recommendations from the entire research effort.

1.2.1 Task 1: Document Modifications and Maintenance Performed on the System

The Trapper's Point Active Wildlife-Sensing and Driver Warning System utilizes extensive technology that must be calibrated and maintained to keep in working order. Periodic modifications are also necessary when the system is not performing adequately. A major task of this research effort was to document these steps in order to determine the level of upkeep necessary for the system. Since this is new technology for the Wyoming Department of Transportation an important thing to learn from the system is the ability of the technology to work in the extreme weather conditions found in Wyoming.

1.2.2 Task 2: Document Data Issues and System Problems

Task 2 is related to the first task in that a portion of the research effort was spent on determining the ease of use in operating the system in a remote site subject to severe weather conditions. Issues with the data collected and other system problems were documented to help WYDOT determine if this is the appropriate technology for use at Trapper's Point and potentially other areas of the state.

1.2.3 Task 3: Success of Detection System

Task 3 of the research effort is to review and analyze data from the project area to determine the number of detection calls made in the different detection zones and summarize these by time of day and time of year. The system will be configured to generate time-stamped data for each positive animal detection call.

Secondly, the video camera data will be reviewed and compared against the detection zone data to determine if positive detection calls from the system correspond to visual detection of large animals along the roadway to determine the frequency of false positives (detection system activated, but no game present).

Lastly, during likely high animal usage times, personnel were placed in the vicinity of the project area to observe the roadway for false negatives (detection system not activated but game present). Researchers will work with ITS Program staff on a continuous basis to modify data collection methods and equipment as necessary to provide the highest quality data available.

1.2.4 Task 4: Effect on Driver Behavior

Speed data collection will be performed at three locations along the project corridor using Wavetronix SmartSensor HD units. The reason for collecting data at three locations is to determine whether any speed differences are sustained throughout the entire high hazard corridor or if there is an initial deceleration reaction followed by acceleration back to normal travel speeds. Statistical analyses to determine if speeds for a given time period are correlated to the percentage of time the signs were activated will be performed.

1.2.5 Task 5: Effect on Crash Rates

The final phase of the research effort is to determine the overall effectiveness of the system on vehicle-wildlife crash rates in the corridor. This requires two to three years of crash data with the system in place to make statistically significant statements about the effectiveness of the system. The crash frequency and crash rate analyses will also consider additional factors relevant to the corridor, such as changes in traffic volumes and wildlife populations during the crash analysis period.

1.3 Report Format

This report is broken into the following sections:

1. Introduction.
2. Literature Review.
3. Project Description.
4. Data Collection.
5. Post-Installation Modifications.
6. Data Analysis and Results.
7. Conclusions and Recommendations.

Chapter 2 contains an in-depth discussion on the success and cost-effectiveness of techniques that have been used throughout the world to reduce deer-vehicle collisions (DVCs). The chapter focuses on the technologies used in past wildlife-sensing driver warning systems and the methods used to determine their effectiveness. Chapter 3 describes the project site in detail, from weather conditions to descriptions of the technology used in the system. Chapter 4 details the techniques that were used to collect data on the system. Chapter 5 discusses the problems experienced by the system since construction and the myriad of changes that were made to correct them. Chapter 6 explains the processes that were used to analyze data on the system and the results of these analyses. Chapter 7 provides a summary and recommendations based on the aforementioned results.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Engineers, planners, and wildlife ecologists have been working on solutions to the DVC-problem for decades. A report published by Traffic Data Systems, Inc. in 1969 evaluated the methods for the detection and counting of deer to reduce the frequency of deer-vehicle accidents (Leedy, Franklin and Hekimian 1975). The writers focused on mechanical, magnetic, sonic, visual light, and infrared systems. Unfortunately, they found the results for all of the techniques to be generally negative at that time.

More than thirty years later, a comprehensive list of sixteen different DVC countermeasures and their effectiveness, compiled in a study completed by the University of Wisconsin, was published to aid professional highway engineers in determining countermeasures that are appropriate for a particular stretch of highway (K. K. Knapp, et al. 2004). The report covers in-vehicle technologies, deer whistles, roadway lighting, speed limit reduction, deicing alternatives, deer-flagging models, intercept feeding, deer crossing signs, roadside reflectors, repellants, hunting, public education, roadside vegetation management, fencing, road design, and wildlife crosswalks. Fencing and wildlife crossings were the only countermeasures that were found to have generally positive study results; however, the report also concedes that the variability and complexity of the DVC problem makes it unlikely that there is one solution that exists for every roadway application. A similar report, published by the Iowa Department of Transportation, also admits that the effectiveness of most methods is still questionable (Danielson and Hubbard 1998). Another comprehensive DVC literature review, prepared by the Jackson Hole Wildlife Foundation and Biota Research and Consulting, Inc of

Jackson, Wyoming, (2003) covers many of the same topics and will also be discussed in the following sections.

2.1.1 Countermeasure Classifications

The sixteen countermeasures listed in the previous section can be broken down into two broad categories, depending on the design target audience of the device. Speed limit reductions, warning signs, in-vehicle technologies, and public education are methods that seek to change the behavior of drivers. Deer crossing behavior is likely to be unchanged as a result of these countermeasures. Likewise, the behavior of drivers are not meant to be changed by construction of underpasses, fences, deer-flagging models, roadside reflectors, or wildlife crosswalks; the start of an intercept feeding, repellant, or hunting program; installation of deer whistles (although only already-wary drivers are likely to install whistles); or the changing of an agency's deicing materials. Roadway design, depending on the nature of the design, can have an effect on both deer and driver. An increase in clear zone width or curve radii, for example, will improve the ability of both the driver and the deer to see each other. Studies in Illinois show that deer crossings were negatively correlated with increased distance between the road and the nearest forest cover (Curtis and Hedlund 2005). Similarly, roadway lighting has been proposed to improve driver visibility and change deer crossing patterns (K. K. Knapp, et al. 2004). In a study performed by D.F. Reed and published by the *Journal of Wildlife Management* in 1981, however, lighting was shown to have no effect on the behavior of drivers or deer (Danielson and Hubbard 1998).

DVC countermeasures that specifically target drivers can be broken down further by the nature of their operation. Passive countermeasures are static devices that remain unchanged regardless of the presence of vehicles or wildlife. Standard, yellow, diamond-shaped deer crossing signs are a common example of a passive countermeasure. In contrast, an active countermeasure reacts, often by activating a flashing light or displaying a message, when a particular condition is met. A warning sign that flashes only when a deer is detected on the roadside and a vehicle equipped with an infrared camera are examples of active, driver-targeted DVC countermeasures.

Devices and techniques that target deer can also be broken down into subcategories. Certain countermeasures, such as fences, underpasses, and wildlife crosswalks, function by restricting the movement of deer. Rather than allowing deer to cross wherever they choose, roadway crossings are pre-selected for them in the form of under/over passes and openings in fence lines. Other countermeasures seek to discourage deer from occupying the area near the roadway without physically preventing deer from accessing the road. Reflectors, repellants, intercept feeding, and vegetation management are examples of this type of countermeasure. There is also one example of an active countermeasure that is directed towards modifying deer behavior in the presence of vehicles that is discussed later in this report.

A device that is targeted towards drivers is assumed to have no effect on the behavior of deer, regardless of whether the device is active or passive.

2.1.2 Extent of Literature Review

The remainder of this literature review will be divided into a discussion on the following eleven DVC countermeasures, grouped by whether the countermeasure is targeted towards modification of the behavior of the driver or the deer, whether the countermeasure is passive or active, and whether it is restrictive or unrestrictive to wildlife movement. These countermeasures are:

- Driver-Targeted Countermeasures.
    - Passive.
        - Speed Limit Reduction.
        - Static Warning Signs.

        - Roadway Lighting.
        - Public Education.
    - Active.
        - In-vehicle technologies.
        - Wildlife-sensing driver warnings.
- Wildlife-Targeted Countermeasures.
    - Restrictive to Wildlife Movement.
        - Fencing.
        - Underpasses / Overpasses.
        - Crosswalks.
    - Unrestrictive to Wildlife Movement.
        - Reflectors.
        - Hunting.
        - Vehicle-Sensing Wildlife Warnings.

There are a variety of additional countermeasures that have been studied that will not be discussed in this report, such as deer whistles, deicing alternatives, deer-flagging models, intercept feeding, repellants, roadside vegetation management, and road design. Information regarding these countermeasures is limited and available elsewhere. It was decided by researchers that these methods were less promising. Rather than re-write something that has already been written, the authors refer readers interested in obtaining more information regarding these countermeasures to the following published literature reviews: K.K. Knapp, et al. 2004; Danielson and Hubbard 1998; Jackson Hole Wildlife Foundation, Biota Research and Consulting, Inc. 2003; Putman, Langbein, and Staines 2004; and Curtins and Hedlund 2005.

2.2 Driver-Targeted Countermeasures

2.2.1 Passive Countermeasures

Speed Limit Reduction

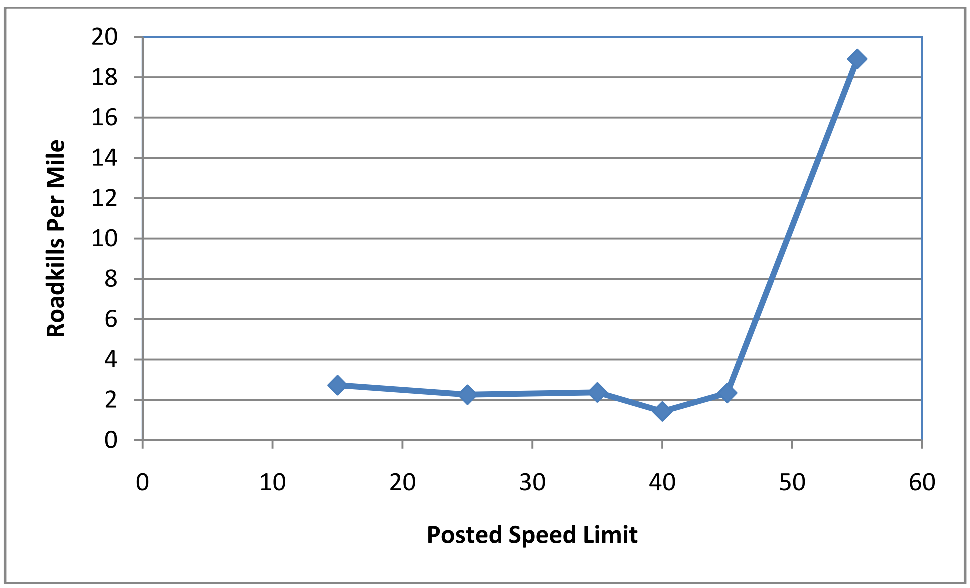
The idea behind speed limit reductions is straightforward. Slower speeds allow the driver more time to react to obstacles, such as deer, in the roadway than faster speeds, and therefore make it more likely for the driver to be able to safely maneuver around the obstacle.

A study completed by Gunther, Biel, and Robinson of the Bear Management Office in Yellowstone National Park determined that speed was the primary factor contributing to vehicle-wildlife collisions (1998). The group also determined several other factors that contributed to wildlife collisions within the park: road reconstruction, vegetation cover type, and the population of a particular species. Data were used from incident reports filed by park rangers; maps showing posted speed limits, landmarks, and vegetation types; estimates of wildlife populations from literature and experts; and data from speed studies conducted on fifteen major road segments within the park.

Between the years 1989 and 1996, 939 large mammals were reported to have been struck and killed by vehicles, 30% of which were mule deer. Significantly higher numbers of large mammals were struck on roads with a speed limit of 55 mph than those with a limit of 45 mph when segment lengths were taken into account. The number of road kills on a newly reconstructed roadway segment over Sylvan Pass increased significantly compared with the numbers killed on the same road before it was rebuilt. Mule deer were struck and killed significantly more often in forested areas than non-forested areas. Species with large populations were significantly more likely to be involved in a collision with a vehicle than species with a smaller population.

Figure 2-1 shows the relationship between posted speed limit and the number of road kills per mile in Yellowstone Park, created using data from the report prepared by Gunther, Biel, and Robison (1998). There is a dramatic difference between the number of road kills on roadways with a 55 mile per hour speed limit and those with a 45 mile per hour speed limit. Only 2.3 road kills per mile were recorded for 45 mile per hour roadways while 18.9 road kills per mile were recorded for the 55 mile per hour segments.

Researchers found that the average operating speed along the 55 mile per hour segments were 9 to 16 miles per hour greater than the posted speed limit. The operating speeds of roads with 35 and 45 mile per hour speed limits were within one to three miles per hour of the posted limit. This suggested that roadway characteristics play a larger role in determining the average operating speed than the posted speed limit.



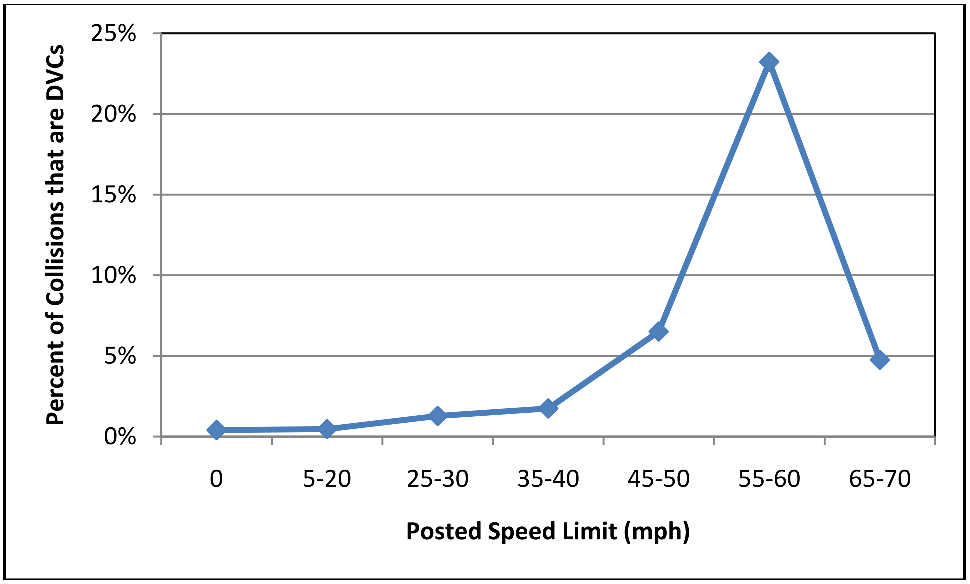
Source: (Gunther, Biel and Robison 1998)

Figure 2-1: Relationship between posted speed limit and the number of road kills per mile in Yellowstone National Park.

The report suggests that road designs that keep vehicle speeds at 45 mph or slower be used in Yellowstone National Park. The report concedes that road design appeared to influence vehicle speed more than the speed limit. Consequently, it is unlikely that drivers would obey an artificially low speed limit established only to lower the probability of animal-vehicle collisions. Other studies have shown that only strongly-enforced lower speed limits have the potential to reduce the frequency of DVC's (Danielson and Hubbard 1998).

Another study used crash data from three counties in southeast Michigan to determine the characteristics that lead to deer-vehicle collisions (Riley and Marcoux 2006). In the year between July, 2005 and July, 2006, Michigan was second in a list of states ranked by the number of accidents involving deer. Only Pennsylvania ranked higher (State Farm Insurance 2006).

The results concerning speed limits from the study by Riley and Marcoux are shown in Figure 2-2 (2006). The percentage of total crashes that are related to deer increase steadily with speed until the 55-60 mile per hour range is reached. For the 65-70 mile per hour range, the percentage of DVCs drops dramatically, to a level lower than the 45-50 mile per hour range. In general, the information collected in this study suggests that the percentage of crashes that are DVCs and increasing posted speed limits are positively correlated. Roads with posted limits of 55-60 mph had 13 times the risk of roads with a 35-40 mph speed limit (Riley and Marcoux 2006).



Source: (Riley and Marcoux 2006)

Figure 2-2: Effect of posted speed limit on the percentage of total crashes that were DVCs in southeast Michigan.

While higher speed limits have been shown to be strongly correlated with the number and severity of wildlife-related accidents, reducing speed limits in areas where DVCs are common is not often practical because neither the road authorities nor motorists appear to be interested in this measure (Jackson Hole Wildlife Foundation 2003). People are likely to drive at a speed that is comfortable given the geometric conditions and condition of the road. Only 20.3% of drivers had been involved in a DVC in their lifetime according to a survey performed by Riley and Marcoux (2006). Since the majority of drivers have never been involved in an accident involving a deer, DVCs remain relatively uncommon events. Drivers cannot be expected to slow down on familiar roads to avoid infrequent collisions with wildlife.

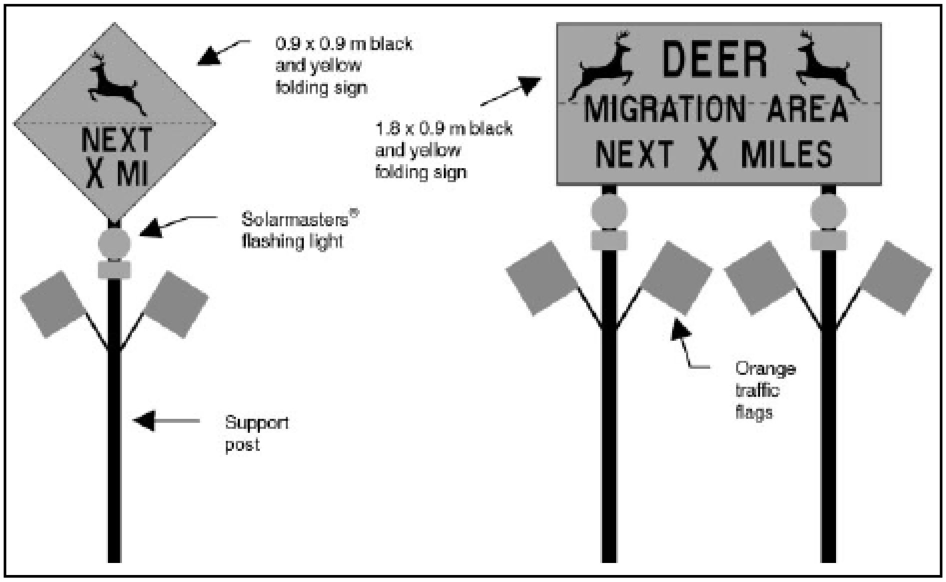
Static Warning Signs

Permanent, static road signs, such as the traditional deer crossing warning sign (*MUTCD* W11-3) shown in Figure 2-3 are still the most common DVC countermeasure used by transportation agencies today (Hughes, Saremi and Paniati 1996). The signs are erected primarily for public relations and liability reasons, in addition to being cheap and easy to install (Jackson Hole Wildlife Foundation 2003). The *Manual on Uniform Traffic Control Devices, 2003 Edition* (*MUTCD*) explains that these signs may be used to alert road users in advance of locations where unexpected entries into the roadway or shared use of the roadway by animals might occur (Federal Highway Administration 2003). Unfortunately, unless the movement of deer is known to follow a predictable path, such as annual migration routes, or is somehow restricted by roadway design, the exact location where a driver will encounter a deer is unknown. The *MUTCD* further explains that these conflicts might be confined to a limited area, or might occur randomly over a segment of roadway. Deer crossing signs use the standard diamond shape and flourescent yellow-green color for warning signs and are generally found in four sizes, ranging from 24" square to 48" square.

Figure 2-3: Advance Warning Sign

A group of researchers from Utah State University and the Insurance Institute for Highway Safety conducted a study on the effectiveness of temporary warning signs on reducing DVC's during deer migrations (Sullivan, et al. 2004). Five highway corridors were selected, throughout Utah, Nevada, and Idaho, that mule deer were known to cross as part of their annual migration. Each of the segments also had high rates of DVCs, based on information supplied by state transportation agencies. They randomly established control and treatment segments in each corridor. Signs would only be installed at treatment segments. They recorded the number of deer killed daily and vehicle speeds at both types of segments. The larger sign in Figure 2-4 was installed on both ends of each treatment segment. Smaller signs, also shown in Figure 2-4, were installed every mile in both directions between the larger signs. The signs were unfolded and visible to drivers only during specific dates and time periods that deer were known to migrate. The length of time that the study covered varied by corridor. One site, for example, used data from 1995 to 2002, while another site used data from 2000 to 2002.

The group found a statistically significant change in DVCs in the treatment segments compared with the control segments. Treatment areas experienced a 51% reduction in DVCs and an estimated 179 DVCs were prevented during the study periods due to the signs. They also found a statistically significant change in driver speed. The number of drivers not exceeding the speed limit by 8 kilometers per hour or more almost doubled when signs were in use (Sullivan, et al. 2004). Their study indicated that temporary warning signs were effective at reducing the DVC rate in narrow corridors where mule deer were known to cross. Since the signs were only activated during known times of mule deer migration, drivers did not become accustomed to the signs and may have respected them more than static, permanent deer warning signs. The signs were relatively inexpensive, with an average cost of $1,740 to install all the necessary signs on a segment of highway (Sullivan, et al. 2004).

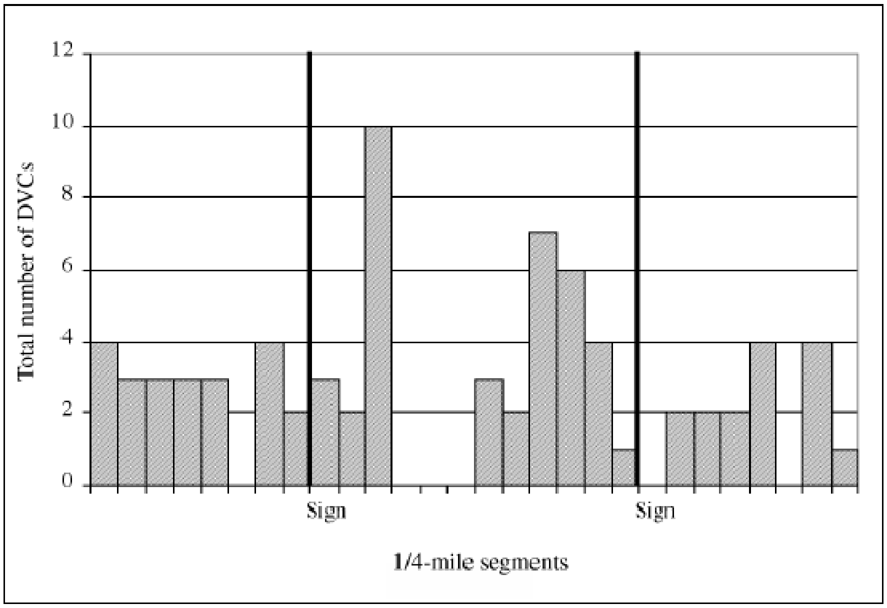


Source: (Sullivan, et al. 2004)

Figure 2-4: Design of temporary signs placed in treatment areas in Utah, Nevada, and Idaho.

A report by Knapp and Yi (2006) recommended that transportation agencies use historical DVC data when deciding where to place static, permanent deer warning signs. According to this report, a survey of the transportation agencies of five Midwestern states revealed that none of the states had quantitative procedures or warrants for the placement of these signs. The signs were found to be overused and had little effect on driver behavior.

Knapp and Yi (2006) suggest that agencies compare a segment's DVC history with that of an overall state or county average. For the signs to be effective, the area enclosed by W11-3 signs should have higher DVC rates than areas not enclosed by the signs. The majority of the signs studied did not enclose the peak number of DVCs on a segment. Instead, the peak occurred on adjacent segments. Figure 2-5 is an example of an installation that encloses the peak number of DVCs on the segment.



Source: (Knapp and Yi 2006)

Figure 2-5: Sample one-quarter-mile DVC frequency near a pair of deer crossing signs.

The report also suggests the use of a more proactive approach to the placement of W11-3 signs, which includes consideration of the roadway and roadside characteristics that past models show are correlated with higher numbers of DVCs (Knapp and Yi 2006). Factors that have been shown to increase DVCs include: traffic volume, number of bridges/culverts, number of roadway lanes, human population, deer population density, and the size of adjacent grass and woodland patches. Using these characteristics to identify potential DVC hot spots before they become a problem or basing sign placement on an analysis of historical DVC records may increase the effectiveness of deer crossing signs.

Although the signs are different in design in the United Kingdom, the problem with static warning signs remains the same. A literature review prepared by Putman et al. indicates that drivers readily habituate to warning signs unless the message is reinforced by the presence of crossing deer (Putman, Langbein and Staines 2004). A literature review written by Danielson and Hubbard (1998) cites a study that suggests that motorists show a greater response to warning signs when they are shown that a hazardous situation actually exists. In this study, motorists slowed down by an average of 8 miles per hour after passing three deer carcasses that had been placed next to a deer-crossing warning sign.

Roadway Lighting

A study completed by Reed in 1981 and cited by Danielson and Hubbard (1998); Knapp, et al (2004); and the Jackson Hole Wildlife Foundation and Biota Research and Consulting, Inc (Jackson Hole Wildlife Foundation 2003) set out to determine whether lighting can enhance drivers' vision and reduce their chance of colliding with a deer. Thirteen lights were placed along a 0.75-mile-long stretch of highway in Colorado. There were a total of 45 DVCs that occurred when the lights were off and 39 when the lights were activated, which led Reed to conclude that the lights had little effect on DVCs (K. K. Knapp, et al. 2004). Reed also concluded that the lights did not have a significant effect on the location of deer crossings or vehicle speed. During a short-lived test that was halted out of concern for public safety, the average vehicle speed was reduced by 8.3 miles per hour when a deer decoy was placed on the side of the road.

Another study, cited by the report by the Jackson Hole Wildlife Foundation (2003), found that moose-vehicle collisions were reduced by 70% along a highway in Alaska after lighting was installed. Drawbacks to the system included regular bulb maintenance, circuit wire repairs, collisions with light poles, and light pollution to the surrounding natural habitats (Jackson Hole Wildlife Foundation 2003).

Public Education

Public education programs seek to inform the public of the danger posed by wildlife on roadways; the times-of-day, time of the year, and other factors that result in the highest risk of a DVC; and the ways to avoid a collision with wildlife while one is driving. For example, a 15 second television advertisement titled *Caution: Deer Crossings* was widely aired throughout the state of Virginia in 2002. The report discussing the ad noted that it won an award, but did not mention any quantitative results stemming from the advertisement (Metropolitan Washington Council of Governments 2006). According to the same report, the Maryland Department of Natural Resources routinely informs the public about DVCs and the methods that can be used to avoid DVC through the media, news releases, and information distributed through the internet via the department's webpage (Metropolitan Washington Council of Governments 2006).

A literature review prepared by Knapp et al. (2004) provides an overview of much of the educational material distributed to the public by non-governmental organizations and public agencies. In general, the material first describes the severity of the DVC problem in the audience's area. This information can include maps, charts, tables, and other graphics. The second portion of most DVC-related public information and education message involves a series of suggestions typically referred to as driver tips (K. K. Knapp, et al. 2004). These driver tips, according to the Knapp report, typically include suggestions to: be on the lookout for deer especially during dusk, dawn, Fall, and Spring; drive with your headlights on and reduce your speed at night; expect more deer when you see one; stay on the road rather than swerve; and report the crash to police and your insurance company. A very thorough list of suggestions for drivers to avoid colliding with a deer has been published by the Wildlife Collision Prevention Program in Canada (Wildlife Collision Prevention Program n.d.). According to the literature review prepared by Danielson and Hubbard (1998), however, very little has been done to quantify the effects of these public awareness campaigns on reducing DVCs.

2.2.2 Active Countermeasures

In-Vehicle Technologies

Animal-vehicle crash frequencies at night can be between two and five times greater than crash frequencies during the day (Hughes, Saremi and Paniati 1996). Making matters worse, drivers experience a greatly-reduced ability to perceive differences in contrast at night, which can make it difficult to distinguish even large objects from a dark background. Due to the illumination pattern of American headlights, pedestrians on the left side of the vehicle, from the driver's perspective, can only be detected at half the distance of pedestrians on the right side of the vehicle (Institute of Transportation Engineers 1999). The same problem undoubtedly exists for all objects on the near the side of a vehicle, including wildlife. Fortunately, automobile manufacturers have developed and marketed several in-vehicle technologies recently that promise to aid drivers with nighttime visibility.

One such technology is currently available in the United States on select BMW models. The company's website claims that their infrared system enables the driver to see up to 328 yards ahead using an infrared camera installed on the front of the vehicle and a video image displayed on the navigation system's screen (BMW n.d.). Figure 2-6 is a sample screenshot of the system, provided by BMW.

Source: (BMW n.d.)

Figure 2-6: A sample screenshot using BMW's Night Vision technology.

General Motors developed a similar system for their now defunct Cadillac DeVille line, beginning with the 2000 year models (General Motors Corp. n.d.). According to GM's website, more than 300,000 vehicle-deer collisions occurred in 1997, many of which could have been avoided if more time had been available to react to the hazard. Their system, they claim, extends a driver's vision to twice that provided by high beam headlights using thermal-imaging / infrared technology developed by Raytheon Systems Co. Unlike the system available in BMW models, however, the system offered by Cadillac presents the image to the driver via a heads-up-display, rather than on a screen near the center of the dashboard. A heads-up-display projects information onto the windshield, within the driver's line of sight. With General Motors' system drivers do not need to divert their eyes from the road in order to see the image generated by the infrared camera. According to their website, the camera has a horizontal field of view of 11 degrees and a vertical field of view of 4 degrees. Conveniently, this field of view represents approximately the same visual field of view as the average person. Most people have clear vision within a 3° to 5° cone and fairly clear vision within a 10° to 12° cone (Garber and Hoel 2002). As a result, the image presented on the heads-up-display should nearly match a driver's normal view of the road.

According to an article published by the Institute of Electrical and Electronics Engineers, the cost of the Cadillac system is between $1,600 and $2,500. The system projects a 4" by 10" image on the windshield's heads-up-display, which is just below the driver's line of sight. Cadillac wanted the system to be simple to operate so that anyone who gets in the car can understand how to operate it within a matter of minutes. A test by Cadillac found that it usually took new users about 10 to 20 minutes to become accustomed to the display, after which they treated it much like a rearview mirror. Engineers also designed the infrared camera, mounted on the car's grill, to be rugged enough to withstand an impact at 9 miles per hour (Schreiner 1999).

Serious concerns have been raised about the possibility of information overload and distraction associated with in-vehicle technologies, such as the aforementioned infrared camera systems (K. K. Knapp, et al. 2004). A study completed at the University of Michigan, however, concludes that the workload for drivers using a night vision system is not significantly different from the workload experienced by a driver without the aid of night vision technology. In fact, night vision systems were shown to have significantly increased target detection distance for young and old drivers (Sullivan, et al. 2004).

Further advances in in-vehicle DVC countermeasure technologies have been made in Europe. Some European vehicles are equipped with headlights that lessen the tendency for deer to freeze when startled by an approaching vehicle. Unfortunately, these headlights are not street-legal on American roadways. In addition, European windshield wipers are designed to clear a larger area of windshield, faster than their American counterparts. This technology has the potential to reduce the chances of DVC's in poor weather (Danielson and Hubbard 1998).

Wildlife-Sensing Driver Warnings

According to Huijser, et al. (2006), most of the detection technologies used in wildlife-detection systems can be classified as either area-cover or break-the-beam sensors. Area-cover systems report a detection when an object moves within a certain range of a sensor. Break-the-beam systems consist of pairs of transmitters and receivers. A detection is made when the receiver momentarily loses contact with the transmitter, which is continually emitting a signal.

Area-cover systems can be subdivided into active and passive technologies. Passive sensors work as receivers only. The two most common passive area-cover systems, according to Huijser, et al. (2006), are passive infrared and video detection. On the other hand, active systems work by transmitting a signal and measuring the strength of its reflection. Microwave radar is an example of an active area-cover system. An example of an active wildlife-detecting driver warning system used in Sequim, Washington is discussed in the report by Huijser, et al. (2006). This system used directional antennas to detect the radio signature transmitted by radio collars affixed to key individuals in an elk herd. When the elk are within a certain distance of the receivers, roadway signs are illuminated. The report by Putman, et al. (2004) points out that this radio-collar system depends on a herd that follows very predictable migration patterns and therefore may not be appropriate for all locations.

A study completed in Nugget Canyon, Wyoming in 2001 analyzed the effectiveness of three wildlife detection systems: the passive-infrared-based FLASH system, a system utilizing geophones and infrared sensors, and a microwave radar system. The report by Huijser (2006) covers two systems in depth: a break-the-beam system installed near Yellowstone National Park in Montana, and a microwave radar area-cover system near Thompsontown, Pennsylvania. An in-depth description of these projects can be found later in this chapter.

The purpose of an active wildlife-sensing driver warning system is two-fold, according to Huijser et al. (2006). First, the system must detect the presence of wildlife approaching the road. Next, the system must warn drivers of the hazard. The effectiveness of the first step can be measured by recording the number of false detections, while the effectiveness of the second step is typically measured by recording the effect of the sign on drivers' speeds. The effectiveness of the system as a whole is determined by analyzing the effect of the system on crashes, particularly records of crashes involving wildlife.

Active warning systems suffer from two types of false detections: false positives and false negatives (Huijser, et al. 2006). A false positive occurs when the system detects the presence of wildlife when wildlife is not actually present. A false negative occurs when the system fails to detect the presence of wildlife when wildlife is present.

The frequency of false detections can be determined using a variety of methods. The study conducted by Huijser, et al. (2006) on the active warning system installed in Yellowstone National Park used humans as models for elk to determine whether the system could reliably detect movement alongside the road. Humans passed through detection zones at regular intervals. A specific length of time was allowed to elapse between each pass to avoid desensitizing the beam. If the system did not detect the human, a false negative was recorded and the area was flagged as a blind spot.

The team from Montana State University used software to automatically record the time and detection zone number whenever the system recorded a hit. They used this information to determine the cause of the hit based on the patterns defined in Table 2-1. Detections that were caused by anything other than an "animal crossing" were potentially caused by a false detection.

Table 2-1: Reasons for detection based on analysis of detection data patterns

Category	Definition
Animal Crossings	All detections that showed "something" crossed the road and triggered the system in detection zones on opposite sides of the road. This is synonymous with the term "crossing event". Note: we included detections in the right-of-way that seemed to be related to the crossing (i.e., detections immediately before and after the crossing of the actual pavement).
Traffic / Snowplow	A series of consecutive detections in adjacent sections with the direction of travel. The detections may be caused by snow spray from snow plows, signal reflections from large vehicles (buses / trailers) or vehicles driving close to the edge of the road.
Traffic Black Butte Ranch	All detections in detection Zone 3 between 7:00-23:00 hrs that had no match on the other side of the road.

Trailhead	All detections in detection Zone 7 between 7:00-19:00 hrs that had no match on the other side of the road.
Error	Detections associated with a failed radio report or detections that occur simultaneously in adjacent sections.
Unclear	Detections that do not fall in any of the above categories and that cannot be readily explained based on the data patterns alone.

Source: (Huijser, et al. 2006)

The same study by Huijser, et al. (2006) also monitored the snow alongside the road for animal tracks. The team spent a total of twenty five days scouring the roadside for tracks. They used a rake to clear the tracks after each day of recording. When a set of tracks appeared to have crossed the road, the team looked for a matching set of tracks on the opposite side of the road. If a matching pair was found, the event was recorded as a crossing. They matched this information with the data automatically saved by the detection system to help quantify the number of true detections.

Gordon, et al. (2001) used live monitoring sessions to record the number of false detections experienced by the system. Personnel would sit in a trailer near the site and monitor the crossing for deer activity and activity recorded by the detector system. The number of false detections could be easily quantified using the data collected during these sessions. The team also used a video camera to record the number of deer passing through the crossing. A recording device was activated for two minutes whenever the system recorded a detection. The number of false positives and false negatives could be determined by monitoring the recorded video for deer activity and comparing the results with data recorded by the system's data logging device.

Vehicle speed is a common measure of effectiveness used to determine whether dynamic signage has an effect on driver behavior (Huijser, et al. 2006). Unfortunately, previous studies on the effectiveness of active warning signs have been inconclusive. Several studies have recorded decreases greater than three miles per hour as a result of the signs, while other studies have recorded increases in vehicle speed. Changes in vehicle speed are likely to be dependent on the type of warning sign, whether the sign is accompanied by a speed limit, road conditions, weather conditions, and whether the driver is familiar with the road.

A study conducted by Gordon, et al. (2001) used pneumatic traffic recording devices to record the speed, classification, and size of vehicles traveling along the road. Three separate pneumatic tubes and recording devices were used: one on either side of the project site, before drivers encountered the warning sign, and one at the crossing, after drivers had encountered the warning sign. The study exposed drivers to the five different treatments shown in Table 2-2 and compared each treatment for changes in vehicle speed.

Table 2-2:Vehicle Speed Treatments

Treatment	Description
1	The sign read "Attention: Migratory Deer Crossing". Lights were left flashing continuously. This allowed us to determine a baseline change in speed through the crossing in response to a normal deer warning system.
2	The sign read "Deer on Road When Lights are Flashing". Lights were left flashing continuously. From this we can evaluate whether motorists reduce their speed in response to the lights even when deer are absent.
3	The sign read "Deer on Road When Lights are Flashing". Lights were left flashing continuously and a realistic-looking taxidermist's mount of a deer was placed on the shoulder about 3m (10 ft) from the road. From this we determined the effect on motorist

Treatment	Description
	speed of an actual deer in the crossing, after having been warned by the flashing lights.
4	The sign read “Deer on Road When Lights are Flashing”. Lights were deactivated and the deer was placed near the roadway. We used this treatment in conjunction with treatment 3 to evaluate whether the lights have an “alertness” effect. In other words, do motorists slow down less in response to the deer decoy when they haven’t been forewarned of its presence by the lights?
5	The sign read “Deer on Road When Lights are Flashing”. Lights were activated by a remote control as motorists approached, such that motorists could see the lights come on. This treatment was used to determine whether motorists were more likely to slow down given evidence that the system was active.

Source: (K. M. Gordon, S. H. Anderson, et al. 2001)

Transportation agencies usually maintain records of crashes that occur on their road networks. Sifting through these records can result in a list of wildlife-vehicle collisions that occurred on a particular segment of highway. According to Huijser, et al. (2006), using this data to make conclusions on the effectiveness of an active wildlife-sensing driver warning system or the severity of the DVC problem in one area compared to another can be hampered by fluctuating animal populations, changes in traffic volume, changes in animal movement patterns, variability in site conditions, or other factors which are not recorded by the official crash records. Also, since active warning systems are installed over relatively short distances, the number of DVCs that are recorded in that particular area during a year is likely small and can vary substantially between years due to random chance alone.

Research results from four existing active animal detection warning systems will be discussed in the following section. The systems are located in Thompsontown, Pennsylvania; Yellowstone National Park, Montana; Nugget Canyon, Wyoming; and Kootenay National Park, British Columbia.

Highway 22/322 is a four-lane divided highway near the town of Thompsontown, Pennsylvania that experiences approximately 70 DVCs every year (Huijser, et al. 2006). A company called Oh DEER, Inc. installed an area-cover system that utilized microwave radar to detect the movement of large animals on the roadside. The system consisted of a total of 17 poles installed on both sides of the highway, with two microwave sensors on each pole. The sensors were installed at a height of six feet from ground level. Each sensor is capable of detecting movement within 150’ in the direction that the sensor is facing. This range diminishes to only 10’ to 20’ in the perpendicular direction, towards the road.

Standard W11-3 deer crossing signs were accompanied by lights and signs that read “USE EXTRA CAUTION WHEN FLASHING”. These signs were placed 850’ from the first sensor in the westbound direction and 1400’ from the first sensor in the eastbound direction. In addition, signs that read “ANIMAL DETECTION TEST AREA AHEAD” and “END TEST AREA” were placed beyond the beginning and the end of the area covered by sensors. The lights on the signs were remotely activated by the sensors via radio.

The system was plagued with problems. There were difficulties activating the system when humans ran near the sensors, power-related problems related to the batteries and the solar panels, and problems with false detections caused by moving vehicles. Due to these problems, the system was removed and study was halted.

The Western Transportation Institute of Montana State University studied a system installed on US Highway 191 in Yellowstone National Park (Huijser, et al. 2006). A total of 107 automobile-elk collisions had been recorded in this area between 1989 and 1998. A company called Sensor Technologies and Systems (STS) designed a break-the-beam system using microwave signals. The system covers a one-mile-long stretch of highway. A total of nine pairs of sensors were installed. A pair consists of a transmitting station and a receiving station. When the receiving station loses contact with the transmitting station, due to an object between the stations, a detection is recorded. The distance from the edge of pavement varied from 3.3' to 26.3'. The poles on which the sensors are mounted were designed to be break-away for safety concerns. The system is powered by solar panels and batteries.

Four signs were installed to warn drivers when wildlife was detected by the sensors. These signs were activated wirelessly. The signs read "WILDLIFE CROSSING, NEXT X MILE, WHEN FLASHING", depending on the distance to the end of the area covered by the sensors. Additional signs were placed that read "ANIMAL DETECTION TEST SECTION AHEAD" and "END TEST SECTION" on either side of the area covered by sensors.

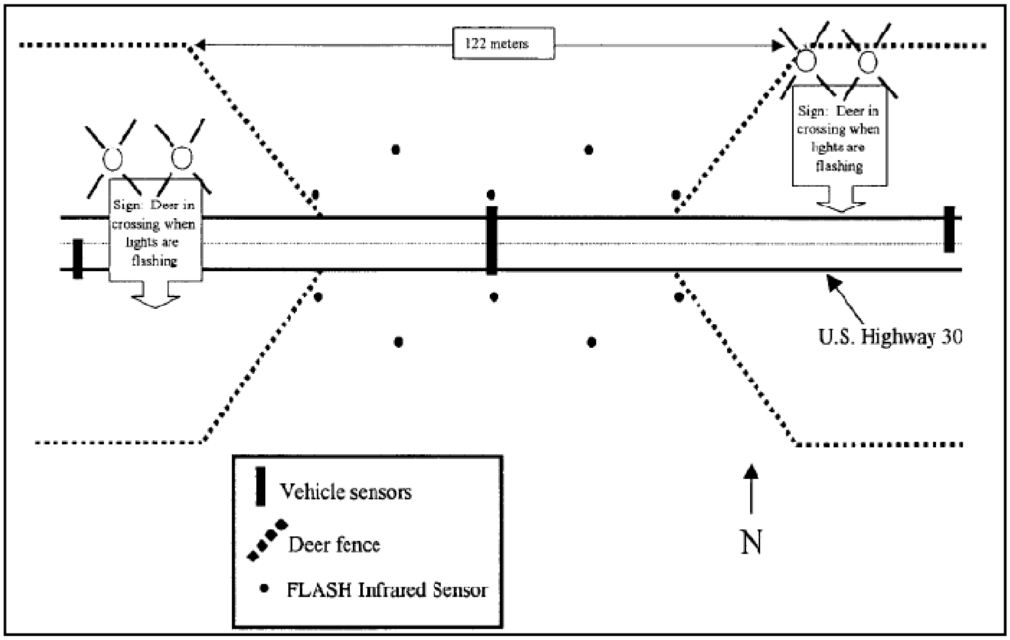
The sensors experienced problems with frequent false detections, the inability to adjust the sensitivity of the sensors, poor long-distance communications with the system via a telephone connection, software problems, interference from other radio sources, misalignment of the beams, and an unreliable radio link. In response, STS installed a similar system near Scottsdale, Arizona to troubleshoot the problems experienced in Montana. A satellite link to the system replaced the telephone link. The warning signs and the flashing lights have been removed until detection problems can be addressed by the manufacturer.

Despite these problems, the team from Montana State University was able to correlate 87% of the elk tracks found in the snow alongside the road to crossing events recorded by the system. Unfortunately, a test using human crossings indicated that movement could not be detected reliably in at least 17.8% of the project length. The lights were programmed to flash for three minutes after the last detection. Many of the detections were clustered, and the time between consecutive detections was often less than three minutes. 72.6% of the witnessed crossing events took less than three minutes to complete, with an average time of 1 minute 29 seconds to cross between sensors on opposite sides of the highway. The group concluded that the system detected large animals reliably based on the correlations of elk tracks to sensor records. A study on the effect of driver behavior has not been completed.

Nugget Canyon is located between the towns of Kemmerer, WY and Cokeville, WY on US Highway 30 and is the site of hundreds of deer/vehicle collisions (DVCs) each year as migrating mule deer cross the highway (K. M. Gordon, S. H. Anderson, et al. 2001). The location has served as a test bed for many DVC-reducing technologies, beginning with the construction of a deer-proof fence in 1989, followed by installation of warning signs and wildlife reflectors.

The Wyoming Department of Transportation installed a FLASH (Flashing Light Animal Sensing Host) system in 2000 as a test project. The study by Gordon, Anderson, Gribble, and Johnson (2003) was performed to determine how the number of deer crossing the highway varies with time of day and season; to determine how the number of DVCs varies with season, to compare the accuracy of the FLASH system to other systems, and to evaluate the effectiveness of the FLASH system in modifying driver behavior.

The FLASH system uses infrared sensors to detect the body heat of animals and wirelessly relays this information to a radio receiver, which activates a sign that reads “DEER ON ROAD WHEN LIGHTS ARE FLASHING”. The system was laid out as shown in Figure 2-7. Sensors embedded in the roadway recorded vehicle speed and class in both directions before motorists encountered the signs. Another embedded sensor recorded vehicle speed and class within the treatment area, after motorists had witnessed the signs.



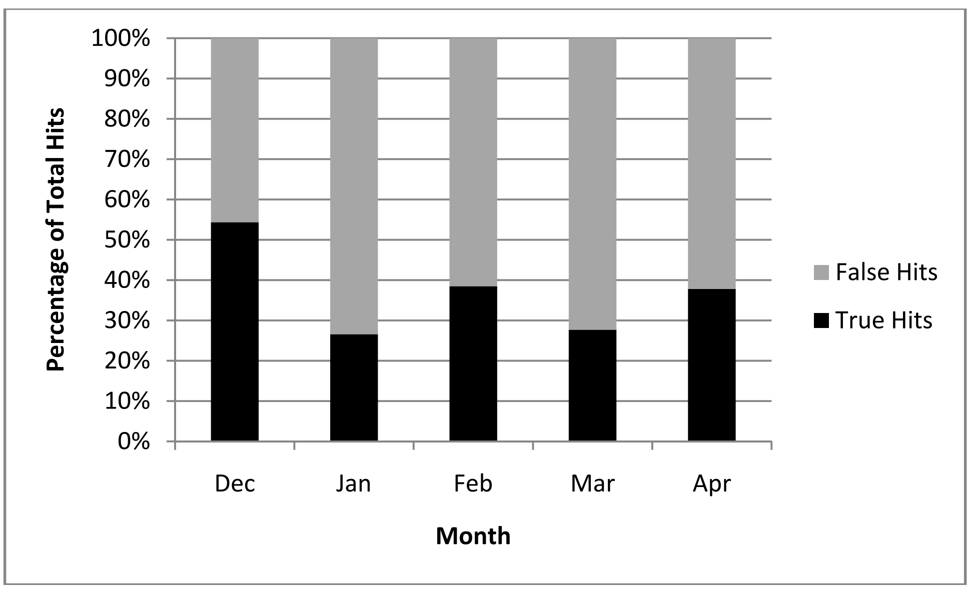
Source: (Gordon, McKinstry and Anderson 2004)

Figure 2-7: Layout of FLASH sensors and lights in Nugget Canyon, WY

Two additional systems, separate from the FLASH system, were later added to the test area for the purpose of gathering additional data on deer crossings. One of the systems consisted of infrared sensors and geophones. The other system used microwave radar to detect wildlife on the highway. A counter recorded the number of detections on all three systems. A video camera and video recorder were activated for two minutes each time the geophone sensor was tripped. Weather data was also downloaded from a nearby weather station. Deer carcass data for the area, which includes the milepost, age, sex, and date of the removal of the deer carcass, were acquired from WYDOT for the area.

To determine the reliability of the system, researchers monitored the site from a remote location for two-hour periods for deer activity and compared the results with data from the detectors. When observers were not present, the reliability of the system was gauged using data collected by the video recorder and detector counter.

Early in the study, the FLASH system and the geophone system appeared to work flawlessly during 30 hours of observation. All deer crossings were detected by both systems and there was no evidence that either system recorded a false hit. Later in the study, however, the FLASH system suffered from false detections due to birds, frost, and snow thrown by snowplows. A faulty transmitter caused the FLASH system to report detections when a tractor-trailer would pass. The geophone system experienced none of these problems. Figure 2-8 is a breakdown of the percentage of hits recorded by the FLASH system that were confirmed as being true or false detections. False hits made up the majority of the detections by the FLASH system in every month except December, 2000. In January, only 27% of the total detections were confirmed as true detections.



Source: (K. M. Gordon, S. H. Anderson, et al. 2001)

Figure 2-8: Percentage of false hits on the FLASH system by month

Motorist behavior did appear to be affected by the system, if only slightly. Speed was reduced by an average of 0.7 miles per hour when the signs were off and no deer were present in the crossing. When the signs were on but no deer were present, the average speed reduction was 1.4 miles per hour. When the signs were on and deer were present, the average speed reduction was 3.6 miles per hour. The researchers found the differences in these three speeds to be statistically significant, but concluded that a reduction in speed of 3.6 miles per hour is unlikely to significantly reduce the likelihood of a deer-vehicle collision (K. M. Gordon, S. H. Anderson, et al. 2001).

The Nugget Canyon researchers also tested drivers' responses to a variety of treatments. They recorded vehicle speed when the lights were activated but no deer was present, when the lights were activated and a deer decoy was placed on the side of the road, when the lights were not activated and a deer decoy was placed on the side of the road, and when the lights were triggered by remote control. The highest average reduction of speed occurred when the lights were activated and the deer decoy was used. However, the next highest reduction of speed was experienced when the lights were deactivated and the decoy was used. This indicated that the FLASH warning system by itself did not cause motorists to reduce their speed enough to prevent deer-vehicle collisions (K. M. Gordon, S. H. Anderson, et al. 2001).

In contrast with the FLASH system, the geophone system performed extremely well (Gribble 2003). Occasionally, the system would record false detections due to passing trains and truck traffic. To remedy this, infrared sensors were added to the system. A valid detection by the system would require that the system receive hits from both the geophones and the infrared sensors. WYDOT later disconnected the geophones to test the reliability of the infrared sensors by themselves and were surprised to find that the scopes detected deer well and did not produce false hits. When scopes were installed on the north side of the road, however; the alignment of the highway caused the scopes to occasionally detect passing traffic.

The report by Gribble (2003) on the Nugget Canyon deer detection systems concludes that the microwave radar system proved totally unsuited for the application. The geophone system was the most accurate and reliable of the animal detection systems tested and even outperformed the FLASH system (Gribble 2003). The geophone system used type PT-200 processor/transmitters, type TT-100 wireless remote interval meters, type SP-500P seismic detector strings, and type IF-540 long range passive infrared detectors, supplied by Telonics, Inc. of Mesa, Arizona.

A system installed on Highway 93 in Kootenay National Park, British Columbia uses infrared cameras to detect wildlife on the side of the road and warn drivers using a set of flashing lights. A specialized tracking computer, developed by the NASA Jet Propulsion Laboratory, could supposedly detect a heat difference of 1/100th of a degree Celsius and interpret patterns of thermal gradients and movements to differentiate between wildlife and other heat sources (Wildlife Collision Prevention Program n.d.). According to the report by Montana State University, the system performed well on cool nights but recorded as much as 43% false detections on nights after a warm day. The system was later removed.

2.3 Wildlife-Targeted Countermeasures

2.3.1 Restrictive to Movement

Fencing

When properly designed, fences can be one of the most effective tools used to prevent DVC's. A report by Ward explains how the number of DVC's along a 7.8-mile-long section of Interstate 80 in Wyoming fell from a range of 37 to 60 DVC's per year to only one DVC per two years after the installation of an 8-foot-high large game fence and several underpasses (Ward 1982). Fencing does not have to be installed along the entire length of a highway to be effective at controlling locations where wildlife crosses. Findings suggest that fence modification may be most worthwhile only in corridors where wildlife is known to migrate (Harrington and Conover 2006). Results of a study performed by the Arizona Game and Fish Department show that 72 percent of elk crossings could be intercepted and funneled into wildlife underpasses by fencing only 25 percent of the section under study (Dodd, Boe and Schweinsburg 2005).

Fences are often installed along highways to delineate right-of-way and private property lines. Where livestock is kept, the fences must be appropriately designed to discourage stock from leaning against and toppling the fence. Unfortunately, fence designed for livestock is often inappropriate and even dangerous for wildlife. A study conducted by Utah State University sought to determine how frequently deer, pronghorn, and elk are killed by fences; the characteristics of fences that increase their lethality; and the most likely locations for wildlife to be killed by fences. The study was conducted primarily in northwestern Colorado. Using information from surveys completed by Colorado Department of Wildlife personnel and field surveys of randomly-selected routes, the group found the following:

- More than 70% of mortalities involved fences taller than 1 meter (3.3 feet).
- Woven-wire fences, such as one seen in Figure 2-9, killed significantly more ungulates than expected based on the surrounding area's ungulate population.
- There is a negative correlation between traffic volume and the frequency of mortalities caused by fences.

Source: (Harrington and Conover 2006)

Figure 2-9: Example of Woven Wire Fence.

The report concludes that it would be useful to modify fences in areas near water sources and in areas where ungulates are known to cross, such as within known migration corridors between summer and winter ranges. Roads with low volumes, and therefore higher deer activity, would also benefit from fence modification. Removal of woven wire fences is also suggested; smooth wire or barbed wire should be used instead. At the very least, current woven-wire fences could be topped by a strand of barbed or smooth wire. The distance between the top two wires plays a role in ungulate mortality, too. As this distance increases, ungulate mortality decreases (Harrington and Conover 2006).

The fences covered by the Utah State University report were designed to restrict the movement of livestock, not deer. Factors such as the height, length, and maintenance of the fence, and the desirability of vegetation within the right-of-way have been found to affect the number of deer that are able to breach a fence line and access the roadside (Danielson and Hubbard 1998). An exclusionary fence that is at least 7.8 feet high has been shown to be effective at deterring deer (Curtis and Hedlund

2005). The mean height of fences found along roadways in northwest Colorado, in contrast, was only 3.3 feet high (Harrington and Conover 2006). The benefit gained by increasing fence height appears to diminish when the fence reaches seven or eight feet. A study in Pennsylvania found that there was no statistical difference in the number of road kills between fences that were 8.9 feet high and those that were 7.2 feet high. Another study, however, found that deer could jump a 7.2-foot-high fence without trouble when food was available on the other side (Danielson and Hubbard 1998). The fence should be made of a sturdy material and be buried to prevent animals from digging underneath. A line of barbed wire or an overhang may be necessary to prevent animals from climbing over the fence (Cavallaro, et al. 2005).

The literature review prepared by Putman, et al. of the United Kingdom points out that exclusionary fencing should not be designed to prevent road-crossings altogether, but should channel animals towards a safer crossing point (Putman, Langbein and Staines 2004). According to another study, fencing is beneficial only when used in conjunction with an appropriate crossing structure (Cavallaro, et al. 2005). The use of highway fences is cautioned against by wildlife biologists, unless associated with structures that provide a passage for wildlife, according to the Jackson Hole Wildlife Foundation (2003). If a deer is able to access the highway right-of-way, an appropriate one-way exit structure should also be provided.

A study conducted by Jaeger and Fahrig (2004) used an advanced computer program to simulate the effects of exclusionary fencing on a population of deer. The model was dependent on the probability that an animal would avoid a road when it encountered one and the probability that an animal would be killed on the road should it choose to cross it. The researchers determined that fences are helpful in maintaining a deer population if the population is decreasing and if there is evidence that high traffic mortality plays an important role in the population decline (Jaeger and Fahrig 2004).

Conversely, if population size is stable or increasing, then adding fences could be harmful (Jaeger and Fahrig 2004).

Underpasses / Overpasses

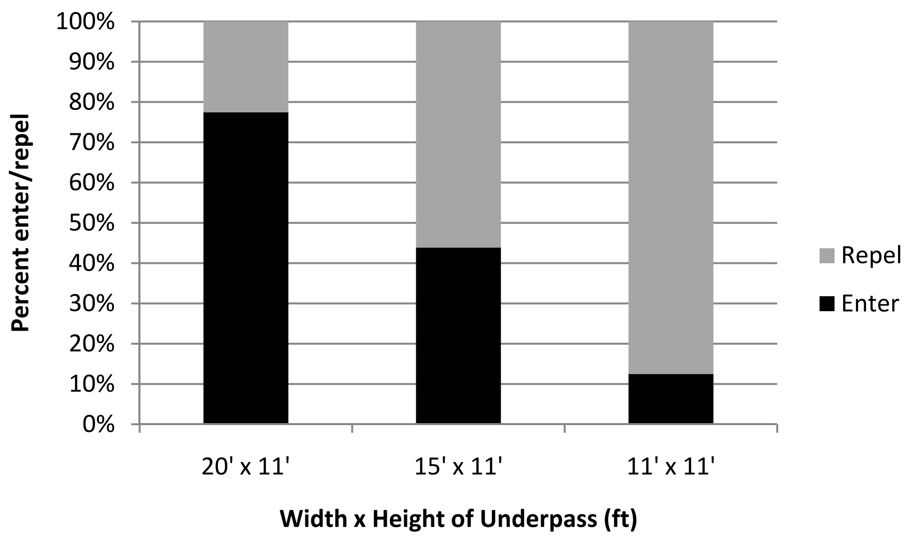
An estimated 14,000 mule deer migrate across a fifteen-mile-long section of US Highway 30 in Nugget Canyon, Wyoming during the fall and spring seasons. The Wyoming Department of Transportation (WYDOT) installed an underpass and an eight-foot-high exclusionary wildlife fence to combat the DVC problem. The 20-foot-wide and 60-foot-long underpass was built with concrete walls and an earth floor. A series of infrared video cameras with LED infrared lights were installed to monitor the entrance, exit, and approach areas of the underpass.

To determine the effect that varying the underpass dimensions has on the usage of the underpass by deer, researchers modified the dimensions of the tunnel using plywood dividers (Gordon and Anderson 2003). Openness is equal to the height of the tunnel multiplied by the width of the tunnel, multiplied by the inverse of the length of the tunnel. The study found a significant relationship between the percentage of deer that were repelled by the tunnel (approached but did not pass through) and the openness ratio of the tunnel. A higher openness ratio resulted in a lower percentage of repelled deer. However, the researchers failed to find a significant relationship between the two when the openness ratio was varied by altering the height of the underpass only. The width of the underpass appeared to have an effect on deer behavior, as shown in Figure 2-10. Researchers varied the height of the underpass but found that mule deer appear to be more sensitive to smaller underpass widths than heights (Gordon and Anderson 2003). The report concludes with the following recommendations for the design of wildlife underpasses:

- An openness ratio of 0.8 or greater.

- At least 20 feet wide.
- At least 8 feet tall.
- Graded gradually to alleviate drainage problems and to increase apparent openness.

The report also concluded that additional research should be conducted on the effectiveness of reducing traffic noise and screening traffic from sight on the effectiveness of wildlife underpasses.



Source: (Gordon and Anderson 2003)

Figure 2-10: Percent enter and repel for varying underpass width

A study in Southern California, where urban sprawl has divided natural areas, monitored the wildlife activity through fifteen highway underpasses to determine the number of animals crossing a particular structure and the characteristics of structures most frequented by species of concern (Ng, et al. 2004). Four of these underpasses were full highway underpasses involving bridge where another road or a river crossed under the highway. Six underpasses were square tunnels primarily intended for livestock. The remaining five underpasses were drainage culverts. The measurements of each of the fifteen underpasses (length, width, height, cross-sectional area), a quantitative description of the surrounding habitat (percent natural, percent developed, percent landscaped), and the number of recorded human passes (by foot, vehicle, or horseback) were recorded for each underpass. The group used cameras activated by motion and heat detectors to capture a series of photographs on some of the underpasses. Where vandalism was a concern, the group placed three meter-wide strips of agricultural gypsum powder across the floor of the underpass to collect wildlife tracks. They used the information from the cameras and the gypsum powder to classify each animal's behavior as a verified crossing, a probable crossing, or an evaluation of the entrance only. The team monitored the underpasses for a year.

Only 5.6% of the 2,723 detections involved native large mammals, including 1 mountain lion, 53 bobcats, 71 coyotes, and 28 deer. 79.7% of these animal detections were classified as verified or probable crossings, including 26 of the 28 recorded deer. The remaining 94.4% of the total detections were caused by human activity, domesticated animals, or small mammals. The group found that there was a significant relationship between length, cross sectional area, and the number of deer crossings. The report did not list specific attributes of desirable crossing structures, but merely provided general relationships between crossing frequencies and crossing attributes. As length increases, deer are less likely to cross. As the cross sectional area of the underpass opening increases, however, deer are more likely to cross. Their final recommendation, in the interest of conservation and habitat connectivity, is to install animal-proof fencing to funnel animals away from road surfaces and into crossing structures (Ng, et al. 2004). "A culvert or underpass", reads the aforementioned report from Southern California, "is of little value as a wildlife corridor if it does not connect suitable habitat" (Ng, et al. 2004, 504).

A study in Banff National Park, Canada, set out to determine whether highway underpasses serve all species of a particular habitat equally and promote habitat connectivity, or whether connectivity varies by species. Engineers designed a 45-kilometer-long stretch of the Trans-Canada-Highway near Banff National Park with a 2.4-meter-high exclusionary wildlife fence. In an effort to promote the movement of wildlife, which is crucial to a healthy habitat, the stretch of highway was also designed with a total of twenty-two wildlife underpasses and two wildlife overpasses. Only eleven of these underpasses were studied. Information regarding the structural, landscape, and human-activity characteristics of each underpass were recorded. Data on animal use was collected using 2x4 meter beds of sand, silt, and clay that were checked and cleared every three or four days, similar to the method used on the study in Southern California by Ng, et al. (2004). The numbers and distributions of black bears, grizzly bears, wolves, elk, and deer were determined using a variety of sources, from information based on animals tagged with radio collars, to predictive models based on the characteristics of a particular habitat.

Twenty percent of the total 14,592 recorded wildlife underpass visits were due to deer. Elk were responsible for 74% of the wildlife visits. For ungulates, the most important factors affecting their use of the underpasses were: underpass openness, noise level, underpass width, use of area by horseback riders, and the distance to the nearest drainage. Contradictory to the results of the Nugget Canyon study mentioned earlier, ungulates appeared to prefer long, narrow structures with a low openness ratio. On the other hand, the attributes of underpass structure contributed little to the use of the structures by large carnivores. Since human activity has an impact on wildlife's use of the structures, the report suggests that the most important thing that authorities can do to increase the structures' effectiveness would be to manage human activity near each underpass (Clevenger and Waltho 2000).

Crosswalks

According to the literature review by Danielson and Hubbard, deer crosswalks consist of dirt paths that run from one-way gates in highway fencing across portions of the ROW to a marked crosswalk across the paved surface (Danielson and Hubbard 1998). They cite a study by Lehnert and Bissonette in 1997 that found that crosswalks reduced the mortality by 42.3% and 36.8% for 4-lane and 2-lane highways, respectively. Unfortunately, this same study found that the crosswalks may have increased the tendency of mule deer to walk on the road (Danielson and Hubbard 1998). A report from the United Kingdom suggests that cattle guards be installed on the highway, on either side of the crosswalk to prevent animals from walking along the road and becoming trapped (Putman, Langbein and Staines 2004). Also, as a side benefit, traffic would likely slow down if they were required to cross a cattle guard.

2.3.2 Unrestrictive to Movement

Roadside Reflectors

Roadside reflectors are devices installed on posts along a highway that are meant to re-direct light from approaching vehicles' headlights to the side of the road. In theory, this should cause deer on the side of the road to freeze until the vehicle has passed or flee away from the road. A report prepared in the United Kingdom brings up several very good points concerning roadside reflectors. By design, roadside reflectors can only be effective at night. Unfortunately, deer appear to be most active during dawn and dusk when approaching vehicles may not have their headlights on (Putman, Langbein and Staines 2004). Also, if reflectors have an effect on deer, they would likely only be effective on roads with relatively low traffic volumes or else the reflectors, and the roadside, would be continuously lit. Their effectiveness may also diminish as dirt collects on their surface or as deer become accustomed to their presence. The primary reason that many agencies use the reflectors is because the devices are inexpensive and easy to install compared with other DVC countermeasure alternatives. Many references to studies discounting the effectiveness of roadside reflectors are cited in a literature review prepared by the Jackson Hole Wildlife Foundation (2003). Five studies involving the popular Swareflex reflector, designed in 1971, are cited in the literature review. Four of the five studies reported no significant evidence that the reflectors decreased the rate of deer-vehicle collisions. One study, in fact, witnessed more DVCs after installation of the reflectors than they witnessed before installation. A lone study completed in eastern Washington, however, recorded significantly fewer deer-vehicle accidents when the reflectors were uncovered compared with when the reflectors were covered. The literature review completed by the Jackson Hole Wildlife Foundation also cites literature that suggests that the reason that many of these studies returned with negative results may be due to insufficient sample sizes. A review of literature not covered by previously-mentioned literature reviews follows.

A group from the University of Georgia tested Strieter-Lite wildlife warning reflectors and four different color mirrors, made by the Strieter Corporation, to determine their effectiveness at deterring deer. The manufacturer claims that their product creates an optical warning fence for deer by distributing light from oncoming vehicle headlights across the road and into roadside corridors (D'Angelo, et al. 2006). Unfortunately, the group found that all four colors of mirrors actually increased the chances of a deer-vehicle collision compared with not having the mirrors installed at all. The group installed the reflectors on posts along a 182.9-meter-long segment of lightly travelled, private road per the manufacturer's instructions. Using an infrared camera, the group observed wildlife for 4 hours per night, beginning 30 minutes after sunset. When a deer was spotted and no vehicles were nearby, the observers would signal to a driver waiting off-site to drive through the site. Deer activity was classified using one of following five categories for the period when the deer entered the test area and when the car passed the deer: passive, active towards the road, active away from the road, active parallel to the road, and on the road. The responses of deer to a vehicle were given a score, based on the desirability of the deer's response to the driver. For example, a deer which was headed towards the road or on the road before the arrival of a vehicle and was active away from the road or active parallel to the road once the vehicle passed would be given a positive score, since this behavior would not lead to a DVC. Any responses that caused a deer to be active towards the road or on the road, however, would lead to a negative score, since this behavior might lead to a DVC.

The results of the test were disappointing. Instead of repelling deer from vehicles, the reflectors appear to have attracted deer to the road. Significantly greater negative behavior, compared with records made before installation of the reflectors, was recorded for all four colors of reflectors: red, white, blue-green, and amber. Red reflectors resulted in the smallest increase in negative behavior of the four colors tested, but the result was still significantly higher than that of the pretreatment conditions. Blue-green reflectors resulted in the greatest change in negative behavior. The report suggests that the differences in deer response to different reflector colors may be due to the sensitivity of deer eyes to varying wavelengths of light. Deer may have responded differently to the red reflectors merely because their eyes are not as sensitive to high wavelengths of light, such as red light, as they are to low wavelengths, such as blue light. Therefore, the report suggests, negative responses by deer may directly increase with greater perception of light from the reflectors (D'Angelo, et al. 2006).

A study performed by the University of Nebraska and the United States Department Agriculture hoped to quantify deer reactions to different colors of light. Through prior studies, they had determined that deer are most sensitive to short light wavelengths. They set out to test the effectiveness of blue and green lasers at deterring deer. A group of researchers searched for deer in 114 different fields in wildlife refuges in Nebraska and Iowa. The fields were planted with agricultural crops or native grasses. When a deer was spotted, they would track the response of the deer with night vision goggles to ensure that the deer did not flee due to their presence. Assured that the deer had not fled, they proceeded to shine a laser of a particular color on the vegetation near the deer for 15 seconds. If this did not evoke a response in the deer, they then shined the laser on the body and head of the deer. Unfortunately, flight responses did not differ between any of the 3 laser treatments and the highest percentage of deer that fled for a particular laser was only 14% (VerCauteren, et al. 2006). Researchers found that deer appeared to be more curious than frightened when exposed to laser light and were no more likely to flee laser light than they were to flee a nearby moving vehicle (VerCauteren, et al. 2006).

Hunting

Using DVC records for the entire state of Michigan, Michigan State University determined a relationship between hunting season and the frequency of deer-vehicle collisions (Sudharsan, Riley and Winterstein 2006). They obtained data from 1997 to 2001 from the Michigan State Police. They averaged the number of DVCs per day for 28 days, 14 days, and 7 days before and after the start of hunting season in Michigan and compared the before and after results to each other using a paired *t*-test. They excluded DVC crashes that occurred between 0600-0900 and 1800-2100 because deer activity during these dawn and dusk periods was shown to be relatively constant. Table 2-3 shows their results.

Table 2-3: Mean number of deer-vehicle crashes per day 28, 14, and 7 days before and after the start of the hunting season in Michigan.

Time Period	Mean DVCs Per Day	SE	n	t	Significance
28d before	432	8	140	6.96	<0.001
28d after	332	9	140		
14d before	485	10	70	5.03	<0.001
14d after	404	12	70		
7d before	484	13	35	1.09	>0.10
7d after	462	18	35		

Source: (Sudharsan, Riley and Winterstein 2006)

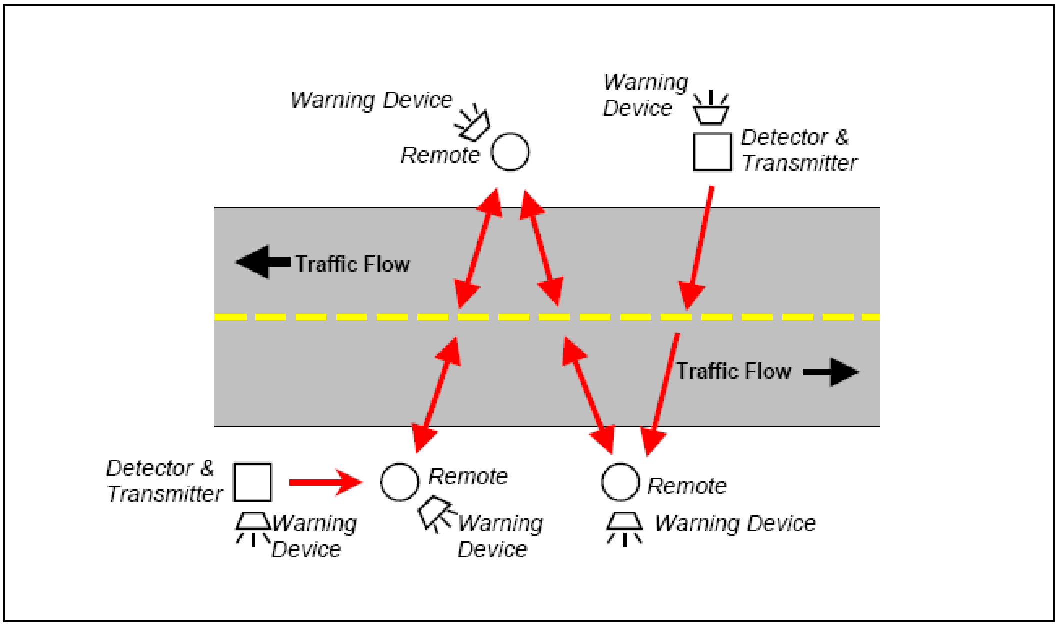
The mean number of DVCs per day 28 days before and 14 days before the start of deer hunting season were significantly lower than the mean number of DVCs per day 28 days after and 14 days after the start of hunting season, respectively. The difference between the mean number of deer accidents 7 days before and 7 days after the start of hunting season were not significantly different. The study only centers on changes in DVC frequency around the opening day of hunting season; it does not attempt to analyze the long-term effects of hunting on deer behavior. Their report, however, does cite a number of studies that show that the number of deer carcasses along roadways to be highly correlated with numbers of deer killed during the firearm-hunting season and that human hunting activity causes an increase in daily movement activities and changes in home range for white-tailed deer. The report concedes that they did not take traffic volume into effect. Although unlikely, the decrease in DVCs could have been explained by a sudden decrease in traffic volumes around the opening day of hunting season (Sudharsan, Riley and Winterstein 2006).

The states of Maryland and Virginia have used techniques to decrease deer population and reduce the risks of DVCs, according to a report published by the Metropolitan Washington Council of Governments (2006). Efforts have been made to allow hunters to harvest more deer, to supplement regular hunting with special managed hunts in State and local park lands, to use sharpshooters to remove deer at night, and to allow the use of fertility control in controlling deer populations (Metropolitan Washington Council of Governments 2006).

A literature review prepared by Putman et al. of the United Kingdom mentions several studies that suggest a relationship between the density of a local deer population and the number of DVCs. The report concludes that none of the cited studies used adequate statistical controls and therefore, a relationship between animal populations and DVCs is only suggested, not proven. The effectiveness of hunting and other population-reducing measures has little meaning unless the technique can actually be used to prevent DVCs. A state transportation agency likely has little control over hunting policies and game populations and, therefore, has little say in whether hunting should be increased or deer populations should be reduced.

Active Vehicle-Sensing Wildlife Warnings

A unique method of reducing DVCs is described in a report published by International Road Dynamics, Inc. (IRD). The report describes the Wildlife Warning System (WWS) that the company designed for use in Saskatchewan, Canada (Bushman, Vinek and McCaig 2001). Most active DVC countermeasures seek to warn drivers of the presence of a deer on the roadway. Instead, the WWS system developed by IRD attempts to warn wildlife of the presence of a vehicle on the roadway and frighten the wildlife away from the roadway, towards safety. The system is made up of a series of detectors, transmitters, and warning devices placed alongside a roadway, as shown in Figure 2-11. Each remote device has the ability to transmit and receive information. This means that each unit must only be able to communicate with the devices adjacent to it; allowing the system to be as large or as small as the installation requires without concern for wireless communication range over the entire project area. By warning wildlife, animals can still cross the roadway freely when traffic is not present and are less likely to become accustomed to the warning devices if their activation is irregular and infrequent. Also, from examples cited elsewhere in this report, detection of vehicles, which follow a very predictable path, is undoubtedly much more reliable than detection of wildlife.



Source: (Bushman, Vinek and McCaig 2001)

Figure 2-11: Example of WWS System Layout.

No specific, technical details are given on the method that the WWS system uses to detect oncoming vehicles besides microphone sensors. There are no details describing why this particular method was chosen to detect vehicles over other methods. Since the system relies on highly portable, easy-to-install, remote units, it is assumed that microphones were chosen to detect traffic simply because this capability can be built-in to the remote units without need for any additional infrastructure on-site. Not many details are given concerning the warning devices, either. The report mentions deer-repelling horns and flashing light emitting diodes (LEDs) as the current methods used to warn deer to an oncoming vehicle in the test system. No mention is made of the system's effectiveness, most likely because the system is relatively new and is likely still under development.

2.4 Cost Effectiveness of Countermeasures

Wu of Ohio University calculated the cost effectiveness of several DVC countermeasure alternatives in terms of the costs of human injury, property damage, deer hunting value, and deer nuisance (1998). The study calculated that a single deer, in 1996, was worth \$182.54. This price was calculated by summing the price that an average deer hunter paid for transportation, gas, lodging, supplies, licenses, and time per deer in addition to the income that the state of Ohio received from licenses per deer and the market price for the venison from a single deer. The study also calculated that every deer that was not killed would cost farmers \$207.38 in eaten crops. A human injury cost \$35,700 and the property damage incurred by a DVC was \$1,700. The study gauged the effectiveness of reflectors, fencing, concrete underpasses, and wildlife overpasses using cited literature. Using real-world data from two Ohio highway segments, it was calculated that, had these particular countermeasures been installed on the highways, the Swareflex wildlife roadside reflector would have resulted in the highest benefit-to-cost ratio. Overpasses resulted in a B/C ratio greater than one but much less than that for reflectors (Wu 1998).

Furthermore, a study on road crossings in Ventura County, California considered the lifetime cost of alternative crossing structures to accurately assess the total cost of mitigation (Cavallaro, et al. 2005). The literature review by Danielson and Hubbard (1998) includes information regarding the monetary cost of many of the countermeasures included in this report. Note, however, that the costs quoted are relevant only for the year that the study was completed. The following is a list of costs, years, and type of DVC countermeasure, compiled from information gathered from the literature review by Danielson and Hubbard (1998):

- Fencing
    - An eight-foot-high game-proof fence cost \$240,000 to install along a 7.8-mile-long corridor on I-80 in Wyoming in the early 1970's.
    - An eight-foot-high chain-link fence cost \$42,000 per mile to install along one-side of a highway in Iowa, date unknown.

- Crosswalks
    - The estimated cost of a wildlife crosswalk in 1997, not including the cost of the fence and gates that are required, was $28,000 and $15,000 for 4-lane and 2-lane highways, respectively.
- Underpasses
    - The estimated cost of an underpass in 1997 under an existing highway was $173,000 and $92,000 for 4-lane and 2-lane highways, respectively.
- Reflectors
    - Swareflex reflectors cost between $8,000 and $10,000 per mile in 1998.

2.5 Conclusion

There is no single solution to curing the deer-vehicle collision problems of a particular highway. The most successful DVC countermeasure, to date, appears to involve a combination of exclusionary fencing and wildlife underpasses. Unfortunately, even this solution is prone to failure and has not resulted in the complete elimination of deer-vehicle collisions. A variety of factors must be considered when implementing a countermeasure to reduce the number of DVCs on a highway. One study contacted twenty-eight policy-makers and DVC experts in the state of Wyoming and several others around the world to determine the criteria that are used to make decisions about DVC countermeasures (Wells 2003). The most important criteria, in order of importance to the interviewed experts, were: economic feasibility, technical feasibility, political viability, measurable results, effectiveness, and wildlife biology. All of the potential alternatives have the ability to be monitored and evaluated for measurable results (Wells 2003). Confidence in the remaining five criteria, however, is undoubtedly much more difficult to attain.

The examples presented in this literature review show that, once implemented, the success of any DVC countermeasure is highly variable. Deer are very fickle creatures whose behavior is difficult to predict. The experience, awareness, and other characteristics of drivers vary widely and are equally unpredictable. It is impossible to design a single countermeasure that can be applied universally with consistent results. The effectiveness of a particular countermeasure is difficult to quantify before implementation and review. Often, as with active deer-sensing warning signs, the technical feasibility of a project is unknown before construction. A successful application of a DVC countermeasure, therefore, is the result of extensive research, collaboration, and luck.

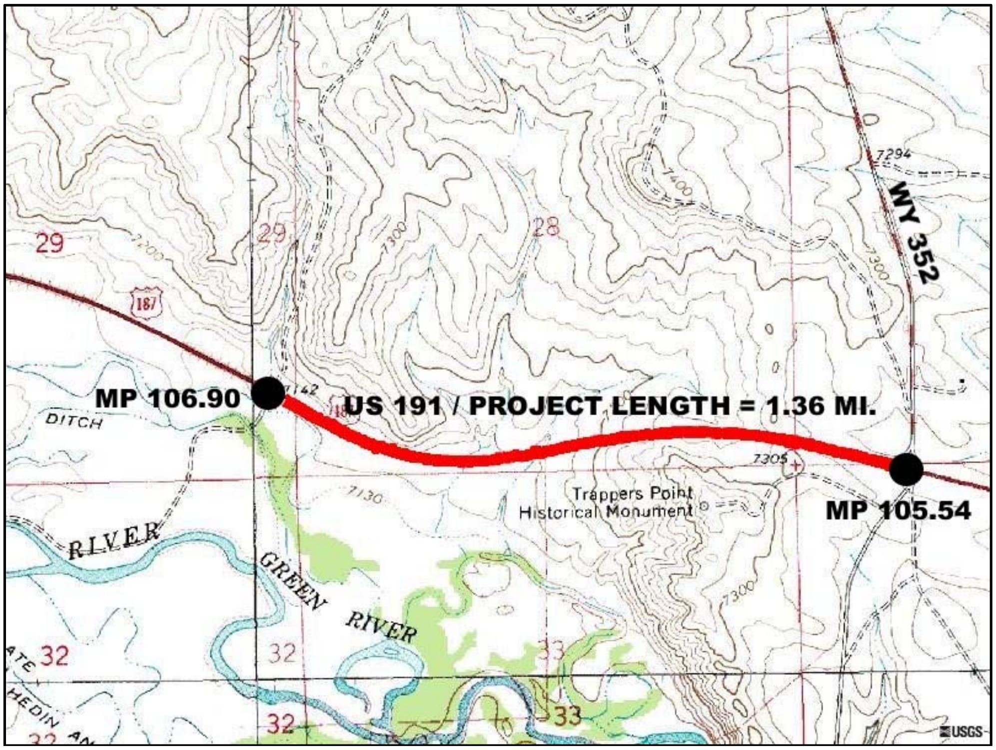
CHAPTER 3: PROJECT DESCRIPTION

The following is a description of the animal detection system and driver warning system installed by the Wyoming Department of Transportation at Trapper's Point, including descriptions of: the project's location, wildlife characteristics at the site, crash history at the site, a history of the installation, and technology used in the system.

3.1 Location

The animal detection system at Trapper's Point is located within the state of Wyoming in Fremont County, approximately six miles north of the town of Pinedale on US Highway 191. The longitude and latitude of the project site are 110° 00' west and 42° 53' north, respectively. The project begins at the intersection of US 191 and Wyoming Highway 352 (WY 352) at milepost 105.54 and extends 1.36 miles to milepost 106.90. The altitude of the site varies between 7140' and 7300' above sea level.

Figure 3-1 is a topographical map of the area and shows a small valley, approximately at the center of the map, which runs from the Green River on the south side of the highway. The valley is thought to funnel migrating wildlife across the small section of highway under study.



Source: US Geologic Survey

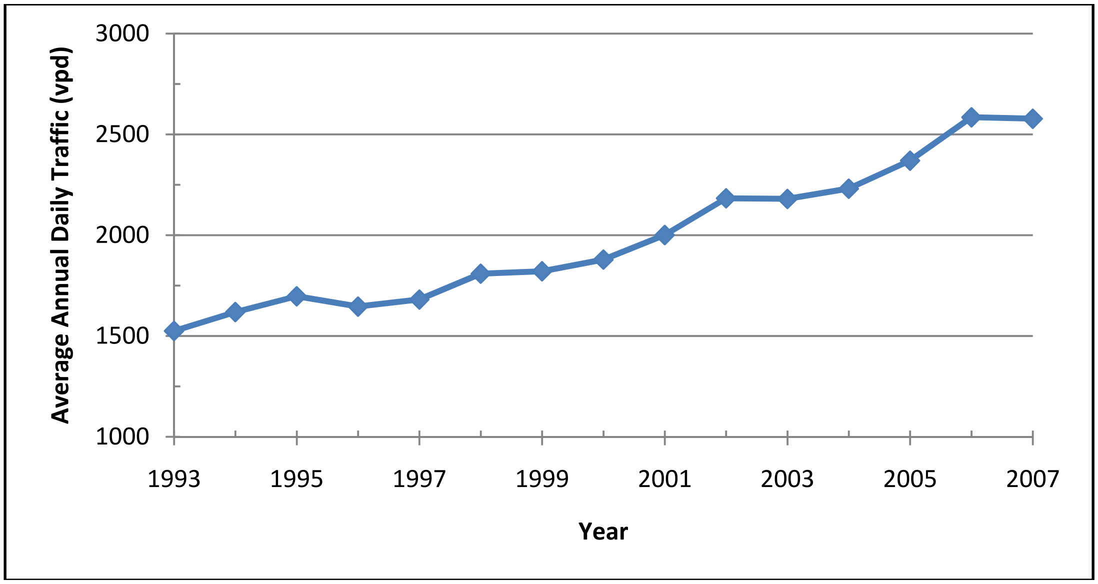
Figure 3-1: Topographic Map of Project Location

3.1.1 Roadway Characteristics

US 191 is a two-lane, undivided highway with a lane width of twelve feet and a shoulder width of four feet between mileposts 106.52 and 106.90. The remainder of the section, between mileposts 105.54 and 106.52, has an additional twelve-foot-wide climbing lane for traffic in the southbound direction. The surfacing is asphalt over the traveled way and the shoulders and appears to be in good condition. The posted speed limit in this area is 65 miles per hour in both directions. The 1.36-mile-long segment contains two horizontal curves. Neither curve is posted with a suggested curve warning speed. A stock pass is located on the southern half of the project (Figure 3-2). The stock pass is not covered by the wildlife detection system so animal activity in the stock pass will not trigger the detection system and activate the flashing lights. The use of this stock pass by wild animals is not known.

Figure 3-2: Photo of the stock pass along the project's length

Figure 3-3 shows the average annual daily traffic (AADT) of US 191 from WYDOT's permanent counter at milepost 110.47, which measures traffic on the east leg of Daniel junction. This counter is less than four miles north of the project area. Traffic volumes appear to have been increasing steadily since 1993. In 2007, the AADT on this stretch of US 191 (both directions combined) was 2,578 vehicles per day. For 2004, the month with the highest average daily traffic (ADT) was July, with an average of 3,376 vehicles per day and the month with the lowest ADT was January, with an average of 1,545 vehicles per day.

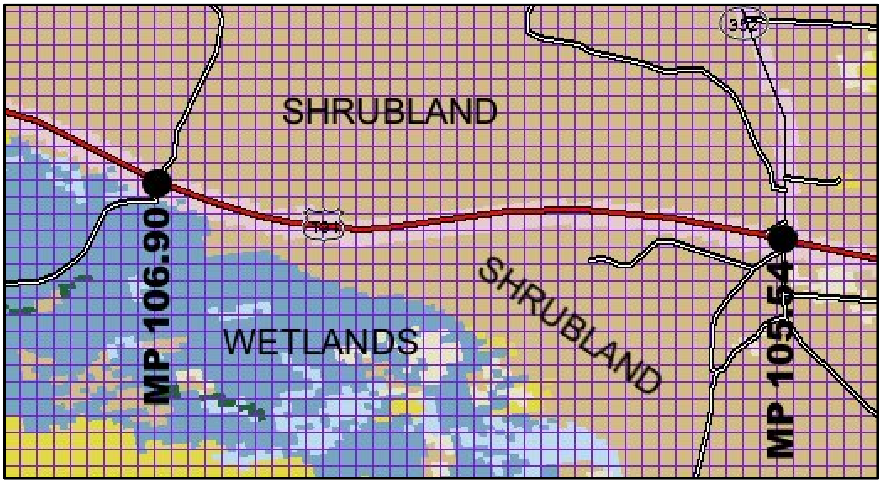


Source: (Wyoming Department of Transportation Planning Program 2004)

Figure 3-3: Historical AADT on US Highway 191

3.1.2 Surrounding Terrain

Figure 3-4 is a map of land cover taken from the National Map software available through the US Geologic Survey (2006). The map shows data from the 2001 National Land Cover Data (NLCD) set. Shrub land covers both sides of the highway. The USGS defines shrub land as an area "characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking" (2007). Wetlands follow the path of the Green River, on the southern side of the highway. Figure 3-5 is a photograph of the project site, taken from approximately halfway between mileposts 105.54 and 106.90, facing west (or northbound). Vegetation is sparse, short, and not sufficient to hinder drivers' view of approaching wildlife. In addition, side slopes are gradual enough to provide for a reasonable clear zone distance along the road.



Source: (US Geologic Survey 2006)

Figure 3-4: Land Cover Types of Adjacent Area

Figure 3-5: View of Project Site (looking west)

3.2 Wildlife-Sensing Driver Warning System

The following section discusses the wildlife sensing driver warning system that was installed at Trapper's Point in 2006, beginning with a brief discussion of the history of the project, including a discussion of earlier technology that WYDOT installed at Nugget Canyon.

3.2.1 History of the Project

The Wyoming Department of Transportation had experience with wildlife detection systems before developing the system at Trapper's Point. In 2000, WYDOT installed the FLASH (Flashing Light Animal Sensing Host) system and two other wildlife detection systems on the Nugget Canyon section of US Highway 30, between the towns of Cokeville and Kemmerer. A major objective of the study by Gordon, et al. (2001) was to determine the accuracy of the FLASH system in comparison with several other systems. One of these systems involved passive infrared sensors and a string of geophones. The geophone and infrared system worked well compared with the FLASH system. More than half of the detections recorded by the FLASH system were false detections. Except for detections caused by a nearby railroad track or heavy truck traffic, the geophone system did not register any false hits. WYDOT added infrared sensors to the geophone system to prevent false detections caused by the railroad. In order for a detection to be recorded, both sensors (geophones and infrared) would have to be triggered. The team also experimented by disabling the geophones and found that the passive infrared sensors, when working alone, did not produce any false hits.

Due to the success of the project at Nugget Canyon, the same passive infrared and geophone technology was chosen for installation at Trapper's Point. The system that worked so well at Nugget Canyon only involved two strings of geophones and four infrared sensors along a short length of straight highway where deer were known to cross. The system at Trapper's Point, however, would span more than a mile on terrain with hills, curves, and a wide area available for wildlife crossing.

The development of the wildlife detection system at Trapper's Point began with a series of meetings by a group called the Trapper's Point Coalition (Maxam 2007). These meetings were headed by Wyoming state representative Monte Olsen and consisted of thirty to forty local representatives of the oil & gas industry, ranchers, wildlife groups, the Wyoming Game and Fish Department, the Wyoming Department of Transportation, the Wyoming Governor's office, and others. After several meetings and a couple years, WYDOT decided to install a detection system at Trapper's Point on US Highway 191. According to Bob Maxam, WYDOT resident engineer in Pinedale, the detection system passed through the planning and development stages and into construction very quickly. The system was installed in October, 2005 at a cost of approximately $1,000,000, including the cost of contract administration and inspection work.

3.2.2 Intrusion Detection System Technology

The animal detection system at Trapper's Point uses the Eagle Intrusion Detection System (EIDS), developed by Telonics, Inc. of Mesa, Arizona. According to the company's website, EIDS is capable of operating in extreme temperature ranges for long periods of time and is currently in use by US and foreign military organizations, the US Border Patrol, US Forest Service, National Park Service, and the Bureau of Land Management (Telonics, Inc. 2007). A wide variety of sensors can be used with EIDS, depending on the application. Their website lists seismic, magnetic, passive infrared, active infrared, break wire, and pressure mat sensors as compatible with EIDS. Seismic sensors enable the system to discriminate between the walking patterns of four-legged and two-legged animals, or to detect the movement of heavy vehicles. Magnetic sensors can detect the signature of a passing metallic vehicle. Sensors sensitive to infrared radiation can be used to detect vehicles, people, or other objects. The website makes little mention of the break wire and pressure mat sensors.

The Trapper's Point application, however, is limited to geophone (seismic) sensors and passive infrared sensors. These sensors are spread along the side of the road at regular intervals along the entire length of the 1.36-mile-long project. Each group of sensors feeds into a model PT-210M transmitter, which wirelessly communicates with a model RP-3000 receiver / repeater installed at each "DEER ON ROAD WHEN FLASHING" road sign. The flashing lights on the road signs are activated whenever the RP-3000 units receive a signal from one of the 34 PT-210 transmitters. The receivers can also be set up to only activate the signs when a signal is received from particular transmitters.

Geophones

Two strings of model SP-500P seismic detectors (i.e. geophones) were initially installed at each of the 34 transmitter sites. One string is located parallel to the road in each direction from each transmitter site. Chapter 5 describes subsequent changes that were made to the system layout. Each SP-500P string consists of five individual SP-500 seismic detectors. A photo of these detectors, uninstalled, is shown in Figure 3-6. According to the manufacturer's website, each SP-500 detector is capable of detecting a person from 50 feet away or a vehicle from 100 feet away (Telonics, Inc. 2007). An area with a length of a thousand feet can be monitored when a string of geophones (the SP-500P) is used, according to the EIDS manual. The website warns, however, that detection range is dependent on several variables, such as: the type of terrain, sensitivity of the processor, and the number and type of intruder. The EIDS manual also warns that false alarms may occur if the units are placed near wooded areas, running water, chain link fences, motors, pumps, pipelines, or railroads. When placed near trees, high winds can cause vibrations in tree roots and cause a false detection. Heavy rain can also cause false detections. Each geophone should be buried two to six inches deep, but the installer must consider the soil density for optimum detection, according to the manual. A heavy layer of snow will reduce the detection range. The detectors have minimum and maximum operating temperatures of -40° C and 60°C, respectively.

Source: (Telonics, Inc. 2007)

Figure 3-6: Photo of Uninstalled Geophone Sensors

Infrared Scopes

Each of the 34 transmitter sites was initially equipped with two model IF-540 passive infrared detectors. They were set up so that there was one detector pointed in each direction, parallel to the road at each transmitter site. According to the manufacturer's website, the IF-540 is capable of detecting people within 350 feet of the sensor and vehicles within half a mile of the sensor (Telonics, Inc. 2007). The IF-540's field of view is approximately 10 feet wide and 12 feet high at 500 feet from the sensor. The field of view is approximately half that size at a distance of 250 feet from the sensor. Similar to the geophone units, the minimum and maximum operating temperatures for the passive infrared units are -40°C and 60°C.

A single IF-540 unit is a cylindrically-shaped tube 13 inches long and 4 inches in diameter. Both units are mounted on a single, shared treated wooden pole, as shown in Figure 3-7. The lowest infrared sensor is mounted 28 inches from the ground to the center of the sensor. The upper sensor is mounted 33 inches from the ground to the center of the sensor. Each sensor unit is attached to a 10-inch-long stainless steel strut with a 3¾ inch diameter steel clamp. The steel strut is connected to the wooden pole via a ¼" steel 90 degree bracket. One ½ inch diameter bolt attaches the bracket to the pole and one ½ inch diameter bolt attaches the bracket to the strut. This means that one bolt prevents the sensor from tilting up and down and one bolt prevents the sensor from rotating side to side. This was done to allow for easier aiming of the sensors. With a single bolt in each direction, an adjustment can be made in the aim of the sensors without drilling additional holes into the wooden pole.

Figure 3-7: Close-up photo of an IF-540 passive infrared sensor installed on-site

Note that the vehicle shown in the background of Figure 3-7 is parked on a driveway and is facing perpendicular to the highway. Filters were added to several infrared sensors to limit the number of false detections. These filters are honeycomb-shaped and work to limit wayward, high-angle infrared signals similar to the way horse blinders allow the animal to see only what is directly in front of it. A filter is not installed on the sensor shown in Figure 3-7.

PT-210M Transmitter

SP-500P geophone strings and the IF-540 passive infrared sensors are attached to a model PT-210M processor / transmitter buried in a pull box at the base of the wooden poles supporting the infrared. Initially, two geophone strings and two infrared sensors were attached to each PT-210M. Later, as described in Chapter 5, this setup was modified so that only one infrared sensor and one geophone string was attached to each PT-210M. Figure 3-8 is a photograph of one of the pull boxes after this modification was made. The photo shows two PT-210 processor / transmitter boxes and all of the necessary wiring. Despite the manufacturer's claim that the units are waterproof to a depth of three feet, the units were mounted to the wall of the pull box to prevent complications caused by water intrusion (Telonics, Inc. 2007).

Figure 3-8: Photo of PT-210M transmitters installed in pull boxes on-site

According to the manufacturer's website, the PT-210M processor / transmitter was designed for quick deployment in tactical or covert operations, but there are plenty of features of the PT-210M that make it suitable for roadside wildlife detection work. A handheld computer, such as a PDA, can be used to program the units. A Trimble TDS Recon Pocket PC was used at Trapper's Point to adjust a variety of settings, from the sensitivity of the sensors to the identification numbers of the PT-210M units.

Each PT-210M unit is equipped with a wireless transmitter, capable of transmitting FM on any frequency between 138 MHz and 174 MHz with 12.5 KHz steps. The manufacturer claims that the transmitters have a line-of-sight range of 5 miles under ideal conditions, which can be increased by using an optional, remote antenna. The transmitters have a power output of 2.5 watts into a 50 ohm line when fed with a 9 volt power supply. At Trapper's Point, a remote, Icom model FA-S57V flexible handheld antenna is mounted on each of the wooden poles supporting the infrared sensors and is attached to the PT-210M transmitters in the pull box below. Figure 3-9 is a photograph of one of these remote antennas. The transmitters at Trapper's Point are all set to transmit on a frequency of 154.60 MHz. Each transmitter can be set up with a unique ID number that is transmitted along with the signal. This information is used for recording and tracking purposes.

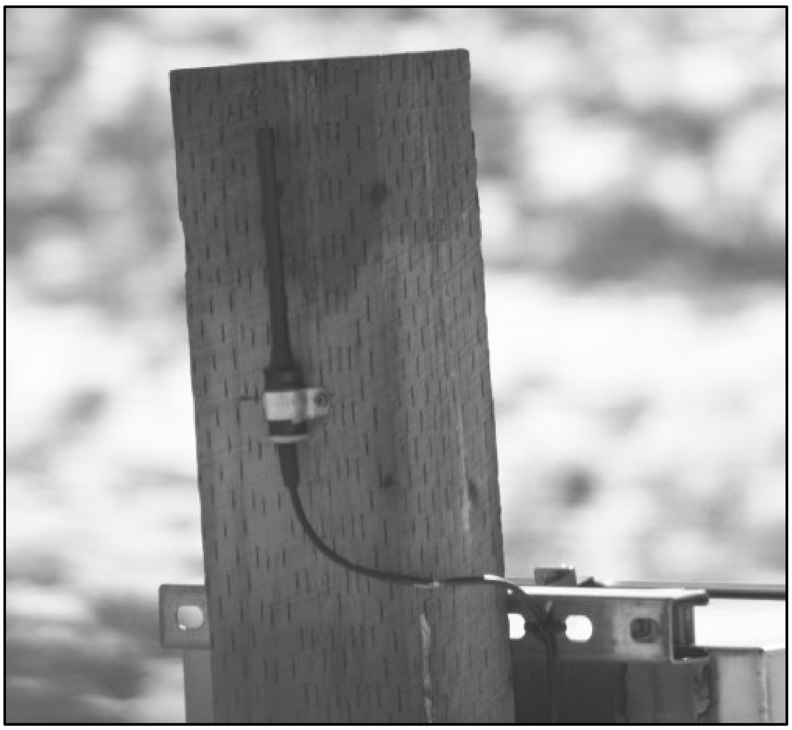


Figure 3-9: Photo of PT-210M external antenna installed on-site

The PT-210M is also equipped with a specialized "animal filter", which is capable of distinguishing the seismic patterns of human footsteps from those of wildlife. The manual warns that this feature can mistakenly interpret a group of pedestrians as a four legged animal (Telonics, Inc. 2007). Human activity, especially pedestrian activity, does not appear to be significant along US Highway 191 in this location, so this option is not used at Trapper's Point. The PT-210M units are also capable of counting footsteps. According to the manual, a five second timer is started when the first footstep is recorded. If a particular number of footsteps are detected before the five seconds elapse, then a detection is recorded. A setting of 3 footsteps is used at Trapper's Point.

The PT-210M can also be set up to be active only during specific times of day or days of the week. The units will not process sensor inputs and will not transmit reports of detections during the inactive times specified by the user. This feature is not used at Trapper's Point, but could be used to limit false detections at specific times of the day (sunrise / sunset) from particular sensors.

The two most-common methods of adjusting the infrared and geophone sensors via software are the "sensitivity" value and the "qualify time" settings on the PT-210M. These two items, as well as the unique ID number, are discussed in greater detail below.

When multiple sensors are attached to a PT-210M, such as a geophone string and an infrared sensor, a feature called "Qualify Mode" can be activated. In this mode, both sensors must be triggered within a set time period before the transmitter will signal that an event has occurred. This time period, called the "Qualify Time", can be as short as 1 second and as long as an hour (Telonics, Inc. 2007). The processor begins counting when one of the sensors is triggered. In order for the transmitter to signal that an event has occurred (or that wildlife has been detected), the other sensor must be triggered before the qualify time has elapsed.

At Trapper's Point, qualification times were set to between 2 and 10 seconds. These times were adjusted several times, as discussed in Chapter 5, to correct problems with multiple false detections. When large trucks were suspected to be the cause of false positives from a particular transmitter, for instance, the qualify time would be lowered to limit the amount of time between detections by the infrared sensors and the geophones. The footstep counter is also used at Trapper's Point. Three footsteps must be detected within five seconds in order for the geophones to be triggered.

The manufacturer's manual does not mention whether lowering the qualification time below five seconds has an adverse effect on performance if the footstep counting feature is not disabled.

The sensitivity of the seismic, geophone sensors is set independently from that of the infrared sensors. The sensitivity of the geophones can be set to a value between 1 and 5, where 1 is the least sensitive and 5 is the most sensitive (Telonics, Inc. 2007). The manual explains that a setting of 3 is satisfactory for most installations. The sensitivity of each infrared sensor can be set, too, depending on how the sensors are attached to the PT-210M unit. The PT-210M has three physical input ports for sensors: one for the seismic sensor, one port marked "LEFT", and one port marked "RIGHT". If two infrared sensors are attached to a single PT-210M, one can be plugged into the "LEFT" port, and one can be plugged into the "RIGHT" port, allowing independent operation. The sensitivities of the "LEFT" and "RIGHT" sensors can be set to a value between 1 and 5, where 1 is the least sensitive and 5 is the most sensitive. The manual recommends a value of 4.

Each PT-210M unit is given a unique ID number. The ID number can be any whole number between 0 and 8175. There are 34 PT-210M units at Trapper's Point, and each is assigned an ID number between 1 and 34. The ID number is transmitted digitally along with every transmission from the PT-210M. The receiver can use this information to keep track of which sensors were tripped, and when.

The RP-3000 voice/digital portable repeater was designed to extend the transmission range of the PT-210M processor / transmitters when communication is necessary over hilly terrain or long distances (Telonics, Inc. 2007). A 5-watt transmitter can extend the range of the PT-210M units by another 7 miles in ideal conditions. The units are also equipped with an additional port which allows the RP-3000 to trigger a camera or other device, such as a large, roadside sign. The additional port feature is the reason these units were chosen for installation at Trapper's Point. The repeater function is not used.

Each of the six "DEER ON ROAD WHEN FLASHING" signs is equipped with an RP-3000 repeater, enclosed in the sign's above-ground cabinet. Figure 3-10 is a photograph of the interior of one of these cabinets. The RP-3000 can be seen on the bottom shelf and the necessary equipment to run the sign's flashing lights can be seen on the top shelf. When the RP-3000 receives a signal from one of the PT-210M transmitters, the unit sends a signal to the flash timer and causes the lights to flash for a specified amount of time. The RP-3000 can be set up to react only to signals from specific PT-210M ID numbers. For example, if the user wanted a particular road sign to flash only when wildlife is detected in the immediate vicinity of the sign, the user could program the RP-3000 with the ID numbers of the appropriate PT-210M units.

Figure 3-10: Photo of an RP-3000 Repeater installed on-site

The RP-3000 units at Trapper's Point use the same Icom model FA-S57Vexternal antenna as the PT-210M units. The external antenna is attached to the top of the wooden pole that the cabinet is attached to, as seen in Figure 3-11. The EIDS manual warns that the RP-3000's antenna should be at least 15 feet away from the transmitter's antenna to prevent RF interference with the receiver. Unfortunately, Figure 3-11 shows that the distance between the antenna for the sensors nearest the signs and the antenna for the receiver is less than 15 feet.

A device with a serial port and the ability to log serial data, such as a laptop or ticker-tape printer, can be attached to the RP-3000, as well as the RP-2000 handheld receiver discussed in Chapter 4, to log detection events.

Figure 3-11: Photo of PT-210M and RP-3000 antennas

3.2.3 Driver Warning System Technology

The driver warning system is comprised of six road signs that were erected in the project area that read "DEER ON ROAD WHEN FLASHING". Each sign also has two yellow, 12" diameter, flashing lights fixed to the top. The sign shown in Figure 3-12 has a camera attached to it for data collection purposes and is discussed in Chapter 4. The controls for the flashing lights are enclosed in the same cabinet as the RP-3000 repeater, shown in Figure 3-10. Each sign is located approximately 20 feet from the edge of pavement.

Figure 3-12: Close-up photo of Trapper's Point road sign (Sign D)

3.2.4 System Layout

The original layout of the system is shown in Figure 3-13. The signs are shown as rectangles and are labeled A through F. Each post, which holds the infrared sensors, is located between 35 and 40 feet from the edge of pavement. One PT-210M was mounted in a pull-box near each post. Two infrared sensors, one looking in either direction parallel to the road, were attached to each PT-210M. Two strings of geophones, one spread in either direction parallel to the road, were also attached to each PT-210M.

Unfortunately, due to the way that the PT-210M handles qualified detections, the layout was modified so that two PT-210M units were installed at each post. This new configuration is discussed in greater detail in Chapter 5. WYDOT did not purchase 34 new PT-210M units for this change;

instead, they moved units from the outside edges of the project to posts in the center. This shortened the length of the road that was covered by sensors from 1.36 miles to approximately 1.00 mile. The new configuration begins at sensor number 7 on Figure 3-13 and ends at sensor number 23.

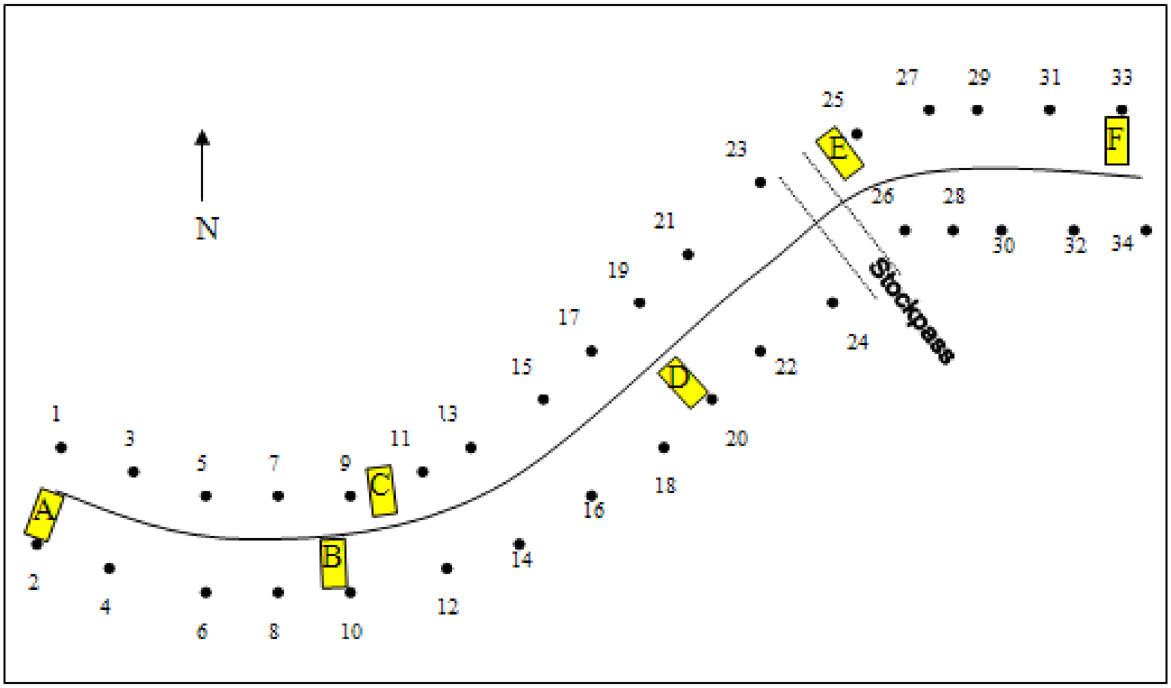


Figure 3-13: Original Layout of sensors and road signs

CHAPTER 4: DATA COLLECTION

The three of the objectives of this study, as outlined in Chapter 1, are to determine the effectiveness of the animal detection system, determine the effect of the system on driver behavior, and determine the effect of the system on crash rates. This chapter describes the data that was collected for the analyses of the effectiveness of these three measures.

4.1 Wildlife Characteristics

According to the Wyoming Game and Fish Department, there are two major herds of pronghorn antelope in the area surrounding Pinedale (Wyoming Game and Fish Department 2007). There is one primary herd of mule deer, two herds of elk, and one herd of moose. No collisions with elk or moose have been recorded between mileposts 105.54 and 106.90 since 2005 (Appendix H).

Figure 4-1 shows the estimated population of all of the wildlife herds in the Trapper's Point area, broken down by species and year and is based on wildlife population estimates provided by the Wyoming Game and Fish and found in Appendix G. Due to a lag in reporting, the 2006 estimates are the latest available numbers at this time. In 2006, the population of pronghorn antelope has increased to an estimated population of 60,100. The population of mule deer has varied between a low of 22,060 in 1993 and a high of 36,000 in 2000. Elk and moose populations appear to be steady, at around 6,000 each.

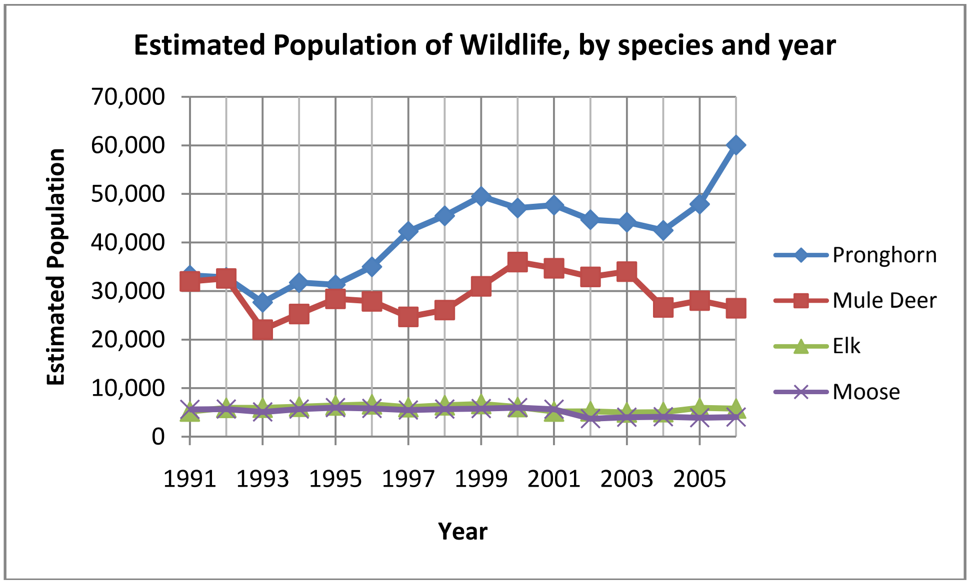


Figure 4-1: Estimated population of wildlife, 1991 to 2006

4.2 Animal Detection System Data

The effectiveness of the animal detection system will be determined by the number of false positive and false negative detections compared with actual or "verified" detections. A false positive detection is defined as any detection that is caused by anything other than an animal. A false negative occurs when the system fails to detect the presence of an animal. If the system worked flawlessly, 100% of the detections would be caused by animals alongside the road and no wildlife would be able to access the roadside without activating the warning lights.

To determine the number of false detections (both positive and negative), video was recorded and compared with data collected from the RM-2000 receiver / monitor. Video was monitored for animal activity. If an animal was not seen in the video when a detection was recorded, the detection was counted as a false detection.

The digital video recorder (DVR) was enclosed in a cabinet located near sign D (shown in Figure 3-13). A camera was mounted on the top of sign D on the post furthest from the road, as shown in Figure 4-2. Two models of DVRs, both were manufactured by Pelco, were used in this study the DX1000 and DX4000. The DVRs digitally record footage from the camera onto an internal hard drive. The DX4000 is equipped with a 160 gigabyte hard drive while the DX1000 is equipped with a 60 gigabyte hard drive. Video cannot be downloaded directly from the DX1000; instead, the video must be transferred to a cassette tape or to a computer using a USB television tuner. The DX4000 allows video to be downloaded directly to a computer using an Ethernet connection. Unfortunately, the download rate of the DX4000 is slow requiring that the DVR must be taken back to the office in Laramie for analysis. Because of this the two DVRs were swapped at each site visit so that a DVR was recording video at all times during this study.

Due to limited space available on the hard drives, video would be overwritten if the unit was left in the field too long. The amount of space that is available on the hard drive is dependent on the quality of the video that the user desires. Both DVRs are capable of recording video at 30 frames per second, but this much data was not needed by this study. A setting of 10 frames per second or less was used on both DVRs to conserve hard drive space without compromising the usability of the video.

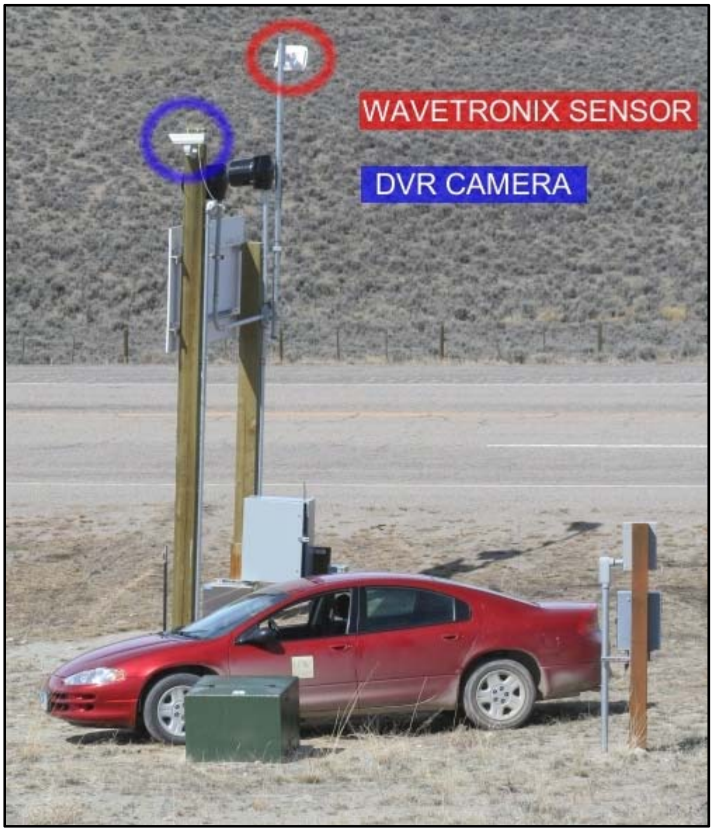


Figure 4-2: Photo of Wavetronix sensor and camera on road sign

The camera is mounted on sign D and faces west. Southbound traffic heads towards the camera, northbound traffic travels away from the camera. Figure 4-3 is a screenshot captured by the DVR. Sign C is visible in the upper-right corner of the frame. The rear of sign B is visible across the road from sign C. The beginning of the southbound climbing lane taper can be seen in the center of the photo. All of the sensor detection zones between sensor numbers 17 and 7, and 18 and 8 (See Figure 3-13) are visible by the camera.

Figure 4-3: Screenshot of video recorded by the DVR

4.3 Driver Behavior Data

The system's effect on driver behavior will be determined by monitoring vehicle speed in relation to the activation of the sign. This analysis will require two types of information: time-stamped information of vehicle speed, and time-stamped information from the wildlife detectors. The data will be statistically analyzed to determine whether the amount of time that the signs were activated has a significant effect on the speed of vehicles. The necessary data was collected using three Wavetronix SmartSensor HD units to record data on vehicle behavior and an RM-2000 receiver / monitor to record data from the wildlife sensors.

4.3.1 Wavetronix Speed Sensors

WYDOT purchased three Wavetronix SmartSensor HD units for use in this study. Manufactured by Wavetronix, these units use Frequency Modulated Continuous Wave (FMCW) radar at a frequency of 24.125 GHz to measure traffic volume, individual vehicle speed, average speed, 85th percentile speed, average headway, average gap, lane occupancy, vehicle classification, and presence (Wavetronix LLC 2006). They have a detection range of 250' and can monitor up to 10 lanes of traffic simultaneously.

In addition, the units are capable of automatically detecting the number and location of lanes, detecting vehicles that are separated by guardrails, medians, and gore areas, and detecting lane-changing vehicles.

A Wavetronix sensor was placed atop each of the three southbound signs (A, B, and D). The signs locations were chosen because they provided a convenient mounting location with available power. The original plan was to cover up and disable the northernmost sign (Sign A) so that the sensor mounted in this location could record the speed of vehicles before drivers had a chance to react to the system. Unfortunately, WYDOT was never able to cover up this sign during this study. The lights, however, were disabled on sign A so the drivers at this location were never presented with an active sign. The SmartSensor at the next southbound sign (Sign B) would record the speeds of vehicles after drivers had had a chance to read and react to the sign and flashing lights since the speeds are measured perpendicular to the sign location and the drivers would be able to read the sign in advance. A sensor at sign D would be used to determine whether drivers maintained their speed after reacting to sign B. The final mounting location of the Wavetronix sensor is approximately 5.5 feet higher than the "DEER ON ROAD WHEN FLASHING" sign, as shown in Figure 4-2. This mount location was used for the sensor on sign D only. The sensors attached to signs A and B were attached to the pole nearest the road, without an extension pole. Sign D required additional mounting height because the beginning of the truck climbing lane at this location caused some sensor visibility problems. The additional mounting height resolved these issues and is described more in Chapter 5.

Power and communications connections were made in the cabinet shared by the RP-3000 repeater and the flashing light controls. The same Trimble TDS Pocket PC that was used to communicate with the EIDS system was used to control the Wavetronix sensors. The SmartSensor Manager CE 1.1 software program was installed on the Pocket PC for this purpose. The software includes a feature that indicates whether the sensor has been properly mounted relative to the surface of the road. All three sensors were mounted properly according to the software.

The Wavetronix SmartSensors use internal flash memory to store traffic data. The site at Trapper's Point was not equipped with a telephone connection or any sort of communications wiring, so regular downloads of data from the SmartSensors were required. The sensors were set to handle the flash memory on a FIFO (first in, first out) basis. This means that, when the flash memory was full, every new record would require the deletion of the oldest record.

The sensors aggregate data into bins of a user-defined length. For instance, if one-minute-long bins were selected, the sensor would record the volume, average speed, 85th percentile speed, classification breakdown of the volume, occupancy, average headway, and average gap for one-minute-long periods. Information on individual vehicles cannot be retrieved unless a single vehicle was all that passed during that one-minute-long period. The minimum bin size, 10 seconds, was used for this study to try to maximize the number of bins with only one vehicle.

With 10 second bins, the sensors had about twenty days' worth of memory storage. Unfortunately, downloading the data from the sensors was a time consuming process. A full download of the data from the sensors is about 60 megabytes. The connection to the sensors is made via a serial connection. Often, it would take longer to download the data than the time available during the site visit. Even when downloading began the first thing in the morning, the downloads would not be finished by the time the UW researcher had to leave that evening. To ensure the most usable data, the researchers were instructed to begin downloading two-day data sets from each sensor and then to return to each sensor for additional data if time permitted.

Figure 4-4 is an example of the data that is downloaded from the Wavetronix sensors. The data is downloaded into a single text file, and can be easily imported into other applications, such as

Microsoft Excel. Only the volume, speed, class counts, and sensor time columns were used for analysis in this study. Each row accounts for one ten-second-long bin of data for a particular direction of travel. The "speed" column shows the average speed of the vehicles that passed by the sensor during those ten seconds.

```
#################################################################################################
#                                                                                               #
#                         DATE         : April 26, 2007                                         #
#                         SERIAL NUMBER: SS125 U100000111                                       #
#                         DESCRIPTION  : SS125 ITS Radar                                        #
#                         LOCATION     : Trapper's Point North                                  #
#                         ORIENTATION  : EE                                                     #
#_______________________________________________________________________________________________#
#          |         | Occu-  |        |  85%   |    Class Count    |         |       |                     #
#          |         | pancy  | Speed  | Speed  |___________________|         |       | SENSOR TIME         #
# NAME     | VOLUME  |  (%)   | (MPH)  | (MPH)  | C1 | C2 | C3 | C4 | HEADWAY |  GAP  | YYYY-MM-DD HH:MM:SS #
#################################################################################################
  SB            0      0.0       69       69     0    0    0    0       0.0      0.0   2007-04-14 13:23:00
  NB            0      0.0       70       70     0    0    0    0       0.0      0.0   2007-04-14 13:23:00

  SB            0      0.0       69       69     0    0    0    0       0.0      0.0   2007-04-14 13:23:10
  NB            0      0.0       70       70     0    0    0    0       0.0      0.0   2007-04-14 13:23:10

  SB            0      0.0       69       69     0    0    0    0       0.0      0.0   2007-04-14 13:23:20
  NB            0      0.0       70       70     0    0    0    0       0.0      0.0   2007-04-14 13:23:20

  SB            0      0.0       69       69     0    0    0    0       0.0      0.0   2007-04-14 13:23:30
  NB            0      0.0       70       70     0    0    0    0       0.0      0.0   2007-04-14 13:23:30
```

Figure 4-4: Example of data downloaded from Wavetronix SmartSensor HD

Table 4-1 is a list of dates that data were successfully collected from each Wavetronix sensor.

Table 4-1: Site Visit Dates and Speed Sensor Data

Time Period	Dates of Site Visits	Speed Sensor Data
Spring 2007	February 22, April 10, and April 26	Sensor A: 2/8–2/22, 4/14–4/26 Sensor B: 4/8–4/10, 4/15–4/26 Sensor D: 2/21–3/21, 3/29–4/10, 4/13–4/26
Fall 2007	September 29 and October 20	Sensor A, B & D: 9/28– 9/29, 10/14– 10/16
Spring 2008	April 5 and May 13	Sensor A, B & D: 4/02–4/05 Sensor B: 4/21– 4/26

Time synchronization between devices was difficult to maintain. The "SmartSensor Manager CE 1.1" software that was installed a Pocket PC and used to communicate with the Wavetronix sensors includes a feature that synchronizes the time on the Wavetronix sensor with the time on the Pocket PC. This operation was performed on each of the three Wavetronix sensors during every site visit after verifying that the time on the Pocket PC was correct. Unfortunately, the time on the three sensors would drift apart to the point that the volumes for each ten-second bin would not correspond between sensors given the time required to travel between them. The disparity between times for each sensor was also not constant. The amount of time that a particular sensor is fast or slow when compared with another sensor is dependent on the amount of time that has elapsed since the clocks were last synchronized. Due to the complexity of this problem, the data recorded by each sensor were not adjusted for their slight time differences. For example, between 16:00 on 4/8/07 and 9:00 on 4/10/07, the sensor mounted on sign D recorded an average of one more vehicle per half hour than the sensor on sign B. During this same time period, the sensor on sign D recorded a total volume of 2,078 vehicles. The sensor at sign B recorded 51 fewer vehicles, or 2,027 total. The time difference between sensors required the speeds to be aggregated into 30-minute bins so that the difference could be assumed negligible.

The mounting location at sign D may also contribute to the disparity in recorded volumes. A southbound climbing lane begins near the sign. At sign D, the highway is transitioning between two lanes and three. As mentioned earlier, the Wavetronix SmartSensor HD is equipped with a feature that automatically detects the number and width of travel lanes. Unfortunately, at this location, the southbound lane is somewhere between twelve and twenty-four feet wide. Drivers will not follow predictable paths in this transition zone: some will hug the yellow line to take the left lane and others will steer to the right to take the right lane. The software on the Pocket PC allows the user to monitor what the sensor sees in real-time to verify whether the sensor is operating properly. Problems with the detection of speed, length, or even the number of vehicles would occur when a faster vehicle would overtake a slower vehicle directly in front of the sensor. Changes to the sensor software limited the problems associated with the climbing lane and the sensor attached to sign D. This issue will be discussed more in Chapter 5.

4.3.2 RM-2000 Receiver/Monitor

The RM-2000 receiver / monitor is a handheld radio that is kept in a cabinet near sign D to record details of each event whenever a PT-210M reports a detection. Figure 4-5 is a photograph of the interior of the cabinet, and shows the DVR, the RM-2000, a receipt-tape printer attached to the RM-2000, and the Pocket PC used to communicate with the Wavetronix SmartSensor HD units, PT-210M units, and RP-3000 units. The RM-2000 was kept in its charging cradle. It was commonly referred to as the "handheld radio" throughout this project.

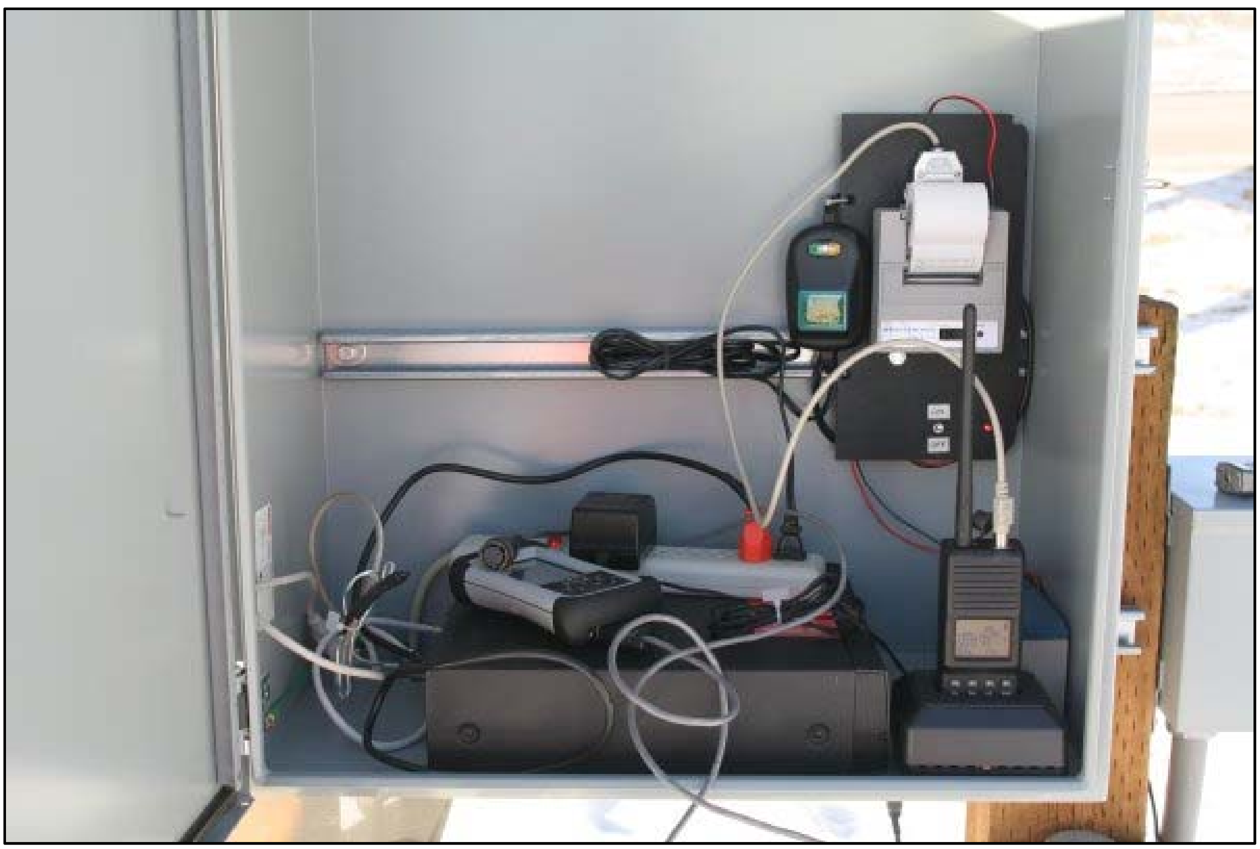


Figure 4-5: Photo of RM-2000, printer, Pocket PC, and digital video recorder at sign D

The radio features an RS-232 data port for exporting received data to either a PC computer or a serial printer (Telonics, Inc. 2007). A serial printer was originally used to record received data but the work of inputting all of the data from weeks' worth of detections was reason to replace the printer with a laptop computer. The laptop used the HyperTerminal terminal emulation program, installed by default on most Microsoft Windows machines, and recorded the same data as the printer, but in an electronic and easy-to-handle format. The printer was originally left as a backup data recording device but malfunctioned later in the project.

Table 4-2 lists the Detection Data Collected from spring 2007 to spring 2008. Complete detection records for Spring 2007 can be found in Appendix B and records for Fall 2007 and Spring 2008 can be found in Appendix C.

Table 4-2: Site Visit Dates and Detection Data

Time Period	Detection Data Collect
Spring 2007	2007.04.08 16:00:00 – 2007.04.10 09:00:00
Spring 2007	2007.04.11 19:30:00 – 2007.04.12 09:30:00
Spring 2007	2007.04.26 18:00:00 – 2007.05.16 09:00:00
Fall 2007	2007.09.28 10:06:38 – 2007.09.29 10:47:03
Fall 2007	2007.10.14 08:12:53 – 2007.10.18 08:34:18
Spring 2008	2007.09.28 15:36:46 – 2008.04.05 12:40:58
Spring 2008	2008.04.21 08:14:47 – 2008.04.23 15:51:54
Spring 2008	2008.04.25 21:01:10 – 2008.04.26 08:49:53

Figure 4-6 is an example of the output from the RM-2000 that is recorded by the printer or the laptop computer. The first column is the date and the second column is the time that the detection was received. The third column is the ID number of the PT-210M that transmitted the data. Occasionally, the RM-2000 would receive nonsensical data and place a question mark to the right of the row. A question mark indicates that a CRC (cyclic redundancy check) error has occurred, which means that the processor has detected a problem with the received transmission. For instance, one of the question marks corresponds to a transmission from ID numbers 135. At Trapper's Point, there is no ID number greater than 34. Also, due to the way that the PT-210M units have been configured, all of the detections should be "QUAL/PED". This indicates that both the geophones and the infrared sensors have made a detection during the qualify time, and that the geophones have detected the presence of footsteps.

```
2007.04.10 19:15:28 0135 QUAL/VEH  50 ?
2007.04.10 19:19:24 0011 QUAL/PED  28
2007.04.10 19:19:25 0005 QUAL/PED  35
2007.04.10 19:20:18 0001 QUAL/PED  10
2007.04.10 19:28:35 0001 QUAL/PED  11
2007.04.10 19:34:42 0001 QUAL/PED  44 ?
2007.04.10 19:53:55 0011 QUAL/PED  29
```

Figure 4-6: Example output from RM-2000 receiver / monitor

4.4 Crash Rate and Carcass Data

The final, and arguable the most important, measure of system effectiveness is the effect on crash rates in the corridor. This section will look at the data used to analyze the crash rates.

Between 1995 and 2007, US 191 between mileposts 105.54 and 106.90 experienced a total of 41 reported traffic crashes according to crash records kept by the Wyoming Department of Transportation (Appendix H). Twenty seven of these crashes (68%) were the result of a collision with deer. Antelope were responsible for two crashes during this time period and a cow for one. Therefore, the total number of crashes resulting from a collision with an animal is 30 (73%). The remaining eleven crashes were the result of either a collision with guardrail (2 crashes), a collision with another vehicle (6 crashes), overturning (2 crashes), or other (1 crash). Thirty animal-related crashes during that time period works out to an average of 3.0 reported vehicle-animal collisions per year.

The extent of under-reporting of animal-vehicle collisions in this area becomes obvious when the official crash reports are compared with carcass counts collected by WYDOT employees. Between March 1999 and December 2007, WYDOT personnel recorded 155 carcasses along US 191 between mileposts 105.0 and 107.0. Mule deer comprised 92.9% of the total. The remaining carcasses were pronghorn antelope. Assuming that all of the carcasses were the result of a collision with a vehicle, 155 carcasses spread over 3,220 days works out to approximately 17.8 animal-vehicle collisions per year. This number is much higher than the rate of 3.0 animal-vehicle collisions reported by the official crash counts and evidence that the true severity of the DVC problem in this area is difficult to determine from reported crash data alone.

The months with the highest number of reported crashes involving deer along this segment, in order, are: November (30%), April (24%), January (19%), December (19%), May (4%), and October (7%). 52% of these crashes occurred during low-light nighttime conditions, while 44% occurred during the day and 4% occurred during dusk. The road was dry in 81% of crashes involving deer.

CHAPTER 5: POST-INSTALLATION MODIFICATIONS

Many technical challenges have been encountered since the Trapper's Point wildlife-sensing driver warning system was installed in October of 2005. This chapter provides an overview of how problems with the wildlife detection system, Wavetronix SmartSensor HDs, RM-2000 receivers, and RP-3000 repeaters were addressed. The information presented in this chapter was gathered from site visit reports, available in Appendix A.

For the first part of this research effort, extensive modifications and adjustments were made to the system to get the system in best working order. This took place from Fall 2005 through the Spring of 2007. The second part of the research effort only did minor modifications for routine maintenance to see how the system performed under more these more "typical" maintenance conditions. This took place from Fall 2007 through Spring 2008. Modifications to the system described in the following sections are divided into these two time periods.

5.1 System Modifications from Fall 2005 through Spring 2007

5.1.1 Wildlife Detection System

The wildlife detection system consists of the PT-210M processor / transmitters, passive infrared sensors, and the geophone strings. The details of these components are discussed in earlier chapters. Problems have been encountered with multiple false detections, poor alignment of the sensors, and faulty equipment. Each of these problems is discussed in the following sections.

Multiple False Detections

There are two types of false detections: false positives and false negatives. A false positive occurs when the sensors detect the presence of wildlife without wildlife actually being present. A false negative occurs when sensors fail to detect the presence of wildlife when wildlife actually is present.

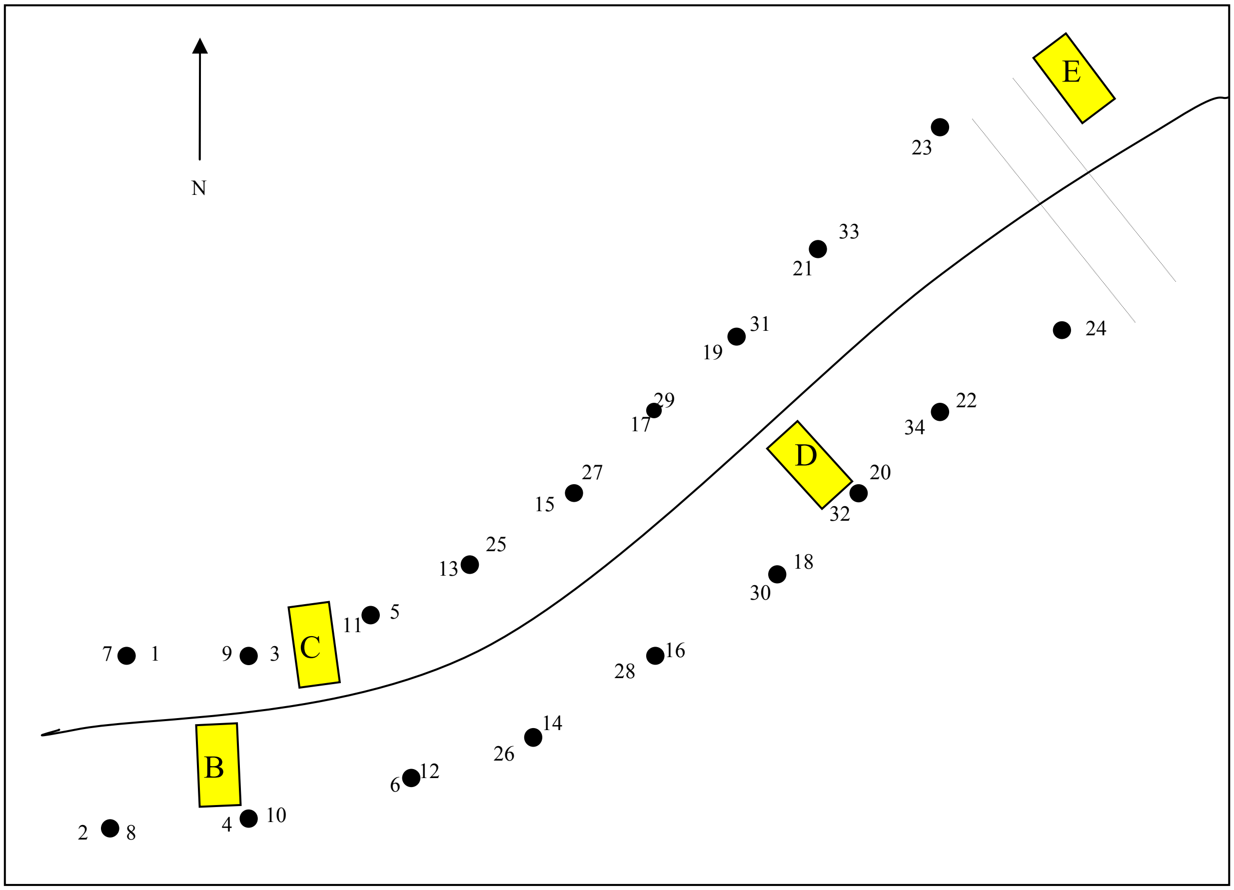
On May 9th, 2006, a group of two WYDOT engineers and a consultant from Transcore of Salt Lake City visited the Trapper's Point site (Cox, Trapper's Point Animal Detection Site Visit May 9-10 2006). Transcore is a company that has been contracted by WYDOT to perform work on the system at Trapper's Point. The group noticed that the flashing lights were on for 75% of the time during a 30-minute period. It was found that detection zones 5, 7, 11, and 22, which are located on the inside of highway curves, were being activated by passing tractor-trailer trucks. The flashing lights were originally set to flash for two minutes following a detection. In response to the high numbers of false positives, the group reduced this value to thirty seconds. They believed that thirty seconds was enough for any vehicle travelling at 55 mph through the project to see at least two flashing signs.

A site visit on August 30th and September 1st, 2006 was attended by two WYDOT engineers, an ITS maintenance technician, a telecommunications specialist, and a consultant from Transcore of Salt Lake City (Cox, Trapper's Point Animal Detection Site Visit August 30th - September 1st 2006). Between 8:30 AM and 11:30 AM, the group witnessed 67 false positive detections from detection zones 5, 7, and 11. These detections appeared to be caused by passing tractor-trailer trucks. Later, the group witnessed 58 false positive detections that were dispersed randomly throughout the project area. The RM-2000 handheld radio reported that all of these detections were "QUAL" detections rather than "QUAL/PED" detections. A "QUAL", or qualified, detection requires that the PT-210M transmitters receive a detection from at least two sensors. At the time, four sensors were attached to each PT-210M: two passive infrared sensors, and two geophone strings. Both infrared sensors are attached to the same wooden pole, but face in opposite directions and parallel to the highway. The geophone strings extend in opposite directions, away from the wooden pole, and parallel to the highway. A

"QUAL" detection, therefore, could occur when both infrared sensors are triggered, regardless of whether the geophone strings are triggered. The group determined that passing clouds caused enough temperature variation to trigger both infrared sensors and cause a "QUAL" detection. A "QUAL/PED" detection, on the other hand, requires a detection by an infrared sensor and a geophone string.

This was a serious problem. The system was designed to require a detection by a geophone and an infrared sensor to eliminate the problems inherent with both types of sensors individually. A geophone, by itself, is susceptible to false detections from wind, loud vehicles, trees, fences, etc. A passive infrared sensor can be fooled by temperature variations caused by a rising or setting sun and passing clouds. In theory, the system should be much less vulnerable to false detections when a detection from both sensor types is required to trigger the PT-210M transmitter. Unfortunately, the PT-210M transmitters had an unforeseen software loophole which would satisfy the conditions of a qualified detection when only the infrared sensors were triggered.

The only solution that the group could find to combat this problem was to move PT-210M transmitters from the outside thirds of the project length to the middle third so that only one geophone and one passive infrared sensor was attached to each transmitter. This was a reasonable solution since the middle of the project is the area where wildlife are witnessed crossing most often. Two PT-210M transmitters were installed at each of the wooden posts with this new configuration, as shown in Figure 5-1. The "DEER ON ROAD WHEN FLASHING" signs are shown as rectangles in Figure 5-1 and are labeled B through E. Signs A and F are outside the boundaries of this diagram. The sensors locations are marked as dots in Figure 5-1 and are labeled with the ID number of the PT-210M units, 1 through 34. Only one PT-210M is installed at the eastern-most locations nearest the stock pass, since only one infrared sensor and one geophone sensor are installed at these locations.

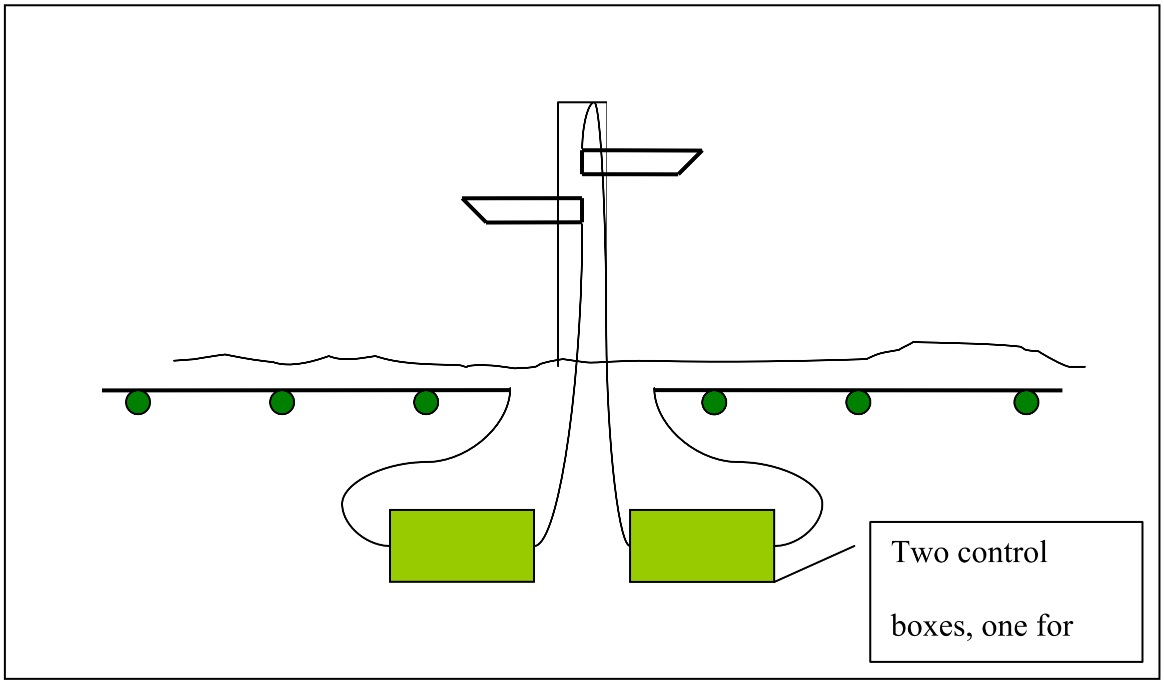


Source: (Cox, Trapper's Point Animal Detection Site Visit August 30th - September 1st 2006)

Figure 5-1: Layout of sensors

Each of the PT-210M transmitters was attached to a single infrared sensor and a single geophone string, both facing the same direction (Figure 5-2). The PT-210M with the ID number 25 as shown in Figure 5-1, for example, was only attached to the infrared sensor and geophone string which covered the area to the northeast of the wooden pole. The PT-210M with the ID number 13 was attached to the infrared sensor and geophone string which covered the area to the southeast of the wooden pole. Only “QUAL/PED” detections were possible with this new configuration, since only one infrared sensor was attached to each transmitter. “QUAL/PED” detections also require the PT-

210M to differentiate between footsteps and vehicles. A “QUAL/VEH” detection indicates that the seismic sensors have detected the movement of a vehicle. Since the footstep counter, described in Chapter 3, was enabled, only “QUAL/PED” detections were possible.



Source: (Cox, Trapper's Point Animal Detection Site Visit August 30th - September 1st 2006)

Figure 5-2: Diagram of the new PT-210M configuration

During the site visit on August 30th and September 1st, 2006, the group also installed filters on the infrared sensors at transmitter locations 2, 5, 6, 8, 12, 16, 18, and 28 (Figure 5-1). These filters are honeycomb-shaped and work to limit wayward, high-angle infrared signals that reach the infrared sensors. The group found that the filters slightly reduced the number of false positives caused by a rising, low-angle sun on the sensor attached to transmitter number 18 (Figure 5-1). The filters were proposed during the site visit on May 9th, but were not installed out of concern that they would fill with snow or dirt and degrade the performance of the sensor. During a site visit on October 20th, 2006, attended by WYDOT engineers and representatives of Telonics, Inc, the group found that the filters noticeably reduced the number of false positives. The filters were also clean and free of debris.

The qualify time is the user-defined time within which both the infrared sensor and geophone sensors must be triggered to cause the PT-210M to transmit. The group that visited the site on August 30th decided that the minimum qualify time should be two seconds. If a particular transmitter appears to have large numbers of false negatives, this value should be increased gradually and re-evaluated. On October 20th, the group from WYDOT and Telonics reset all of the PT-210M transmitters with qualify times of 4 or 5 seconds, except for a few troublesome sensors on the north side of the road, which they left with a qualify time of 2 seconds. The group also disconnected the sensors from transmitter number 31 (Figure 5-1) and plugged them into transmitter 19, returning transmitter 19 to its original configuration. This did not appear to have any effect on the number of false detections coming from unit 19, except during sunrise and sunset. Telonics recommended that further observations should be made to verify whether doubling-up the PT-210M sensors and using a qualify time of 2 seconds rather than 4 or 5 seconds is absolutely necessary. They also recommended that filters be installed on all of the infrared sensors.

Despite the changes made by Telonics, the system still suffered from frequent false detections. All of the transmitters had been configured independently based on qualitative data and infrequent observations. If troublesome sensors and transmitters were to be properly identified through statistical analysis, all of the transmitters would need to be reset with the same sensitivities and qualify times. Individual transmitters could be configured once there was statistical evidence that those particular transmitters were behaving differently from the rest. On March 21st, 2007, all 34 of the PT-210M transmitters were programmed by UW researchers with the following values: left and right sensitivities of 4, a seismic sensitivity of 5, and a qualify time of 5 seconds, per Telonics' recommendation. The EIDS manual recommends a sensitivity setting of 3 for geophones and a sensitivity setting of 4 for infrared sensors. Walking tests, especially at the extremes of the geophone strings, determined that a setting of 5 would be a more appropriate starting place for the geophone sensitivities. A setting less than 5 would often result in transmitters that were unable to detect the presence of a human.

Many false positives were immediately recorded from transmitters 1, 11, and 5 (Figure 5-1) and appeared to be caused by passing tractor-trailers. The qualify time on these three sensors was reduced from 5 seconds to 2 seconds, as recommended by the site visit team on August 30th. A site visit on April 10th, 2007, found that reducing the qualify time on these sensors was not enough to prevent frequent false positives, since over half of the detections during the entire day of April 9th, 2007, had been caused by transmitter number 1 (Figure 5-3). Transmitter 11 had been responsible for 13% of the detections during the day. Since the qualify times on these transmitters had already been set to the minimum, 2 seconds, the sensitivities of the sensors were reduced to 3 for the infrared sensors and 3 for the geophone sensors.

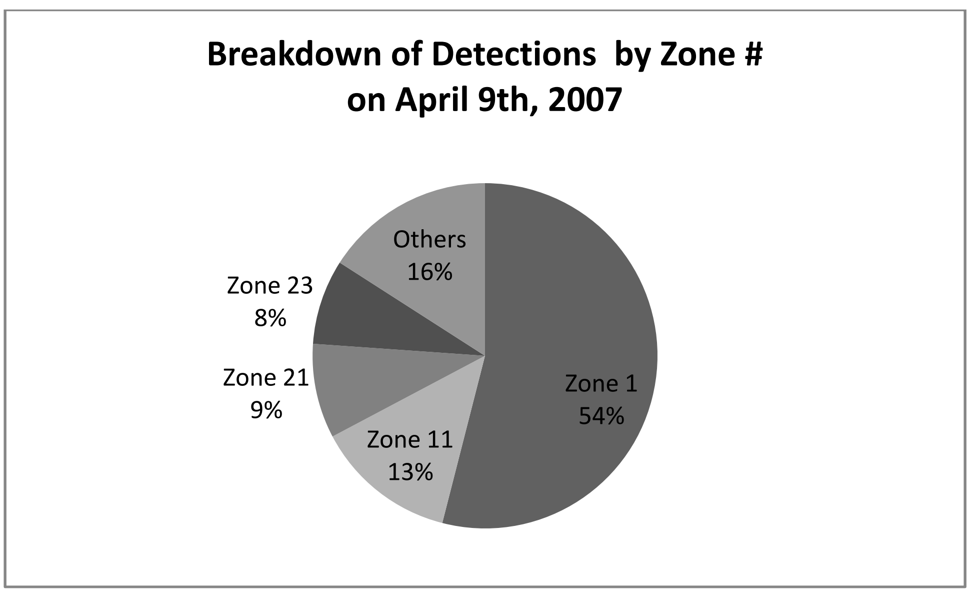


Figure 5-3: Breakdown of detections by zone number, April 9th, 2007

The number of detections coming from transmitter number 1 on April 9^{th}, 2007 peaked during the morning hours. Slightly more than half of the total number of detections from transmitter 1, or 50.8%, occurred during the two and a half hours between 6:30AM and 9:00AM, which comprise approximately a tenth of the day (Figure 5-4). The infrared sensor attached to transmitter number 1 faces directly east and towards the rising, morning sun. The transmitter is also located on the inside of a curve, which could allow the infrared sensors to detect a passing, high-profile vehicle. According to the EIDS Manual, published by Telonics, Inc, the IF-540 passive infrared sensor is capable of detecting vehicles within a half mile of the sensor (Telonics, Inc. n.d.). Since every detection requires the geophones to be triggered within 2 seconds of the infrared sensors, or vice versa, passing traffic is a more likely explanation for the high number of false positives from transmitter number 1 than the angle of the sun alone. The rising sun, which shines directly into the infrared sensor, may increase the sensor's sensitivity towards passing traffic, which is also detected seismically by the geophone sensors. Consequently, UW researchers lowered the sensitivities on both types of sensors to a value of 3 on transmitter 1.

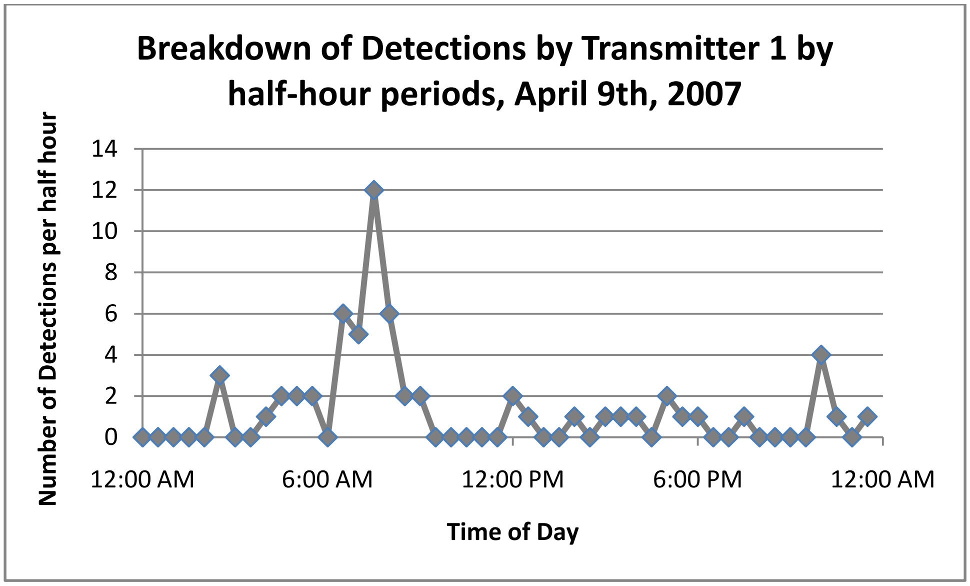


Figure 5-4: Breakdown of detections by transmitter 1 by time of day, April 9th, 2007

The modifications made to the PT-210M configurations on April 10th, 2007 appear to have had an effect on the breakdown of detections by zone number, as shown in Figure 5-5. Before those modifications were made, more than half of the detections came from zone number 1 (Figure 5-3). After the sensitivities of the geophones and infrared sensors were lowered to 3 on units 1, 11, and 5, however; only 30% of the detections between April 10th and April 12th (Figure 5-5) and 9% of the detections between April 26th and May 16th (Figure 5-6) came from zone number 1.

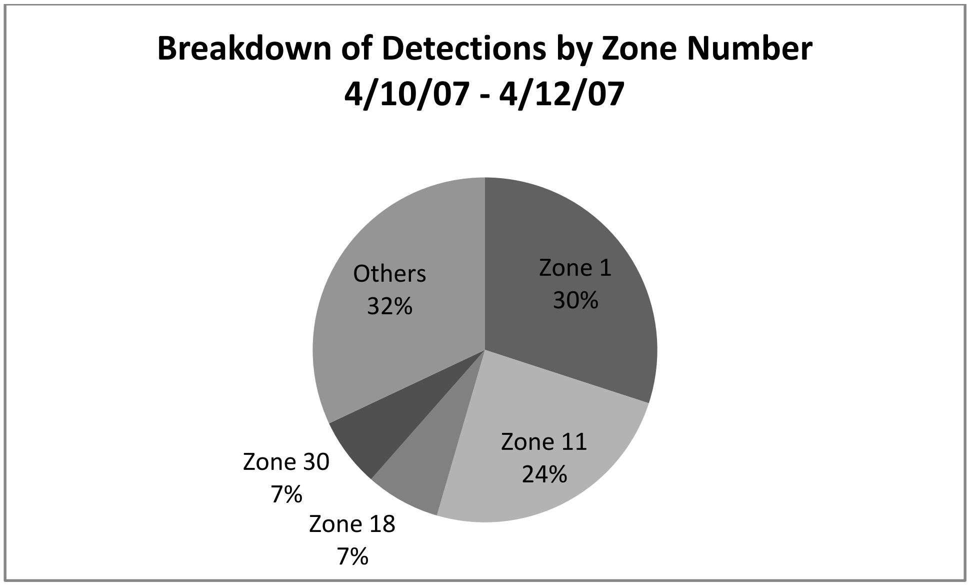


Figure 5-5: Breakdown of detections by zone number, 4/10/07 through 4/12/07

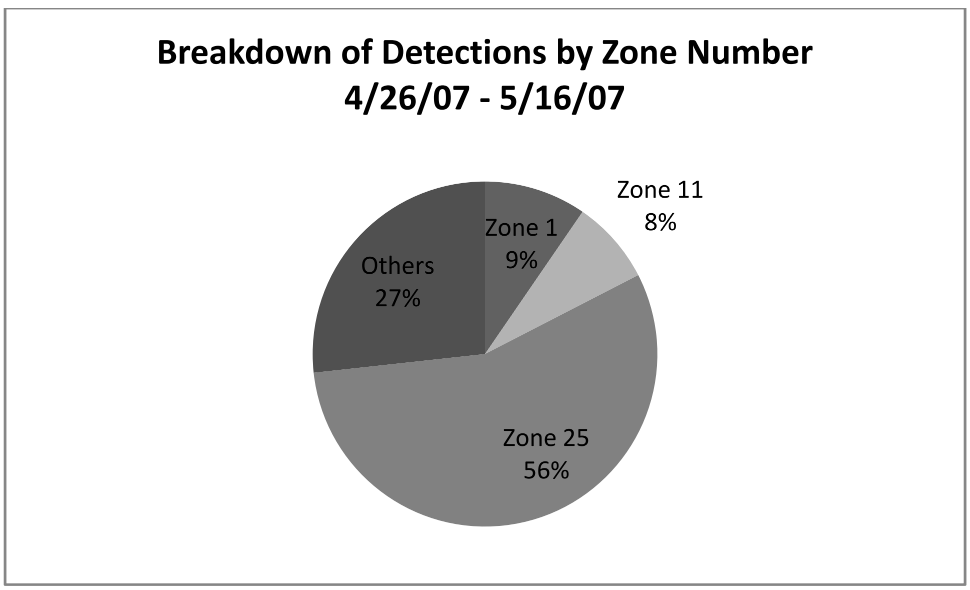


Figure 5-6: Breakdown of detections by zone number, 4/26/07 through 5/16/07

According to Figure 5-6, in fact, more than half of the detections, or 56%, came from zone number 25. The number of detections from zone 25 was not large enough to be singled out in Figure 5-3 or Figure 5-5. Since no modifications have been made to unit 25, besides the configuration changes that were made to all of the PT-210M units on March 21st, Figure 5-6 suggests that something has happened to zone 25 to cause a sudden increase in detections. The infrared sensor may need to be checked for alignment issues.

Up to this point, the discussion of problems with false detections has mostly involved false positive detections. False positives at Trapper's Point are thought to be caused by passing traffic and sunlight.

However, there may also be a problem with false negatives, too. Between April 26th and May 16th, 2007, UW researchers determined that no detections were received from zones 3, 4, 8, 9, 10, 20, 24, 29, or 31. The lack of detections from unit 31 is explained by the fact that Telonics, Inc disconnected the sensors from unit 31 and plugged them into unit 19 during the site visit on October 20th, 2006. The reason why no detections were recorded by the remaining eight sensors during the 21-day period is unknown. Perhaps those eight sensors are configured properly, but no wildlife passed through those zones. It may also be possible that the sensitivities of the sensors are set too low or that the qualify times are too short. An analysis of the video from the DVR is necessary to determine the number of false negatives.

Determining the effect of configuration changes on 34 individual sensor groups on the performance of the wildlife detection system as a whole is a difficult task. After each modification, data from the handheld radio and DVR should be analyzed to determine whether the modification resulted in fewer false detections. Up to this point, however, the process of configuring the system to minimize false detections appears to be one of trial-and-error. Insufficient data has been collected to make further modifications to the system at this time due to difficulties with the data-collecting equipment, described later in this chapter.

Poor Sensor Alignment

On October 20th, 2006, a group of WYDOT engineers and representatives of Telonics discovered that the infrared sensors were out of alignment. The infrared scopes are susceptible to false detections caused by passing traffic if they are pointed towards the highway. Also, since the geophones and infrared sensors are required to make a detection within the qualification time, it is important to aim the infrared scopes in line with the geophone strings to ensure that they both detect wildlife at roughly the same time. Problems can also arise if the infrared scopes are pointed skyward or towards the ground. WYDOT and Telonics personnel spent considerable time re-aiming the scopes and cleaning the lenses. They also discovered that the bolts which fasten a clamp that holds the infrared sensors were loose on the sensors on the south side of the road. They re-fastened the bolts.

Telonics recommended that the infrared scopes be checked, twice a month, for proper alignment and tight fasteners. They also recommend that a walk test be performed twice a month to ensure that the infrared sensors are working properly. Periodic walk tests have been performed by UW researchers during site visits. The remaining suggested maintenance has not been performed due to the remote location of the site.

Faulty Equipment

A large number of false detections were received from transmitter number 30 (Figure 5-1) during the site visit on October 20th, 2006. An intermittent problem with the infrared sensor was discovered at this location. Fortunately, a surplus of on-site infrared sensors was created when the PT-210M transmitters were moved from the outside of the project length to the inside to address the problem with qualified detections. The faulty infrared sensor was removed and replaced with a sensor from the original location of transmitter number 1. This appeared to correct the problem with transmitter number 30.

During the site visit on May 9th, 2006, the team discovered that the geophone strings appeared to have difficulty detecting walking humans at the ends of the strings. On October 20th, 2006, Telonics recommended that the seismic sensors be tested with a walk test twice a month to ensure that they are functioning properly. Whether this problem is a result of faulty equipment, poor installation, or the configuration of the PT-210M transmitters has not been determined. Some transmitters appear to have more difficulty detecting walking humans at the ends of the geophone strings than others. The Telonics EIDS manual explains that the detection range of the geophone strings are dependent on the type of terrain, sensitivity of the processor, and the types and numbers of intruders being detected (Telonics, Inc. n.d.). The manual also warns that the installer needs to take soil density into account to determine the detection range of the geophone sensors. Problems associated with detection at the ends of geophone strings, therefore, may be caused by varying soil densities or inconsistent installation depths.

During a site visit in early 2007, UW researchers walk tested the geophone strings while the side of the road was covered with snow. The geophones were less responsive during this test compared with tests conducted during dry conditions. Researchers would often have to jump directly on top of a geophone string to trip the sensor. Nothing has been done to correct this problem other than adjusting the qualify time and sensitivity settings of the PT-210M transmitter. Snow cover was noted as a potential problem for the operation of the geophones.

5.1.2 Wavetronix SmartSensor HD

A Wavetronix SmartSensor HD was installed on the three southbound “DEER ON ROAD WHEN FLASHING” signs: sign A, sign B, and sign D. Speed data collected from these sensors would be used to determine whether the flashing lights and road signs had an effect on the speed of vehicles passing through the section. Before useful data could be collected, however, difficulties with the sensor mounting locations and software configurations had to be overcome.

Mounting Location

The three Wavetronix SmartSensor HD units were installed at Trapper's Point in November, 2006. According to the SmartSensor manual, the height that the sensors should be mounted, relative to the road, is dependent on the horizontal distance from the sensor to the road (Wavetronix LLC n.d.). Wavetronix recommends a horizontal offset of 25 to 35 feet from the nearest lane and a vertical elevation of 26 to 30 feet above the surface of the road.

WYDOT chose to install the sensors on the "DEER ON ROAD WHEN FLASHING SIGNS" for convenience. Mounting the sensors on the signs did not require the installation of three new posts along the roadway. Also, the signs were equipped with electricity and a cabinet to house the necessary communications tools and wires. Electricity and communications are routed to the sensor via a special, proprietary cable. WYDOT initially purchased a short length of this cable from Wavetronix, but the installers discovered that there was only enough cable to mount the sensors on the pole furthest from the road (Figure 5-7). Ideally, the sensors would have been mounted on the pole nearest the road and on an extension pole to prevent the sign from blocking or re-directing the sensors' transmissions.

The SmartSensor Manager CE software, installed on a Pocket PC, includes a feature that determines the suitability of the sensor's mount. A screenshot of this feature is shown in Figure 5-8. The green arrow in Figure 5-8 indicates that a sensor has been mounted correctly. A red arrow indicated that all three of the sensors, mounted as shown in Figure 5-7, were not installed correctly and would need to be moved.

Figure 5-7: Photo of original Wavetronix SmartSensor HD mount

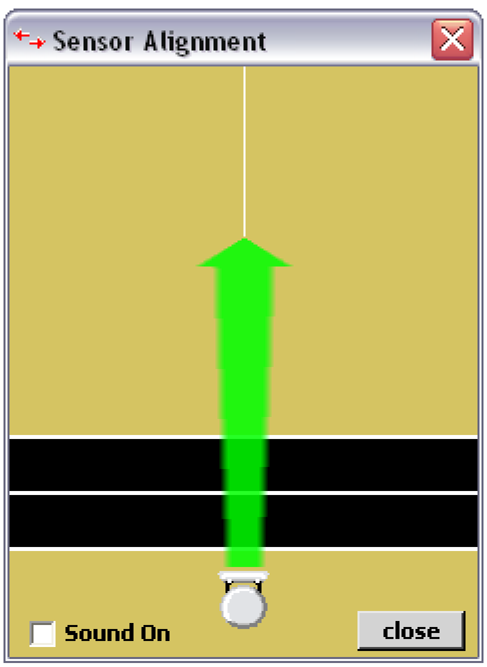


Figure 5-8: Screenshot of the SmartSensor software's sensor alignment feature

On the first site visit after the sensors had been installed, in December, 2006, the sensors could detect the presence of passing vehicles, but were occasionally not able to determine the speed of vehicles. WYDOT agreed to move the sensors to the pole nearest the highway. By February 22nd, 2007, new cable had been bought and the sensors had been moved to the pole closest to the road. This seemed to eliminate most of the problems with the sensors on signs A and B, however; the sensor on sign D continued to have issues with vehicle detection.

The sensor attached to sign D would often report multiple, nonexistent vehicles when a tall vehicle, such as a tractor-trailer combination, passed. Vehicles that were travelling side-by-side at roughly the same speed when passing the sensor (one in the fast lane, the other in the climbing lane) would be reported with a 10-mile-per-hour speed differential. A 5.5-foot mast was added to the pole closest to the road on sign D. The sensor was mounted to the top of the pole. This appears to have corrected the problem with multiple, nonexistent detections caused by tall vehicles.

Configuration Changes

Each SmartSensor HD was configured with a unique name, depending on the sensor's location: "South" (sign D), "Middle" (sign B), or "North" (sign A). Each SmartSensor was configured to store data in ten-second-long bins to maximize the number of bins and improve the probability that each bin contained data for a single vehicle. The SmartSensors were also synchronized with the clock on the Pocket PC. The difficulty caused by unsynchronized clocks is discussed in greater detail in Chapter 4.

In addition, software adjustments were made to the SmartSensor HD attached to sign D to attempt to correct detection problems. Mounting the sign atop the 5.5-foot mast attached to the pole nearest the road appeared to solve the detection problems associated with tall vehicles.

Unfortunately, the sensor still recorded erroneous data resulting from the vehicles in the adjacent climbing lane. Many of the problems with climbing lane detections appeared to result from the SmartSensor HD's ability to automatically detect the location and width of travel lanes. This means that the SmartSensor HD does not need to be configured before it can start collecting useful data. This feature worked well for the sensors located at signs A and B. Both sensors detected that there was one lane for each direction of travel. Unfortunately, sign D is located in the taper between a single lane and two lanes, one of which is the climbing lane. The “lane” in this area is somewhere between 12 and 24 feet wide. Vehicles can choose to hug the yellow line to take the passing lane, stay near the fog line to take the slow lane, or travel anywhere in between.

Consequently, many problems were observed while watching the operation of the sensor in real-time with the Pocket PC. Before the sensor was raised 5.5 feet above the sign, the sensor automatically detected several northbound lanes that were hundreds of feet beyond the highway, caused by the misinterpretation of passing tall vehicles. The sensor also decided that the southbound direction was broken into two lanes. When vehicles would travel in between these two, automatically-configured lanes, the SmartSensor would report that a vehicle had passed in both lanes.

To correct these issues, the automatic lane detection feature was overridden, and lanes were configured manually. The southbound direction was configured to be one extra-wide lane, and the northbound direction was left as the sensor had detected it. Also, the sensor was configured to disregard any erroneous detections coming from the area beyond the far edge of the northbound lane. Watching the real-time sensor operations with the Pocket PC indicated that these changes appear to have corrected most of the detection problems with the sensor at sign D. However, as described in Chapter 4, there is still a disparity between the volumes recorded by this sensor and the sensor at sign B.

5.1.3 RM-2000 Receiver / Monitor

Two significant challenges were experienced with the RM-2000 handheld receiver / monitor, which is kept in the cabinet near sign D and is used to record detection events. The handheld radio had poor reception while locked inside its metal cabinet and could only receive data from nearby transmitters. There were also problems with recording data from the RM-2000 after the printer was replaced with a laptop computer.

Poor Radio Reception

The ticker-tape receipt printer was attached to the RM-2000 and used to keep record of detections, before being replaced on March 21st, 2007. During the site visit on February 22nd, 2007, it was determined that the majority of the records that had been recorded by the printer in the last two weeks had come from transmitter number 19. Transmitter 19 is located directly across the highway from sign D, which is where the RM-2000 and the printer are stored (Figure 5-1). A simple walk test with the RM-2000 radio in-hand confirmed that all other transmitters, besides number 19, were working properly. The handheld radio even received signals from transmitters that were on the opposite side of the project during this walk test.

Next, the RM-2000 was locked inside the cabinet while a walk test was performed between signs D and B. Signs D and C flashed during the walk test, which indicated that the sensors and the transmitters in this area were functioning properly. When the cabinet was opened, however, it was discovered that the RM-2000 had recorded only a single detection from transmitter number 32, which is very near the cabinet. The cabinet was determined to be preventing the handheld radio from receiving distant signals properly.

By March 21st, 2007, an external Icom model FA-S57V "rubber duck" antenna had been installed on the exterior of the cabinet. This appears to have solved the RM-2000 reception problem. The external antenna was so successful that the printer ran out of paper in a matter of only a few days after its installation (Figure 5-9). Most of the data on the printouts shown in Figure 5-9 were unusable, however, since the printer had run out of ink before it ran out of paper.

Figure 5-9: Photo of RM-2000 after installation of external antenna

Limitations of Recording Devices

Inputting the data from the printouts, shown in the photo in Figure 5-9, was tedious work. Consequently, on March 21st, 2007, the printer attached to the RM-2000 handheld receiver was replaced with a laptop computer. Also, recording the data digitally on a laptop computer eliminated the need for ink cartridges and paper tape.

The RM-2000 is equipped with a PS/2-style serial port. A cable, supplied by Telonics, ran from the serial port on the RM-2000 to the 9-pin serial port on the laptop. The laptop was plugged into the same power strip as the DVR and the charging cradle for the RM-2000. Data, in the same format as the printer output, could be recorded by using any terminal emulation program.

A terminal emulation program was needed that would be stable for long periods of time and that would periodically save recorded data to the laptop's hard drive, in case of a power outage. Even if the laptop experienced software failures or its batteries were exhausted, there would still be some useful data stored on the hard drive. HyperTerminal, installed by default on most machines running Microsoft Windows, was chosen for use at Trapper's Point. Unfortunately, it took a couple trips to the site to work out an unforeseen limitation of the software.

On April 10th, 2007, it was discovered that the laptop had only recorded data from the last two days. The software had not failed, the RM-2000 still functioned properly; but the laptop had only recorded data from April 8th. This was determined to be due to a limitation of HyperTerminal. It appears that the software has a limit on the amount of data that can be stored in memory, without saving. Data was handled on a first in, first out (FIFO) basis. Once the memory had reached capacity, after about two days, the oldest records were deleted in order to record new data. On April 10th, HyperTerminal was reconfigured to "Capture Text", to write all of the records to a text file on the laptop's hard drive.

Unfortunately, during the next site visit, on April 26th, it was discovered that the RM-2000 handheld radio had become nonfunctional shortly after being left on April 10th. The amount of data that was collected on April 26th, therefore, spanned only about a day and a half.

On June 22nd, 2007, UW researchers successfully downloaded data from the laptop that spanned the period from April 26th, 2007 to May 16th, 2007. It is not known why the laptop did not record between May 16th and June 22nd, but the modifications to the laptop made on April 10th appear to have had a positive effect, since more than two days' worth of data was collected.

The serial printer should also be attached to the handheld radio for redundancy.

5.1.4 Digital Video Recorder

The digital video recorder (DVR) recorded continuously from the camera mounted at the top of sign D. An advantage of using a DVR rather than an older cassette-tape recorder is that the video on the DVR is already stored digitally and can be easily transferred to a PC for record keeping. Due to the difficulties involved with downloading from the Pelco DX1000 DVR, WYDOT purchased a new Pelco DX4000 DVR. The DX4000 is much more user-friendly, but it brought a new set of unforeseen limitations and challenges to the data collection process. There were also problems with the image-quality of the camera, which were not completely addressed until March 21st, 2007.

Video Backup Concerns

A television must be connected to the Pelco DX1000 in order to configure the unit or view live video. Video must also be backed up through the same connector. According to a Pelco telephone support representative, most users back up video onto a cassette tape by attaching the DX1000 to a VCR. Pelco designs their DVRs with the security market in mind. The DVR has a hard drive that is large enough to store multiple days' worth of video. When a particular event happens that requires a small length of video to be backed up, such as a shoplifting incident, transferring the video onto a cassette tape is a simple process. Unfortunately, according to Pelco's telephone tech support, Pelco does not and has not made a DVR that is designed to back up the entire contents of the DVR's hard drive.

WYDOT purchased a USB device which allowed television to be viewed and recorded on any PC running Microsoft Windows. The DVR could be plugged into this device, and video from the DVR could be viewed or recorded on a PC. Transferring two weeks of video from the DVR to the PC using this device turned out to be impractical. Even at the lowest setting, a seven minute recording required more than a gigabyte of disk space on the PC.

In addition, the DVR had to play back the video at real-time speed for proper recording. Too many frames are lost if the PC records while the DVR plays video at fast-forward speed. Therefore, recording two weeks of video would require that the DVR play and the PC record for two weeks.

A Pelco support representative indicated that the hard drive could “probably” be removed from the DX1000 and plugged directly into a PC. The PC would then, theoretically, have access to all of the DVR’s MPEG video files, which could easily be transferred onto the PC’s hard drive. UW purchased a device that allows a hard drive to be loosely connected to a PC’s USB port. The hard drive that was removed from the DX1000 should have behaved similar to any USB external hard drive. Unfortunately, the Pelco hard drive uses a data format that is unrecognizable by Windows.

The Pelco DX4000 is equipped with an Ethernet port that allows the DVR to be remotely-controlled. Video can be easily viewed and downloaded to a PC over a high-speed data connection. The DX4000 is also equipped with a USB port that allows video to be transferred onto USB storage devices. WYDOT purchased a DX4000 in January, 2007 to replace the DX1000 and to allow video to be backed up easily. The unit was installed on February 22nd, 2007 at Trapper’s Point.

Configuring the DX4000 was simple using the Pelco DX4000 Remote Agent software. The DVR can be controlled and configured remotely using a laptop and an Ethernet crossover cable, as shown in Figure 5-10. This feature turned out to be an unforeseen benefit of the DX4000 over the DX1000. Configuring the DX1000 meant that the unit had to be taken from the site and connected directly to a television, or to a computer using the USB television device. Configuring the DX4000 was a much simpler process that could be done on-site.

Figure 5-10: Photo of S. Vander Giessen remotely configuring the DX4000 DVR

However, downloading video from the DX4000 was not as simple a process as advertised. The DX4000, like its predecessor, was not designed to upload mass amounts of data to a PC. It was designed to download small lengths of video, which it did with ease. Downloading long lengths of video, such as the entire contents of the DVR's 160 gigabyte hard drive, turned out to be impractical. During the site visit on April 10th, 2007, it took approximately 2.5 hours to download 2.5 gigabytes of data from the DVR. A lot of the time spent downloading video was spent by the computer processing the data as it was transferred. The problem was similar and just as frustrating as the problem with the Wavetronix SmartSensors; downloads were too slow to be useful.

Rather than return empty-handed during the April 10th site visit, UW personnel downloaded video that corresponded to detections recorded by the laptop and the RM-2000 handheld radio. While in the field, the list of detections was sorted by detection zone. Five detections were chosen at random for each detection zone, and a three minute video was downloaded that corresponded to each. Detection zones that were outside the camera's field of view were eliminated. The clock on the handheld radio was approximately 2 minutes slow compared with the clock on the DX4000. This time difference was accounted for. Each video began and ended a minute and a half on each side of the detection time.

Unfortunately, the method used on April 10th was only good for detecting false positives. To detect false negatives, the DX4000 was brought back to Laramie on April 26th, 2007 and replaced with the DX1000. Whenever future site visits are made, one DVR will be swapped for the other. While each DVR is in Laramie, randomly-selected video will be viewed and recorded.

Camera

The camera that was originally installed at Trapper's Point produced low-quality video and was replaced with a newer unit sometime in early 2007. Even with the new camera, however, video captured during nighttime hours is useless because no roadway lighting is installed at the project site. The video is completely black, with the occasional streak of headlights from passing vehicles. To be effective, an infrared camera, like the one used in the Nugget Canyon study, would require the installation of costly infrared floodlights along the side of the road (K. M. Gordon, S. H. Anderson, et al. 2001). To preserve space on the DVR, the record time was set on both units so that only the hours between just before dawn to just after dusk were recorded.

During the first site visit after the installation of the new camera, on February 22nd, 2007, the image captured by the camera, as shown in Figure 5-11, was discovered to be unusable. WYDOT sent a technician to repair the camera. The technician determined that vibration had caused the camera to lose focus. The camera was re-focused, cleaned, and verified to be working properly. On March 21st, 2007, a technician met with a UW researcher on-site to adjust the camera's field of view. The technician zoomed out the image slightly, lowered the camera so the horizon was no longer visible, and moved it slightly towards the south so the sensors on that side of the road were visible (Figure 5-12). With the new field of view, detection zones 1-16, 25-28, 18, 30, and 32 are visible (Figure 5-1).

Figure 5-11: Video-capture from camera before modifications were made

Figure 5-12: Video-capture from camera after modifications were made

5.1.5 RP-3000 Sign Receivers

Upon arrival at the site during several site visits, the “DEER ON ROAD WHEN FLASHING” signs would not flash during a walk test of the sensors, even when the RM-2000 handheld radio confirmed that the sensors were detecting movement properly. The power cable was removed from each RP-3000 at signs B, C, and D and quickly reconnected. The signs flashed and behaved normally afterwards.

On February 22nd, signs B, C, and D were re-configured to flash only when a detection was received from specific PT-210M units. Sign B was set up only to accept hits from detectors 1-18 and 25-30. Sign C monitors detectors 1-16 and 25-28. Sign D is configured to flash when detectors 13-34 transmit. This makes the signs more useful to the drivers. The signs will flash only when sensors that are in the vicinity of the sign have made a detection.

However, there also appeared to be radio reception problems with the RP-3000 units. Sign D, which is configured to flash when a signal is received from PT-210M units 13 through 34, would not flash when unit 24 made a detection. Sign C, which is farther away from unit 24 than sign D, would flash when unit 24 transmitted, before sign C was reconfigured not to. A hill separates sign D from PT-210M unit 24, whereas sign C is visible from this transmitter. On March 21st, the technicians who added a 5.5-foot mast to sign D for the Wavetronix sensor and re-focused the camera, also checked the radio coverage of the transmitters. They found no problems.

The Wavetronix SmartSensor that was attached to sign A was intended to provide the speeds of vehicles before they had a chance to be affected by the signs. However, sign A was never covered up in time for this report. The flashing lights on sign A were disabled by changing the flash timer from 30 seconds to 0 seconds.

5.1.6 Summary of System Modifications from Fall 2005 through Spring 2007

Timeline of Modifications

The following is a timeline of modifications that have been made to the Trapper's Point wildlife detection system since construction in October, 2005. The parties that were responsible for the modifications are listed beneath the date.

May 9 – 10, 2006 WYDOT	• Reduced the amount of time that the flashing lights are activated per detection from 2 minutes to 30 seconds. • Rotated IR sensors in zones 7 and 11 slightly away from the road.
September 1, 2006 WYDOT	• Reduced the qualify time from 10 seconds to 2 seconds on units 5, 7, 9, 11, 18, 19, 20, 30, 31, and 32. • Took PT-210M units from the outer thirds of the project and installed them in the inner third. Connected one IR sensor and one geophone string to each PT-210M. • Installed IR filters on sensors 2, 5, 6, 8, 12, 16, 18, and 28.

October 20 – 21, 2006 WYDOT / Telonics	• Changed the qualify time to 4 – 5 seconds on most sensors, except for a few on the inside of a curve on the north side of the road, which were kept at 2 – 3 seconds. • Re-aimed the infrared sensors. • Replaced a faulty infrared sensor at unit 30. • Disconnected unit 31 and plugged all four sensors into unit 19.
Unknown Date WYDOT	• Installed the Wavetronix SmartSensor HD units on the pole furthest from the road on signs A, B, and D.
December 1 – 2, 2006 UW	• Reduced the Wavetronix SmartSensor HD bin size to 10 seconds.
Unknown Date WYDOT	• Replaced the camera on sign D. • Moved the Wavetronix sensors to the poles nearest the road.
February 22, 2007 UW	• Replaced the DVR camera on sign D. • Replaced the DX1000 DVR with the DX4000. • Configured sign B to only flash when a detection is received from units 1 – 18 and 25 – 30. • Configured sign D to only flash when a detection is received from units 13 – 34. • Configured sign C to only flash when a detection is received from units 1 – 16 and 25 – 28. • Reduced the flash timer on sign A from 30 seconds to 0.
March 16, 2007 WYDOT	• Refocused the camera. • Raised the Wavetronix sensor on sign D 5 – 5.5 feet. • Installed an antenna for the handheld radio on the outside of the cabinet at sign D.
March 21, 2007 WYDOT / UW	• Adjusted the camera's view by zooming out and repositioning the camera on its mount. • Configured the DVR to record between 6:00 and 21:00 every day.

	• Replaced the serial ticker-tape printer with a laptop. • Configured all of the PT-210M units with a sensitivity of 4 for the infrared sensors and 5 for the geophone sensors. • Configured all of the PT-210M units with a 5 second qualify time, except units 1, 5, and 11, which were programmed with a 2 second qualify time.
April 10, 2007 UW	• Synchronized the clocks on the Wavetronix sensors. • Configured PT-210M units 1, 11, and 5 with a sensitivity of 3 for the infrared and geophone sensors.
June 22, 2007 UW	• Replaced the DX4000 with the DX1000. • Confirmed that the laptop was recording data from the handheld radio properly and downloaded data from laptop.

5.1.7 State of System as at end of Spring 2007

The Trapper's Point wildlife detection system is configured as follows as of the end of Spring 2007:

- All PT-210M units are located within the center of the project area (Figure 5-1).
    - One infrared sensor and one geophone string are attached to each transmitter, except sensor number 19.
- PT-210M units 1, 11, and 5 are programmed with a sensitivity of 3 for the infrared and geophone sensors and a qualify time of 2 seconds.
- All other PT-210M units are programmed with a qualify time of 5 seconds, and sensitivity of 4 for the infrared sensor and 5 for the geophone sensor.
- The Pelco DX4000 DVR is recording video between 6:00 and 21:00.
- The three Wavetronix SmartSensor HD units are recording traffic data in 10 second bins.
- All detection events are being recorded by the laptop, which is plugged into the handheld radio, and the Pocket PC, which is plugged into the RP-3000 at sign D.
- Sign A has not been covered up, but is not flashing.

- Signs B, C, D, and E are flashing when a detection is recorded from particular sensors.
    - Sign B monitors sensors 1 – 18 and 25 – 30.
    - Sign C monitors sensors 1 – 16 and 25 – 28.
    - Sign D and sign E are configured to flash when a detection is received from any zone.

5.1.8 Suggested Modifications as at end of Spring 2007

During the site visit on October 20th, 2006, representatives of Telonics recommended that the infrared scopes be checked, twice a month, for proper alignment and tight fasteners. They also recommend that a walk test be performed twice a month to ensure that the infrared sensors are working properly. Figure 5-6, when compared with Figure 5-5, shows a sudden increase in the number of detections from zone 25. Since no modifications were made to the configuration of unit 25, this sudden increase is likely to be the result of a sensor that has been knocked out of alignment. Each infrared sensor is held to its post by two bolts: one that prevents the sensor from rotating left and right, and one that prevents the sensor from tilting up and down. High winds, therefore, could easily rotate the sensors out of alignment if the bolts are not kept tight. Regular maintenance and inspections must be performed to ensure proper alignment.

More data should be collected from the handheld radio, Wavetronix speed sensors, and the digital video recorder to determine the configuration changes that should be made to each PT-210M unit to minimize false detections. Preliminary data appears to suggest that false positives may be caused by passing traffic and the time of day. Filters should be installed on every infrared sensor to attempt to minimize the effect of the rising or setting sun. If this is not sufficient, particular PT-210M units, which have been determined by data analysis to be sensitive to low-angle sunlight, may be disabled during certain times of the day. This will keep false positives to a minimum, but may increase the number of false negatives, especially since deer are known to be most active during dawn and dusk.

Find a way to remotely monitor the three Wavetronix SmartSensor HD units or download data from the sensors more often. Downloading two weeks' of data from the sensor currently takes more time than is available. The amount of time required to download could be reduced if these downloads occur more often, such as once a week. Data from the laptop attached to the handheld radio and the DVR can be downloaded during these visits, too. The sensors also have the capability of being remotely monitored over a telephone connection. Researchers could download traffic data from their office. The clocks on the Wavetronix sensors could also be easily and routinely synchronized over a remote connection or during frequent site visits.

Correct the problem with the Wavetronix SmartSensor HD located at sign D. Traffic volumes recorded at sign D do not match those recorded at sign B. Also, classifications, based on the length of passing vehicles, do not match between the two sensors. This is likely to be a problem with the climbing lane located near sign D. The sensor at sign D should be moved further south to eliminate this error. This will require the installation of an additional pole to hold the sensor. If this cannot be done, another type of traffic recording device, such as a pneumatic counter, can be used to record vehicle speeds in place of the Wavetronix SmartSensor.

Ensure that every sign can reliably receive signals from every PT-210M transmitter. On March 16th, 2007, technicians from Transcore ITS checked the radio reception and commented that they had done this procedure before. Unfortunately, in the current state, sign C flashes when unit 24 makes a detection but sign D does not, even though sign D is much closer to unit 24 (Figure 5-1). Sign D is not visible from unit 24 because of a hill, but sign C is visible. It may be necessary to make use of the repeating function of the RP-3000 units present at each sign. The RP-3000 at sign C, for example, could be configured to repeat any signal that it receives. Signs with radio reception problems, such as sign D, could be configured to listen to the repeated frequency from sign C rather than the transmit frequency of the PT-210M units. The output power of the RP-3000 repeaters is twice that of the PT-210M transmitters, which should enable the repeated signal to be heard along the project length even when the PT-210M signal is not.

Troubleshoot and correct the problem with the RP-3000 units that requires them to be periodically turned off and turned back on to function properly. The flashing lights will not operate reliably if this problem persists.

Determine a way to periodically synchronize the clocks on the handheld radio, DVR, and Wavetronix SmartSensor HD units. Error should be minimized if the clocks are synchronized during every site visit. Site visits should be performed weekly to keep download times from the Wavetronix sensors to a minimum. Since the Wavetronix sensors are recording data in 10-second bins, however, it is imperative that the clock synchronization be accurate to the second. This process could be aided with a remote connection to the Wavetronix sensors.

Connect the handheld radio to feed the laptop computer and the serial printer for redundancy. The printer will also need to be stocked with paper and additional ink cartridges. A 9-pin serial cable splitter and several other wires will also need to be purchased.

Cover or remove sign A. The Wavetronix sensor which is mounted on sign A is intended to record the speed of vehicles before they are exposed to the signs or the flashing lights. The sensor could also be removed from the sign and moved upstream of southbound traffic.

The sensors may be too close to the road. During a site visit, UW researchers witnessed a deer-vehicle collision involving a tractor-trailer truck and a small herd of deer. The collision was also recorded on video. Deer were peacefully walking and lounging on the side of the road, but were too far from the sensors to be detected. When the truck neared, the deer sprinted towards the highway. The warning signs began to flash only a second or two before the truck collided with a deer. If the sensors had been installed closer to the right-of-way, the system would have detected the deer much earlier. Much more study would be needed to determine whether varying the sensors' distance from the travelled way has an effect on the DVC rate.

The following is a summarized list of the suggested modifications described above:

- Perform routine checks of the alignment of the infrared sensors.
- Install filters on all of the infrared sensors.
- Collect more data to correctly configure the sensitivity and qualify time of each PT-210M.
- Disable troublesome PT-210M units during specific times to reduce false detections caused by sunlight.
- Limit the long download times from the Wavetronix SmartSensor HD units by remotely monitoring the units or performing more frequent (once a week) site visits.
- Move the Wavetronix sensor on sign D to a point downstream of southbound traffic to prevent difficulties caused by the climbing lane.
- Ensure that every sign can reliably receive signals from every PT-210M transmitter.
- Troubleshoot and correct the problem with the RP-3000 sign receivers that requires them to be periodically switched on and off to function properly.
- Determine a way to accurately and frequently synchronize the clocks on the DVR, Wavetronix sensors, and handheld radio.
- Attach the serial printer to the handheld radio, along with the laptop computer, for redundancy.
- Cover or remove sign A.

1.1 System Modifications from Fall 2007 through Summer 2008

As mentioned in the introduction to this chapter only minor modifications were made to the system after the Spring of 2007 to determine how well the system would work under with only routine maintenance. The following is a list of modifications made from Fall 2007 through the Summer of 2008.

The wildlife detection system was sent to Telonics in the Fall of 2007 for annual calibration. The system was reinstalled in late September of 2007.

During late September of 2007 it was noted by WYDOT personnel that detector number 13 was going off repeatedly. This sensor was turned off and left deactivated for the remainder of the Fall.

During the spring of 2008 the radio malfunctioned and was not sending data to the hyperlink program. New radios were order by WYDOT but were slow in being received. The radios were replaced early summer and the system is once again collecting data.

During the April 5th site visit, the Pelco DX 1000 DVR was brought back to Laramie for data retrival. It was found at that time that a large portion of the hard drive had been corrupted, and according to Pelco, there was no way to repair the unit. This DVR was removed from service. The Pelco DX 4000 was brought back to Laramie during the May 13th, 2008 visit and since there was no replacement DVR, the project was left without video. The Pelco DX 4000 was returned to Trapper's Point on September 8, 2008.

5.2 System Modification Summary

As can be seen from this chapter, particularly in section 5.1, the Trapper's Point system has encountered numerous technology issues since its installation in the fall of 2005. The system requires extensive oversight by personnel familiar with the system, which is made difficult by its remote location. Any recommendations regarding the fate of the Trapper's Point system as well as recommendations regarding installation of additional systems will need to take this in to consideration. As documented in this chapter, the manufacturer recommends site inspections every two weeks, and given what was observed by researchers this is likely the ideal maintenance schedule.

CHAPTER 6: DATA ANALYSIS

This chapter describes the analysis methods used to determine whether the wildlife detection system can reliably detect wildlife, whether the Trapper's Point driver warning system has an effect on driver behavior, and whether the system is effective in reducing animal-vehicle collisions.

6.1 Effectiveness of the Wildlife Detection System

The effectiveness of an active, wildlife-sensing driver warning system at modifying driver behavior is dependent on how reliably the system can detect the presence of wildlife. If the wildlife detection system suffers from too many false positives, drivers will become accustomed to seeing the signs flash without seeing deer and will lose respect for the system. If the wildlife detection system suffers from too many false negatives, drivers will lose respect for the system because the lights are never flashing when they see deer. The loss of respect in both cases will diminish the usefulness of the system at preventing deer-vehicle collisions. A successful, active wildlife-sensing driver warning system will have few false detections and therefore demand respect from drivers.

Huijser, et al., determined that only 47% of the detections by an active wildlife-sensing driver warning system installed in Yellowstone National Park were the result of animal activity (2006). Gordon, et al., found that the geophone and passive infrared system at Nugget Canyon had very few false detections (2001). Both systems were considered effective at detecting wildlife although there are no universally-accepted false detection thresholds that define an effective system. The technology used to detect wildlife and the conditions at each site (road width, traffic, wildlife species of concern, etc.) vary between each system, too. This makes comparison between systems difficult. The system at Nugget Canyon, for example, used the same technology as the system at Trapper's Point, but the two systems have vastly different results in terms of false detections. The size of the system at both locations is also quite different.

6.1.1 Methodology

Determining the effectiveness of the animal detection system is a matter of counting the number of false detections. There are two types of false detections: false positives and false negatives. A false positive occurs when the system records a detection due to something other than wildlife.

False Negatives

A false negative occurs when the system fails to detect large wildlife. The system is not expected to detect every animal that crosses the road, that is, there will not be a recorded detection for each individual animal. Instead, the system is designed to detect "crossing events" that may involve either single animals or several animals in a group. The definition of a crossing event, for this study, is a crossing that involves one or more animals in quick succession. The lights will flash for thirty seconds regardless of whether the animal detection system detects the presence of one deer or an entire herd. The signs are not configured to extend the flash time if a detection is made while the lights are already flashing.

For each day of available DVR data, the time periods corresponding to the daylight times were divided into 30-minute periods. Using a random selection methodology, between 5 to 30% of the 30-minute periods were reviewed, depending on the data availability. A time period was tagged as having a false negative if an animal was viewed within the detection area on the DVR but the system was not activated. Since the original video files were too large to store a DVR monitoring sheet was used to log the results of the DVR reviewing process. A copy of one of these sheets can be found in Appendix F.

During the October 20, 2007 site visit, two graduate student research assistants examined the use of a night vision scope to test the system for false negatives. The researchers returned to the project area at dusk and viewed the site for wildlife activity for a one-hour period using the night vision scope. It was determined that this approach would not be a viable approach for determining false positives both because of the amount of time it took but also because the headlights of passing cars made the night vision scope ineffective for significant periods of time. The scope also had a limited viewing range.

False Positives

False positives were analyzed by comparing the detection data to the DVR data to determine if a detection was the result of animal activity. First the overlapping time periods between the DVR data and the detection data was determined from each site visit. Detections during non-daylight hours and from zones outside of the camera view field were excluded from the analysis. Using random selection methodology, a subset of the remaining detections were identified and a tagged for review. A three minute period of video surrounding the detection time stamp was reviewed to determine if there were any visible animal activity in the detection zone. If animal activity was confirmed in the video the detection was tagged as a verified detection. If no animal activity could be seen the detection was tagged as a false positive.

6.1.2 Results

False Negatives

Table 6-1 gives a summary of number of false negative analysis results for the three available time periods of DVR data. For spring 2007 and fall 2007 periods, the number of false negatives found in the reviewed data was zero, although it must be noted that only 5 to 10% of the available data was reviewed. For spring 2008 period, eight 30-minute periods were reviewed per day for 9 days for a total of 72 review periods. Among the nine days of reviewed DVR data, the number of false negatives were distributed evenly with two periods each day containing false negatives for a resulting false negative percentage of slightly less than 20%. As stated previously there is no set standard for an acceptable level of false negatives but the results shown in Table 6-1 appear to indicate that the system has a low occurrence of false negatives. It should be noted that the Spring 2008 period, which corresponded to the lower system maintenance level described in Chapter 5, had the highest false negative rate.

Table 6-1: False Negative Results

Time Period	# of days Reviewed	# of 30-Min. Periods Reviewed	% of False Negatives (# of False Negatives)	% of True Negatives (# of True Negatives)
Spring 2007	4	10	0% (0)	100% (10)
Fall 2007	2	6	0% (0)	100% (6)
Spring 2008	9	72	19.4% (14)	80.6% (58)
Average	5	29.3	6.5%	93.5%

False Positives

Table 6-2 summarizes the false positive analysis results. Due to issues with the system (see chapter 5), there were no overlapping detection and DVR data for the spring 2008 period with which to conduct a false positive analysis.

Table 6-2: False Positive Results

Time Period	# of days Reviewed	# of 30-Min. Periods Reviewed	% of False Positives (# of False Positives)	% of True Positives (# of True Positives)
Spring 2007	3	38	86.8% (33)	13.2% (5)
Fall 2007	2	30	100% (30)	0% (0)

Spring 2008	Data not Available			
Average	2.5	34	92.7%	7.4%

As the results in Table 6-2 illustrate, false positives are a problem with the Trapper's Point system with the percentage of periods with false positives being 95% or greater. The wildlife detection system has been witnessed, during both site visits and through DVR video monitoring, to be reporting more false positives during sunrise and sunset than any other time periods during the day. Furthermore, the configuration and calibration of the system has a large effect on the false positive detections. For instance, on Sep. 28th 2007, approximately 90% of the false positive detections came from sensor 13, which was malfunctioning and later turned off. One malfunctioning sensor can create a large percentage of false positives. One issue with the Trapper's Point system is the remoteness of the location. Malfunctioning sensors can go undetected for long periods, resulting in many false positive readings in the data retrieved during the infrequent site visits.

Once again, there is no set standard for an acceptable level of false positives but the results shown in Table 6-2 appear to indicate that the system has a very high occurrence of false positives. It should be noted that the Fall 2007 period, which corresponded to the lower system maintenance level described in Chapter 5, had the highest false positive rate.

6.2 Effect on Driver Behavior

The ultimate goal of the wildlife-sensing driver warning systems is to make drivers more aware when wildlife is present on the road. Ideally, greater awareness will cause the driver to slow down, which in turn will allow the driver more time to react to the presence of wildlife, and potentially reduce the likelihood of a deer-vehicle collision. Active signage, such as the Trapper's Point system, will only activate when wildlife has been detected. Drivers should have a stronger reaction to active signage than passive signage, such as the standard W11-3 deer crossing signs. In a study by Utah State University, significantly fewer deer-vehicle collisions were recorded in areas with signs that were only utilized during known migration periods (Sullivan, et al. 2004). Studies have shown that drivers will habituate to signs unless they are reinforced with evidence that a hazard exists (Putman, Langbein and Staines 2004). The value of a sign as a driver warning tool diminishes as drivers become accustomed to the sign. The system at Trapper's Point, therefore, was designed to catch the driver's attention and earn the driver's respect by only flashing when a deer was actually detected on the roadside.

6.2.1 Methodology

Speed was selected as the measure of effectiveness of the driver warning system at Trapper's Point on driver behavior. Vehicle speed was monitored using three Wavetronix SmartSensor HD units, which are described earlier in this report. Originally, data from the three sensors was going to be compared to determine whether individual drivers had changed their speed after being exposed to the signs. The speed at each of the three sensors, the condition of the sign at the time (flashing or not flashing), and the presence of deer would be recorded for each individual vehicle that passed through the study area. Unfortunately, due to limitations of the Wavetronix sensors and difficulties with data collection that were described earlier, this analysis was not possible. An alternative methodology had to be developed to overcome the technology issues.

The speed data available within the study period is listed back in Table 4-1. Speed data must be associated with data that indicates when the flashing signs were activated to determine whether the system has an effect on speed. All three Wavetronix SmartSensor HD units were configured to record data in ten-second bins. The volume and average speed data from these sensors were used in this study. Determining whether there was an effect on driver behavior was accomplished by statistically comparing the average speed during each half hour period for a particular sensor to the number of times that the flashing lights were activated during that half hour. If driver behavior was influenced by the activation of these signs, the average speed should be correlated to the number of times the signs were activated. If driver behavior was not influenced by the signs, there should be no correlation. The question that this analysis will answer is: on average, are the speeds recorded at each sign (A, B, and D) during a half hour period different when a high number of detections by the animal detection system are recorded during the same half hour period? The null hypothesis is that the average speed per half hour at each sign is not affected by the number of detections by the animal detection system during the same half hour period. The number of detections, in this study, is assumed to be equal to the number of 30-second periods for which the flashing lights were activated. A half hour period of analysis was chosen since it was long enough that the clock differences were negligible and short enough to be reasonably confident that the road conditions were constant throughout the period.

Another issue that complicates the analysis is the fact that the roadway does not have a constant grade in the corridor. There is considerable upgrade between speed sensors A and C, which will result in lower speeds at those two sensors. Still, the speeds at these two points should be reduced when the signs are activated when compared to the speeds when the signs are not activated.

Microsoft Excel was used to transform the raw data from the Wavetronix sensors into useful data for statistical analysis. The first step was to calculate the average speed at each sensor during each half hour period. Excel was used to calculate a weighted average speed for each half hour period by multiplying the volume during each ten-second bin by the average speed during that ten-second bin, summing those values, and dividing by the total volume during the half hour. Moving half hour periods were not used. Instead, the average speed was calculated for 3:00:00 through 3:29:59, 3:30:00 through 3:59:59, 4:00:00 through 4:29:59, and so on. The times reported by each sensor could not be corrected for clock variations.

The work of transforming the data from the handheld radio was also performed in Excel. The laptop attached to the handheld radio recorded the number of times that the sensors were tripped and not the number of times that the flashing lights were activated. Every sign, except sign A and sign F, were set to flash for thirty seconds whenever a particular RP-3000 received a signal from a PT-210M which met the RP-3000's unique ID requirement, described in chapter 4. If another signal was received while the signs were already flashing, the flashing time would not be extended. In order for the signs to flash for more than thirty seconds, another signal would need to be received thirty seconds after the signal that set off the signs. Therefore, it was necessary to eliminate detection events from the data recorded by the laptop and the handheld radio that occur within thirty seconds of the last detection event. This produces a list of detection events that should match the number of times that the flashing lights were activated.

Unfortunately, since the handheld radio is independent of the RP-3000 units, there is no way to confirm whether the lights were actually flashing at a particular time or not. A curious problem with the RP-3000 units, which requires the units to be periodically turned off and back on, along with problems with radio reception, which are both described in chapter 5, may prevent the signs from flashing. Despite these problems, the signs were assumed to flash whenever a signal from an appropriate PT-210M transmitter was received.

Linear regression models were run on each day's data using each half-hour period's average speed as the dependent variable. To account for changes in speed due to lighting conditions, a binary variable was included to account for daylight versus nighttime conditions. In addition, the number of detections per half hour was included.

Lighting condition was included as a predictor variable because it appears, from experience during site visits, that the animal detection system is more sensitive to passing traffic at times when the sun is low on the horizon. This phenomenon is described in more detail in chapter 5. Also, drivers cannot see as well at night compared with the day and are likely to drive slower. This natural change in speed must be taken into consideration.

Civil twilight is defined as the amount of light that is necessary for outdoor activities to commence. This should allow enough light for drivers to feel comfortable driving at their normal daytime speed. For example, according to the U.S. Naval Observatory , the beginning of civil twilight occurs at approximately 6:20 at Pinedale in the month of April in 2007. Sunrise, sunset, and the end of civil twilight occur at approximately 7:00, 20:00, and 20:30, respectively. For simplification, only two lighting conditions were used in this study. "Day" would begins at 6:30 and ends at 20:00. "Night" describes all times in-between. Day is expressed as a value of 1. Night is expressed as a value of 0. This variable was calculated for the varying light conditions for each day of data.

The linear model that will be studied, therefore, takes the following form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where β_0 is the base average speed at a particular sign (or intercept), X_1 is the total number of detections in each half hour period, X_2 is the lighting condition (1 or 0), ε is the error term, and the β_x variables are the estimated regression coefficients. The least squares method and the SAS computer software were used to fit the model to the data.

6.2.2 Results

Table 6-3 summarizes the results of the individual regression models that were run for each day for each sensor for the available data. Most of the p values (shown in the right-hand column) are large, but some are small, and therefore, significant. At the 95% confidence level (α=0.05), six of the twelve linear models are significant (shown in Bold in the table) since the p-value was found to be less than 0.05. The complete statistical input for each of the models can be found in Appendix D. The output for each of the models included the estimated coefficients included in Appendix E.

Table 6-3: Average Speed Results

Model #	Begin Date	End Date	Sensor Location	R^2	Pr > F
1	**04/08/2007**	**04/10/2007**	**Sign D**	**0.199**	**0.0002**
2	04/08/2007	04/10/2007	Sign B	0.059	0.0955
3	**04/11/2007**	**04/12/2007**	**Sign D**	**0.652**	**< .0001**
4	**04/11/2007**	**04/12/2007**	**Sign B**	**0.294**	**0.0054**
5	**09/28/2007**	**09/29/2007**	**Sign A**	**0.250**	**0.0013**
6	09/28/2007	09/29/2007	Sign B	0.055	0.2715
7	09/28/2007	09/29/2007	Sign D	0.202	0.6070
8	**10/14/2007**	**10/16/2007**	**Sign A**	**0.066**	**0.0431**
9	10/14/2007	10/16/2007	Sign B	0.005	0.7955
10	10/14/2007	10/16/2007	Sign D	0.002	0.9230
11	**04/21/2008**	**04/23/2008**	**Sign B**	**0.479**	**0.0012**
12	04/25/2008	04/26/2008	Sign B	0.215	0.2355

The results indicate that the system had a greater effect on driver speeds during the earlier data collection periods. This could be due both to the fact that the system was newer to the drivers, although by spring of 2007 the system had been in place for almost a year and a half. As mentioned previously, the sensor at sign A measures speeds of the vehicles at the beginning of the project area, Sign B at the midpoint, and sign D at the end. Both regression models for sign A were statistically significant. The results for signs B and D were mixed with two of the six models (33%) for sign B and two of the four models (50%) for sign D showing a statistical correlation. In general, the results indicate some correlation between the number of system detections and average speeds in the project area, although the relationship is not as strong as is likely desirable.

One of the concerns with the system is that the passing traffic is causing false detections. To test this assumption the number of detections versus traffic volume was graphed for the Spring 2007 data and can be seen in Figure 6-1. Zones 1 and 25 had the largest number of detections for the time period and are graphed separately along with the total detections for all zones. A positive linear relationship can be seen from the figure and indicates that the system likely has problems differentiating between true wildlife detections and passing vehicles.

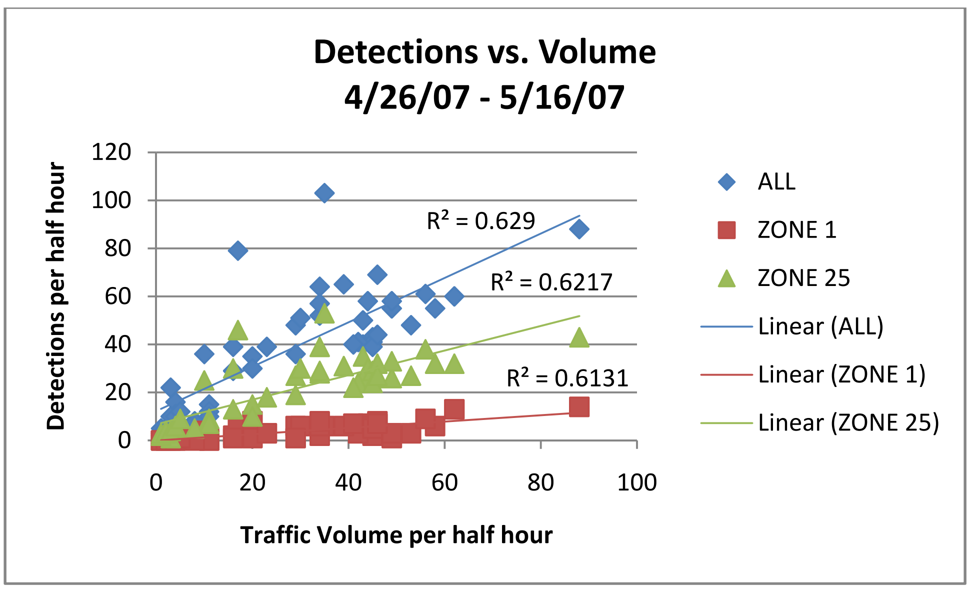


Figure 6-1: Number of Detections vs. Traffic Volume

6.3 Effect on Crash Rates

The ultimate goal of the wildlife detection and driver warning systems is to reduce the number of total and vehicle-wildlife crashes on this stretch of roadway. This requires two to three years of crash data with the system in place to make statistically significant statements about the effectiveness of the system. This section will look take an interim look at crash rates on the corridor to see if the effect of the system on crash rates is discernable at this time.

6.3.1 Methodology

As mentioned previously, reported crash data from the Wyoming Department of Transportation has been compiled from 1995 through 2007 for US 191 between mileposts 105.5 and 106.9. Forty-one total crashes were reported for this section of road, 30 of which involved collisions with animals.

The first part of the crash analysis will look at the total crash data set. This analysis will look for discernable trends in the data. The second part will perform a before and after statistical analysis. Since the system was installed in the Fall of 2005, there are two full years of data available with the system in place. Crashes from 2006 and 2007 will be aggregated into the "After" data set. Crashes from 2003 and 2004 will be aggregated into the "Before" data set. The methodology for determining the system's effect on crashes will consider both the crash frequency and crash rate as well as considering additional factors relevant to the corridor, such as changes in traffic volumes and wildlife populations during the crash analysis period. Both the overall crash rate and the animal-vehicle crash rate will be analyzed. An analysis similar to the analysis used by Young and Vokurka (2007) will be used to determine whether crash rates at Trapper's Point have statistically significant changes since the system was installed.

To take traffic volume into account, the number of crashes per million vehicle miles travelled (MVMT) will be calculated. MVMT will be determined using the AADT reported in the Wyoming Department of Transportation's "Automatic Traffic Recorder Report" for each year. The AADT will be multiplied by 365 days to determine the total number of vehicles that entered Trapper's Point during each year. This will then be multiplied by the length of the project, 1.36 miles, and divided by one million to determine the MVMT. When the number of crashes that occurred is divided by the MVMT, the result is the number of crashes per million vehicle miles travelled.

Wildlife populations can be taken into account by dividing the number of animal-vehicle crash rate for a particular year by the estimated population of antelope and deer in the area during that year. Population estimates are divided by 10,000 animals to keep to results in a similar scale to the other analyses. Wildlife populations will be determined using the same data and geographic regions explained in chapter 3. Only antelope and deer populations are considered since there were no reported crashes involving elk and moose during the study period.

The statistical method chosen for the before and after analyses is based on the assumption that the count of crashes obeys the Poisson Probability Law, which requires that the variance and the mean are equal. This test is commonly applied to crash data since it allows for the probability of rare events (such as crashes) to be determined when given a rate of occurrence.

Lastly, it is well understood that animal-vehicle crashes are underreported events. Carcass removal data can be used to supplement reported crash data to provide additional information about the number of crashes occurring in the area. WYDOT maintains a database of carcass removals reported by maintenance crews on state highways. The issue with carcass removal is that the reporting is highly dependent on the workload and reporting practices of individual maintenance crews and can vary greatly from one time period to the next. Regardless of these issues, carcass data does provide additional insight.

6.3.2 Results

Forty-one total crashes were reported in the study section, 30 (73%) of which involved collisions with animals. Figure 6-2 shows the number of reported traffic crashes involving animals (deer, antelope, and cattle) on US Highway 191 between mileposts 105.54 and 106.90. The line shown in the graph is a three-year moving average. Based on the moving average, the number of DVCs appears to be fluctuating between one and just over three crashes per year with an increasing trend in crashes from 1999 to 2002 and a recent decreasing trend. When considering simple crash statistics, such as those shown in Figure 6-2, it is important to remember that there is considerable variation in crash data. Sudden increases and decreases from year to year should not be interpreted directly. A moving three-year average is one method for "smoothing" the variation in the data.

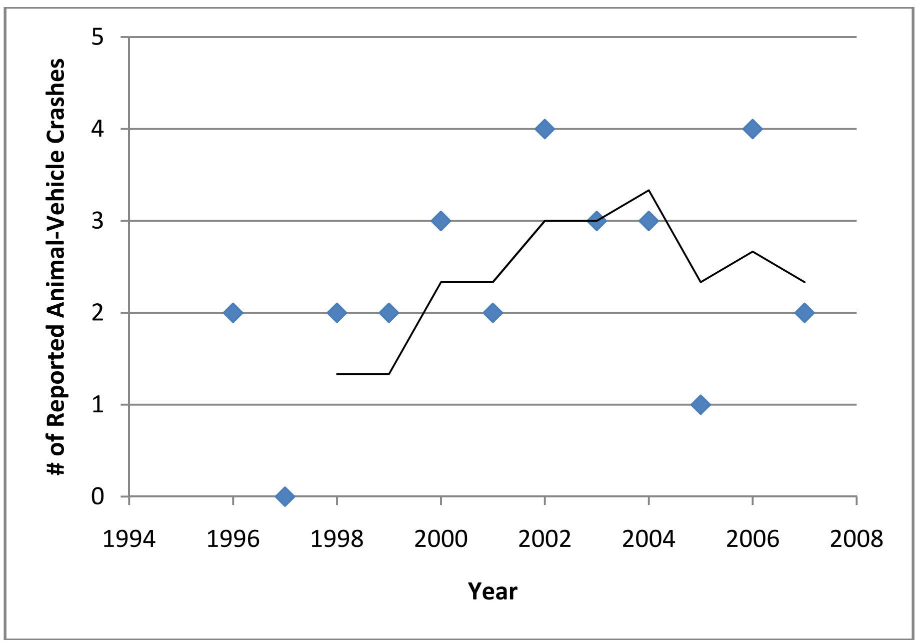


Figure 6-2: Number of Reported Animal-Vehicle Crashes on US 191 between MP 105.54 and 106.90

Figure 6-3 is similar to Figure 6-2 except that is uses the total reported crashes instead of just animal-vehicle crashes for the study corridor. The three-year moving average is also shown for the data. Looking at this average there appears to be a steadier trend in the total crash frequency as opposed to the animal-vehicle crash frequency.

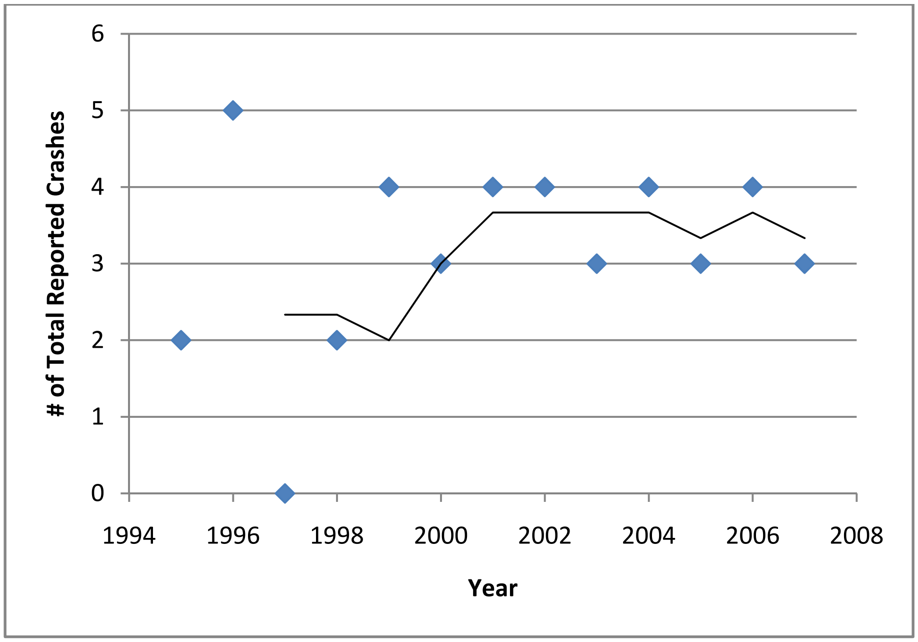


Figure 6-3: Number of Total Reported Crashes on US 191 between MP 105.54 and 106.90

Crash rates (i.e. number of crashes per million vehicle miles traveled) instead of crash frequencies (i.e. number of crashes) accounts for changes in traffic volumes over the study period. It is reasonable that increased traffic results in increased interaction between the animals and vehicles and crash rates and a crash frequency analysis considers this. To convert the crash frequency values into crash rates, the average annual daily traffic data from the permanent traffic counter at mp 110 and the segment length were used to determine the estimated annual vehicle miles traveled in millions of miles (MVMT). The crash frequency values was then divided by the MVMT to determine the crash rates.

Figure 6-4 shows the results for animal-vehicle crashes and Figure 6-5 shows the results for total crashes in the study corridor. These figures show similar trends that were seen in the frequency analysis (Figures 6-2 and 6-3) except with a slightly more pronounced downward trend in last four years for the animal-vehicle crashes. For the total crashes, the steady trend seen in the frequency analysis (Figure 6-3) over the last seven years is shown as a downward trend in the total crash rate analysis (Figure 6-5), which makes sense given that the number of crashes is holding relatively steady during this period even though the traffic volumes are increasing.

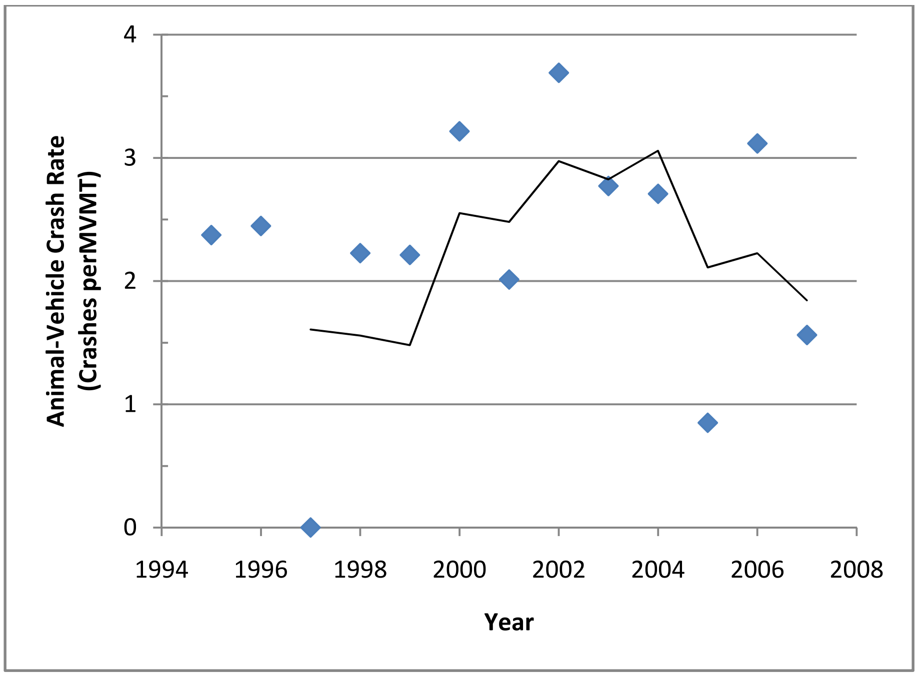


Figure 6-4: Animal-Vehicle Crash Rates on US 191 between MP 105.54 and 106.90

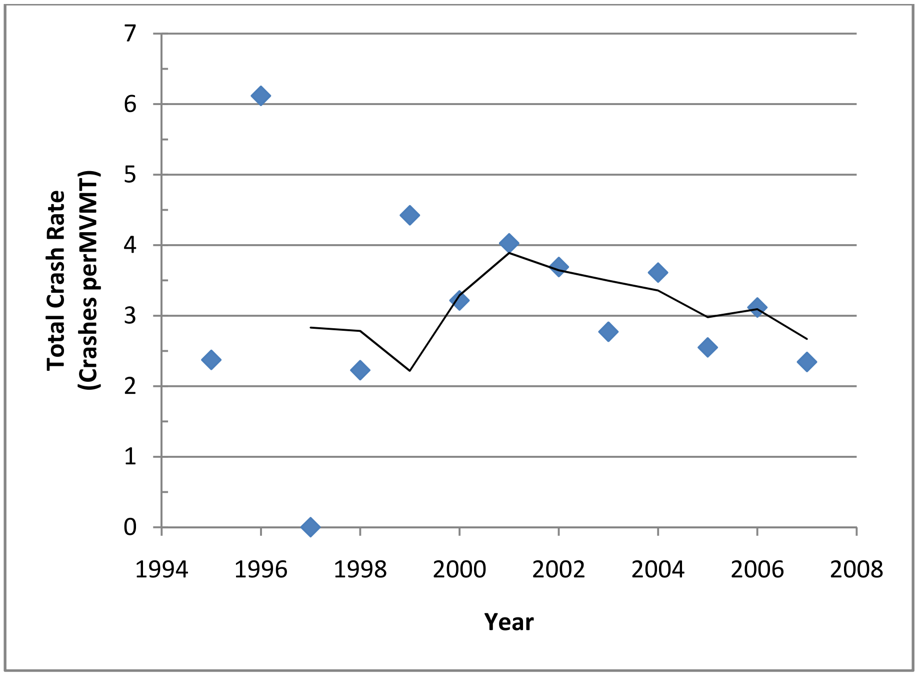


Figure 6-5: Total Crash Rates on US 191 between MP 105.54 and 106.90

Similar to the belief that increased traffic volumes lead to increased animal-vehicle crashes, there is likely to be higher animal-vehicle crashes if there are increases in the animal populations. To account for changes in the animal populations, herd population estimates provided by the Wyoming Game and Fish were used. The crash rate data shown in Figures 6-4 and 6-5 were divided by the herd estimates for the same time period. Since crash rates were used this analysis considers both the change in traffic volume and the change in animal population. The results are graphed in Figures 6-6 and 6-7 and show that, even after accounting for herd population changes, the trends shown earlier remain.

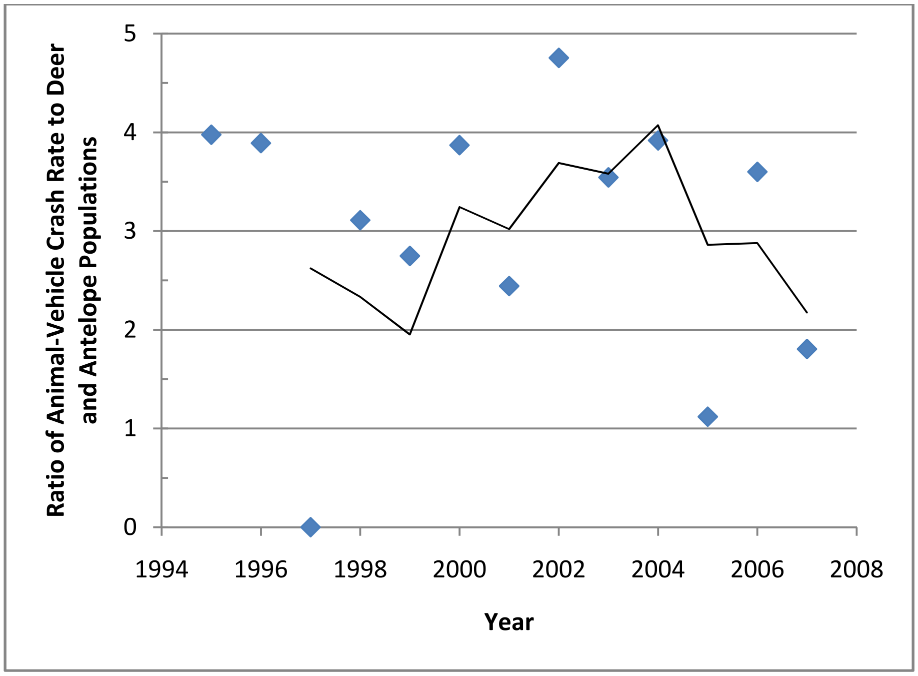


Figure 6-6: Ratio of Animal-Vehicle Crash Rate to Herd Population on US 191 between MP 105.54 and 106.90

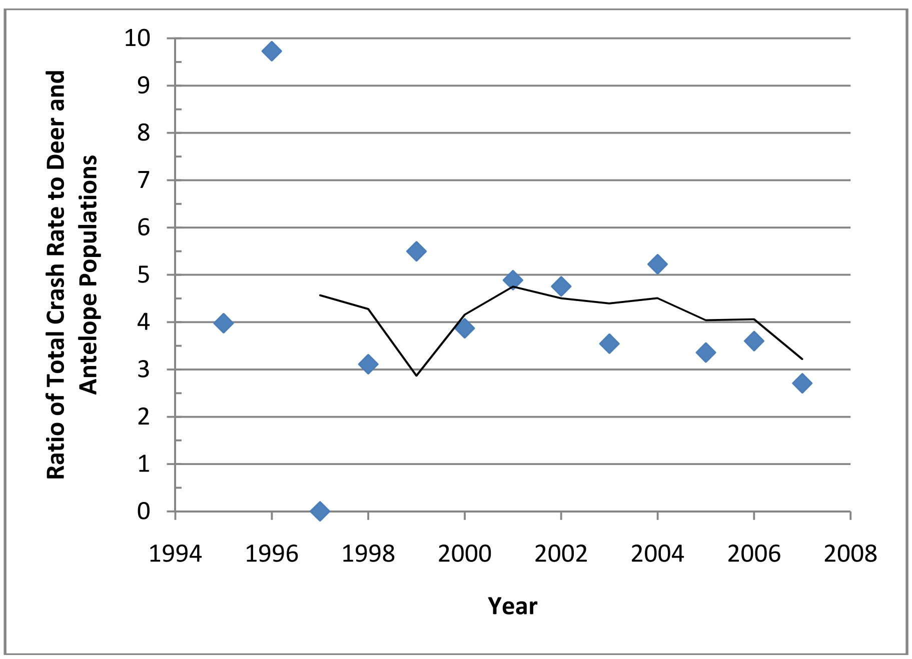


Figure 6-7: Ratio of Total Crash Rate to Herd Population on US 191 between MP 105.54 and 106.90

The animal-detection, vehicle warning system at Trapper's Point was installed in the Fall of 2005. Looking at the two data points available since the system was installed in Figures 6-2 through 6-7, the issue of data variability becomes apparent. If you consider only those two points you could conclude that the system is reducing crashes. But if you look at the entire thirteen years of data the picture is less clear. Therefore, in order to make definitive statements about the system's effectiveness the use of statistical tests are necessary.

As mentioned in the previous methodology section, a before and after analysis based on the Poisson distribution will be used to determine whether the true mean of the number of crashes per MVMT before 2005 is significantly different from the true mean of the number of crashes per MVMT after 2005. The calculated p-value is the probability of getting our observed differences between the before and after period given that there was no real effect associated with installation in the system (i.e. the null hypothesis). The high p-value for our data (see Table 6-4) indicate that there is no statistical reason to reject the null hypothesis indicating that there is not a statistically significant difference between the before and after period. Low p-values would indicate the opposite.

Table 6-4: Before and After Probability Test

	Animal Crashes	Total Crashes	MVMT	Animal Rate	Total Rate
Before (2003-2004)	6	7	2.1896204	2.740200996	3.196901161
After (2006-2007)	7	7	2.5629132	2.731266904	2.731266904
			Numerator	0.008934092	0.465634258
			Denominator	1.522019834	1.579474627
			Test Statistic	0.005869892	0.294803253
			2-tailed normal p-value	0.995	0.768

Statistical analyses of crash data strengthen the more data that can be analyzed. The two years of crash data used in this analysis is the minimum amount suggested for this type of statistical test. This type of analysis should be performed at a future data when more data becomes available.

Carcass removal records from June 2004 through December 2007 was compiled as part of this research effort. For the year 2005 there was a change in format so a complete data set is not available. As mentioned previously inconsistent reporting of carcass removal is always an issue with this type of data so making firm interpretations from the results can be difficult. Table 6-5 summarizes the number of carcass removals reported by WYDOT maintenance crews.

Table 6-5: Carcass Removals by Year and Species Type, 2004-2007

Year	Total Carcass Count	Deer Carcass Count	Pronghorn Carcass Count
2003	22	16	6
2004	23	23	0
2005	Incomplete Data Set		
2006	27	27	0
2007	36	32	4

If it could be verified that reporting practices were consistent for this time period it would be concluded that the time period before the Trapper's Point system was installed (2003-2004) has fewer animal-vehicle crashes than the time period after (2006-2007). Since this cannot be confirmed, it can only be noted that more carcasses were removed in the later period than in the earlier period.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses the conclusions and recommendations that were reached during this study effort. The first section describes the effectiveness of the wildlife detecting driver warning system at Trapper's Point in its current state. The second part recommends future actions that could be taken at the Trapper's Point site.

The Trapper's Point system was installed to test the use of a particular type of technology at reducing animal-vehicle collisions for a well established wildlife corridor. While the majority of the research focused on how effective the system worked for this particular location the research effort also provided more general insight that could be used for evaluating the use of a wildlife detection, active warning system in other areas.

7.1 Effectiveness of Trapper's Point System

The main objective of this research work is to investigate the effectiveness of the Trapper's Point Animal Detection System. To meet this objective the following major research tasks were proposed:

- Determine the success of the system to detect large game in the roadway vicinity.
- Determine the effect of the warning signs with flashing beacons on driver behavior.
- Determine the impact of the system on reducing vehicle-wildlife crashes.

Another major component of the project was to document the modifications and maintenance necessary to keep the system in working order.

7.1.1 Effectiveness of Wildlife Detection System

The wildlife detection system consists of 34 PT-210M processor / transmitter units and the geophone string and passive infrared sensor attached to each. The PT-210M units are configured to wirelessly report that a detection has been made when detections are reported by both the infrared sensor and the geophone strings. This configuration should eliminate the problems that are inherent with both types of sensors.

The effectiveness of the animal detection system was determined by the percentage of false positive and false negative detections compared with actual detections by monitoring the video recorded form the site visits. A false positive detection is defined as any detection that is caused by anything other than an animal. A false negative occurs when the system fails to detect the presence of an animal.

As described in the previous chapter, the Trapper's Point system was found to be reliable in detecting wildlife when analyzed for false negatives. The analysis showed there were only between 0 to 20% of the reviewed periods where wildlife was observed but no detection was recorded. However, the system did show problems with false positives with between 86% and 100% of the reviewed detections being considered as false since no wildlife was observed during the three-minute period around the recorded detection. One of the main issues with this observation is that frequently it was a single malfunctioning sensor that was causing the false positives. Unfortunately the remoteness of the site and lack of system monitoring made this a pervasive problem. There are no accepted standards regarding what an allowable amount of false detections is but the problem with false positives is well outside a reasonable acceptable value.

7.1.2 Effectiveness of Driver Warning System

The driver warning system consists of six "DEER ON ROAD WHEN FLASHING" signs with two flashing, yellow beacons fixed to the top. The beacons are configured to flash for thirty seconds whenever the wildlife detection system, described later, reports that it has detected the presence of wildlife. The beacons are activated by an RP-3000 repeater that monitors for wireless signals from the wildlife detection system.

All three Wavetronix SmartSensor HD units were configured to record data in ten-second bins. The volume and average speed data from these sensors were used in this study. Determining whether there was an effect on driver behavior was accomplished by statistically comparing the average speed during each half hour at a particular sensor to the number of times that the flashing lights were activated during that half hour. If driver behavior was influenced by the activation of these signs, the average speed should be correlated to the number of times the signs were activated. If driver behavior was not influenced by the signs, there should be no correlation between the average speed at a particular sign and the number of times that the sign was activated.

Linear regression models were run on each day's data using each half hour periods average speed as the dependent variable. To account for changes in speed due to lighting conditions a variable was included in addition to the number of detections per half hour to account for daylight and nighttime conditions.

The results in Chapter 6 indicate that the effectiveness of the system in modifying driver behavior through observed speed reductions when the system was activated may have had problems during the second study period. As mentioned previously, the sensor at sign A measures speeds of the vehicles at the beginning of the project area, Sign B at the midpoint, and sign D at the end. Both regression models for sign A were statistically significant. The results for signs B and D were mixed with two of the six models (33%) for sign B and two of the four models (50%) for sign D showing a statistical correlation. In general, the results indicate some correlation between the number of system detections and average speeds in the project area, although the relationship is not as strong as is likely desirable, this correlation seemed to weaken over the study period.

7.1.3 Effectiveness of System at Reducing Crash Rates

Lastly, and most importantly, the system was analyzed to determine whether it was impacting the number of animal-vehicle crashes in the area. When reviewing simple trend lines based on three year moving averages, there did appear to be a downward trend in the number of animal-vehicle crashes. This remained true even when considering changes in the traffic volume and changes in the herd populations. However, a before and after statistical analysis for a two-year period before and a two-year period after the system was installed did not find a statistically significant result in the number of crashes. When reviewing the carcass data reported by WYDOT maintenance crews, there appears to be an increasing number of carcasses in the project area.

7.1.4 Required System Maintenance

Chapter 5 documented the extensive adjustments and maintenance made on the Trapper's Point System throughout the research period. The first period of the research project involved more extensive adjustments to the system while the second period allowed the system to operate under more routine conditions.

Many of the adjustments documented in Chapter 5 were one time issues that were resolved but several important issues arose during the project that illustrate the maintenance commitment a system like this is for an agency. The following list summarizes the key maintenance issues that will be an on-going issue with the Trapper's Point system or any similar system:

- Sensor alignment and adjustment issues arise causing a particular sensor to be activated frequently. This can cause a significant number of false detections that lead to the warning signs being frequently or continuously activated. The system manufacturers recommend that adjustments be made on the system every two weeks.
- Snow cover over the geophones appears to make them insensitive and can cause the wiring strings to break.

- System detections appear to be highly correlated to traffic volumes, which mean that passing traffic, particularly heavy trucks, can be activating the system.
- Infrared sensors appear to be sensitive to sun angles and passing clouds. The east-west orientation of the sensors for this project likely makes this an even greater issue for this site than it could be for others.
- Lack of communication and the remote location of the site make detecting system errors difficult. While WYDOT personnel may be close to Trapper's Point the technology used requires knowledge and resources that may not be locally available. Without communication it is difficult to know when sensors are malfunctioning without visiting the site in person and looking at logs of the system detections.

As the list above illustrates, the maintenance commitment to the system is extensive. One reason the commitment for this particular system is so extensive when compared to other systems like the one used in Nugget Canyon is the length of the corridor and the number of sensors required. Roadway curvature can create additional problems with the roadside sensors picking up on passing traffic. The combination of roadway curvature and topography can cause complications with communications between system components. It is possible that installation of a similar system on a smaller scale and in a more ideal location could lead to a more reasonable maintenance requirement.

7.2 Recommendations for the Trapper's Point System

The following section makes recommendations about potential future actions for the Trapper's Point System. These recommendations are based on the findings in this report and on discussions between researchers and others involved with the system over the past several years in various capacities.

Possible futures for the system include maintaining the system in its current state, modifying the system, or completely removing the system. Each of these courses of actions has different alternatives associated with them and will be discussed below.

The first possibility for the Trapper's Point System is to leave it installed in its current state. As shown in this report the system has extensive maintenance requirements and it appears that the effectiveness of the system is related to the amount of maintenance effort put in to the system. If left in its current state, it would be recommended that WYDOT dedicate personnel to the maintenance task and ideally the personnel would be located near Trapper's Point. Adjustments to the system would be required every other week and ideally the system could be monitored on a more continuous basis to determine if sensors or other system components are malfunctioning. Maintenance on the system would be continuous but would be particularly intensive during the Spring and Fall migration periods. Related to that point, a second option would be to only activate the system during the Spring and Fall migration periods. At time other that the signs would be removed or covered. Animal-vehicle crashes do appear to be concentrated in the months of April, November, and December with over 77% of the reported animal-vehicle crashes occurring during those three months.

The second possibility for the Trapper's Point System is to modify the current system. This could involve partially deactivating the system to reduce the number of components requiring maintenance. It could also involve removing the geophones and using only the infrared sensors for detection or some combination of the two (i.e. reducing the scope of the system and removing some of the redundant components). If the scope of the system were to be reduced, exclusionary fencing along the deactivated portions would be necessary to funnel the animals to the detection area. While the geophones were found to be problematic in the system there were also problems with the infrared sensor due to sun angles and clouds. Further research into the existing system would be necessary to determine if the use of only one type of sensor would likely increase the system's reliability to acceptable levels.

The last possibility is to remove the Trapper's Point System in its entirety and pursue other animal-vehicle crash mitigation measures as discussed in Chapter 2. Potential mitigation measures include "break the beam" systems or wildlife overpasses or underpasses. While the effectiveness of the Trapper's Point System in its current state is likely unacceptable, the need for animal-vehicle crash mitigation measures at this location is well documented and no findings from this research effort can be used to debate this issue. Removal of the system without the addition of other mitigation measures is not recommended. Additional investigation into other mitigation measures is recommended before a particular measure is selected for this site.

The potential future actions for Trapper's Point are summarized in the six options listed below:

7. Keep system in its current state and operate year round with dedicated maintenance staff.
8. Keep system in its current state and operate only during spring and fall migration periods.
9. Reduce the scale of the system and use fencing to funnel the animals to the detection zones.
10. Remove the geophones and use only the infrared sensors for wildlife detection.
11. Use of other animal detection technology such as "break the beam" systems.
12. Use of a wildlife underpass or overpass.

The choice of future action should be made carefully and will most likely require additional study. The choice should be based on the resources of the Department and in consultation with local authorities and the Wyoming Game and Fish.

One recommendation from this research is clear in that the existing system should not be left in its current state without the required maintenance commitment. The system will continue to decline in effectiveness without this maintenance commitment.

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APPENDIX A

SITE VISIT REPORTS

- December 1st & 2nd , 2006
- February 22nd , 2007
- March 21st , 2007
- April 10th , 2007
- September 29th & 30th, 2007
- October 20th & 21st, 2007
- April 5th & 6th, 2008
- May 13th, 2008

Trapper's Point Animal Detection Site Visit

Prepared by: Steven Vander Giessen (UW)

Date: December 1st & 2nd, 2006

I met with Kevin Cox on site. He gave me keys for the control boxes and took me on a tour of the site. The northern and southern most signs do not have active detection between them and the next sign but the lights at these signs still blink when the system is tripped.

The three traffic sensors have been installed on existing sign posts. Extensions of the sign posts were not used, as expected, and performance is suffering. The sensors are installed on the top of the sign post furthest from the road. The sign may be interfering with the sensors' sight lines. Vehicle speeds are occasionally not recorded as a result.

Figure1: Speed Sensor Mounting Location

The radio receiver which is hooked to the receipt printer is not responsible for activation of the lights. Each control box below each sign is equipped with a similar radio receiver. Each junction box for each set of sensors has a radio transmitter. The lights are activated whenever a transmission is received. Settings for each of the sensor sets must be changed at *every* sensor junction pull box using the EIDS software installed on the Pocket PC. Only a couple of the northern sensor boxes are equipped with serial cables that are accessible without opening the pull box. These sensors are deactivated, however, since equipment was taken to correct problems with sensors in the middle of the project.

I installed the software for the speed sensors on the Pocket PC. Nothing appears to be different from the PC version. I also corrected the time on the speed sensors. The sensors have only filled 2% of their memory in the few weeks that they have been recording. The sensors should have plenty of space to record two weeks' of traffic statistics. They are currently set to record data in five minute bins. This is too long to be able to match speeds with the record of when the sign is activated, since the signs are currently set to flash for only thirty seconds. I recommend a bin size of ten seconds or less, but this may result in less storage capacity. Speed data is not entirely accurate right now due to the sign mounting issue anyway.

There are problems with the DVR. The hard drive is formatted in a non standard format which is unrecognizable by Windows. Video compression algorithms that came with the WinTV software and hardware are not sufficient to capture weeks' worth of video. A seven minute recording required more than a gig and a half of disk space.

The new camera has not been installed, either. The DVR's recording using the current low res camera can not be effective at detecting animals more than a couple hundred feet from the from the camera. The camera may not be the most effective way to record false negatives, or false positives that are detected outside the camera's limited view. I recommend manual deer counts to count false negatives.

Figure 2: Location of Camera on Sign D

Fortunately, the camera can be set up to record whenever the lights are activated and only during daylight hours. This will limit the length of video that must be watched and can be useful at counting false positives that are detected within the camera's field of view.

There are problems with detection from all sensor groups. The receipt printer and associated radio receiver only appear to be receiving transmissions from units 19 and 32, which are very near the sign with the attached camera. Driving a car over many of the sensor groups did not activate the lights. Kevin suspects that the vendor set the sensitivity too low when they also set the requirement that both the IR and geophones must be tripped within a qualification period.

Figure 3: DVR, handheld receiver, printer

Installed a terminal emulation program on the Pocket PC that can be used to capture data from the radio receiver. This can be left in the cabinet rather than the laptop.

I will not be able to collect any useful data during this trip. I will, however, have a much better understanding of what needs to be done when I return next time.

Changed the speed sensor interval to fifteen seconds, which will allow twenty two days of recording time. The northern sensor is not currently recording the speeds of southbound vehicles. Both sensors report that they are poorly positioned using the onboard adjustment tools. They will need to be moved.

There are three lanes next to the southern sign and sensor. The southbound direction has an additional passing lane. The taper ends about a hundred feet upstream of the sign.

The south sensor is not recording the position of vehicles well, especially tall vehicles. Tall vehicles show up as two separate vehicles; one in the appropriate lane and the other well off the road.

I successfully recorded data from the receiver (not handheld) tied to light D. I used the terminal emulation software on the Pocket PC. The output was all numbers, consisting of the date, time, sensor number, and other information. Connection to the handheld should work if a 25 pin to 9 pin adapter is used.

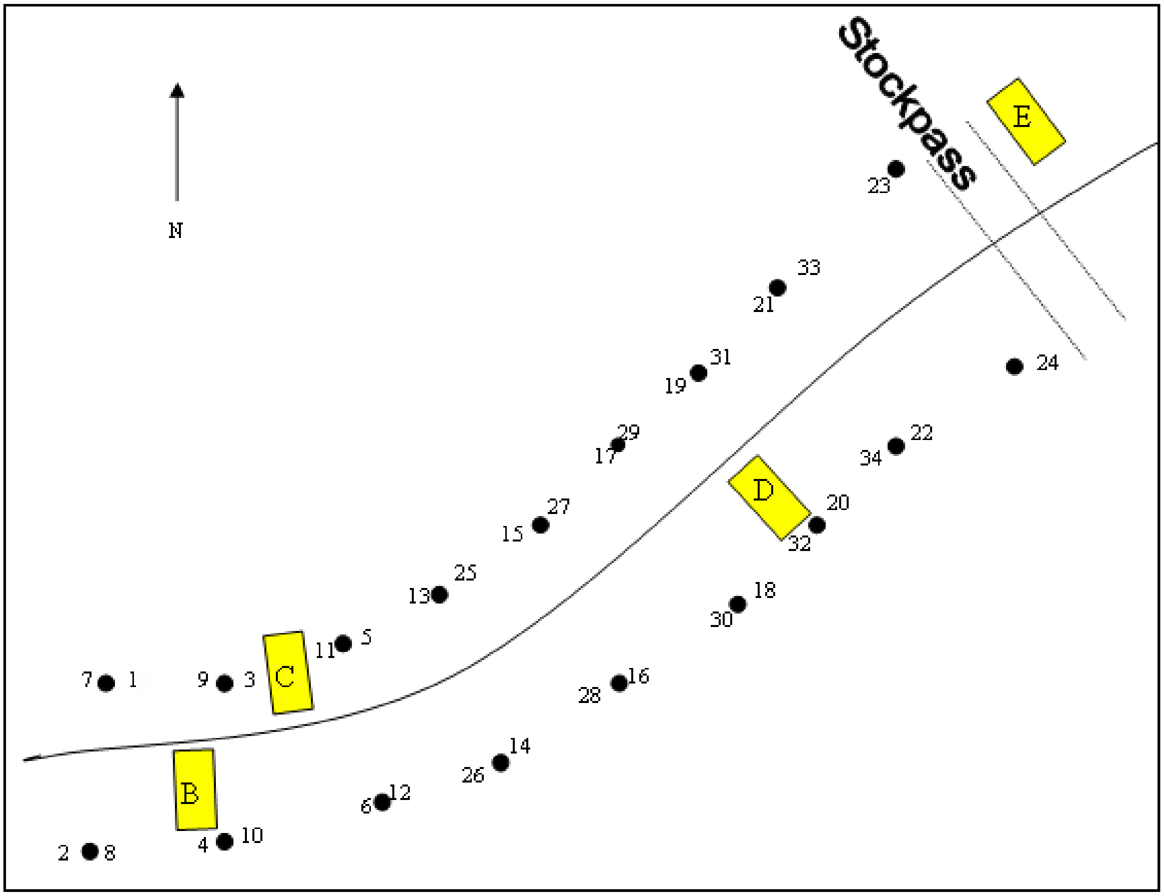

Figure 4: Site Layout

Light receivers appear to be set up to only activate when a signal is received from particular sensors. Light B was not operating at all and the receiver was not responding to the Pocket PC software. I unplugged the receiver box and plugged it back in. I then tested the light with sensor four. The lights came on. I have no idea if other lights were activated; I could not see.

Walk testing with the handheld receiver; I confirmed that sensors 7, 1, 9, 3, 11, 5, 2, 8, 4, 6, 12, 19, and 32 were operational. I did not test the other sensors. Although the handheld reported that a sensor was tripped, this often did not result in flashing lights.

Left at 3:00 pm on December 2nd having made no changes to the system besides setting changes on the three speed sensors.

CONCLUSION

What needs to be done before meaningful data can be collected:

- Move speed sensors to the sign post closest to the road.
- Cover up and deactivate the northernmost sign.
- Run cables from the transmitters to the above ground boxes so changes can be made and settings can be checked without opening pull boxes.
- Update the camera.
- Change camera recording system to one that allows information to be downloaded by computer.
- Replace printer with laptop.
- Install heater in the DVR box.
- Install an external antenna for the handheld receiver.

Trapper's Point Animal Detection Site Visit

Prepared by: Steven Vander Giessen (UW)

Date: February 22nd, 2007

VIDEO RECORDING

Dr. Young and I arrived at Pinedale on the night of February 21st. We replaced the Pelco DX 1000 DVR with the new DX 4000 that night and left it recording. The next day, we connected a laptop to the DX 4000 using an Ethernet crossover cable so we could view & store the video that had been recorded. The IP addresses on both ends had been configured before we left Laramie, so there was no trouble making the connection. The cable fell out after about half an hour of data transfer, and only approximately an hour and a half worth of video was backed up in that time. The DVR was set up to record at the highest resolution and the highest quality. Transfer time should be reduced if either of these parameters is lowered.

The DX 4000 is capable of recording only when it detects motion in a user-defined area and recording only during certain times of the day. By setting the DVR to record only during the day and only when it senses motion on the roadside, the amount of video that will need to be backed up should be greatly reduced.

Unfortunately, the image that the DVR captures from the camera is terrible. Settings and connections were checked on the DVR with no result. Figure 1 is a typical screenshot from video that the DVR is currently recording. A car can be made out in the right-hand side of the shot.

Figure1: a typical screenshot recorded by the DVR

This screenshot was taken from video collected at dusk, but the clarity of the video is the same for afternoon times as well. Clearly, this video is completely unusable for detecting wildlife on the roadside. The motion-detection feature of the DVR could not be enabled because we couldn't make out the edge of the road or the horizon in order to set up the detection zones.

HANDHELD RADIO

The vast majority of hits recorded by the handheld RM-2000's ticker-tape printer had come from detector #19, which is located directly across the highway from the radio's cabinet. Figure 2 shows the handheld attached to the ticker-tape printer. At first, we thought this was a problem with the detectors. Dr. Young carried the handheld radio, walked the length of the project, and tested every detector. Most of the detectors worked. Only detectors #9, 3, 29, 11, and 5 could not be tripped. The handheld radio even received signals from distant detectors on the southern extreme of the project while she was walking near sign B, on the northern extreme. The handheld obviously has no trouble receiving while outside the cabinet.

To confirm that the cabinet was upsetting the handheld's reception, we connected the handheld to the ticker-tape printer and shut the cabinet door. We attached the PDA to Sign D's radio receiver (Figure 3). The PDA's terminal emulation program was used to record the signals received by Sign D.

I walked towards Sign B and tried to set off detectors as I passed. The lights on sign C and sign D turned on several times, indicating that they had received a radio signal. The PDA confirmed that the lights had been activated; it recorded hits from the detectors that I had passed. Only a hit from detector #32, the detector closest to Sign D, had been recorded by the handheld and the ticker-tape printer.

Figure 2: Handheld radio & printer in cabinet near Sign D

The handheld receiver needs to be able to receive signals from the entire system since this data will be used to determine when the signs are activated since we are unable to track when the individual signs are activated. Without this information there is no possibility with correlating the speed data to the signs' operations.

SIGN RADIO RECIEVERS

When we arrived at the project, we tested the detectors by walking around with the handheld radio. The radio confirmed that the detectors had been tripped, but we couldn't see any lights flashing. Also, when the signs' radio receivers were attached to the PDA, the PDA would report that the receiver was not responding.

I removed the wire from the "BATT" terminal on the radio receiver (Figure 3) and replaced it. Signs D, C, and B came to life and actually flashed when a detector was tripped after performing this simple procedure on each.

Sign E does not appear to have electricity. A simple test with a voltmeter confirmed this.

We re-configured the radio receiver at sign B to only accept hits from detectors #1-18 and 25-30. Sign D is set up to listen to detectors #13-34. Sign C is listening for detectors #1-16 and 25-28. These signs should now only flash when a deer has been detected in the vicinity of the sign, rather than all signs flashing when a detection is made anywhere in the system. This should prevent the signs from flashing unnecessarily and (hopefully) make them more useful to drivers.

Sign B does not flash when detectors #28, 16, 30, or 18 are tripped. Also, before sign C was set up to listen to a specific set of detectors, the sign would often flash as a result of a hit on detector #24, which is on the extreme southern end of the project. Sign D, which is closer to #24 than sign C, would not flash. Sign C, however far, is within sight distance of detector #24. Sign D is behind a hill. The radio range of the detectors or sensitivity of the receivers may not be sufficient.

The flash timer on sign A was reduced from 30 seconds to 0 seconds to prevent the light from flashing without cutting power to the SmartSensor. This sign should be covered up in order to gauge “before” speeds.

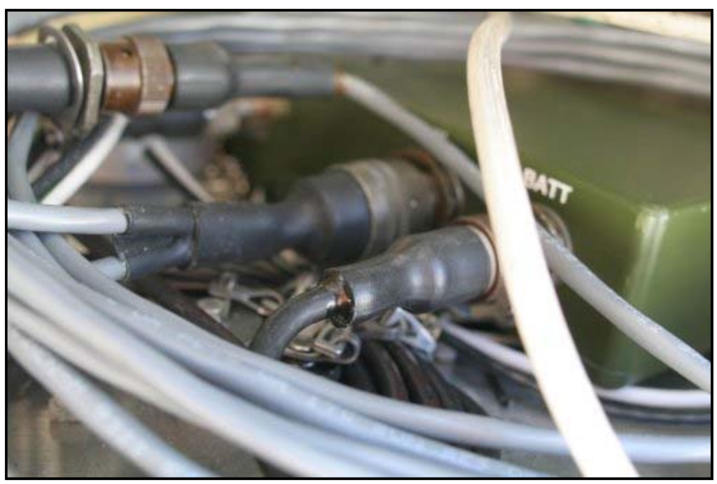

Figure 3: Typical radio receiver inside each sign's cabinet

SPEED SENSORS

The SmartSensor speed sensors were moved to the pole nearest the road, as recommended in the last report. The adjustment software available on each sensor reports that they have been mounted properly, however; when monitoring the sensor attached to sign D using the PDA, vehicles were often detected improperly. The speed sensor would often report multiple, nonexistent vehicles when a tall vehicle, such as a large tractor-trailer combination, passed. Vehicles traveling side-by-side at roughly the same speed would be reported as having a 10 mph speed differential. These errors are likely the result of the passing lane that begins right at sign D or a low mounting height.

Data was downloaded from the sensors attached to signs A and D. Figures 4 and 5 are graphs created from sign A's data. The average speed at this location, between February 10th and 21st, was 66.4 mph.

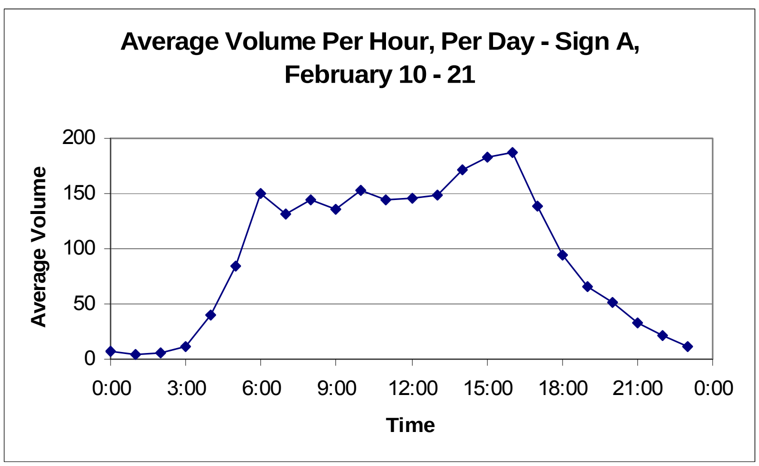

Figure 4: Average Volume Per Hour, Per Day

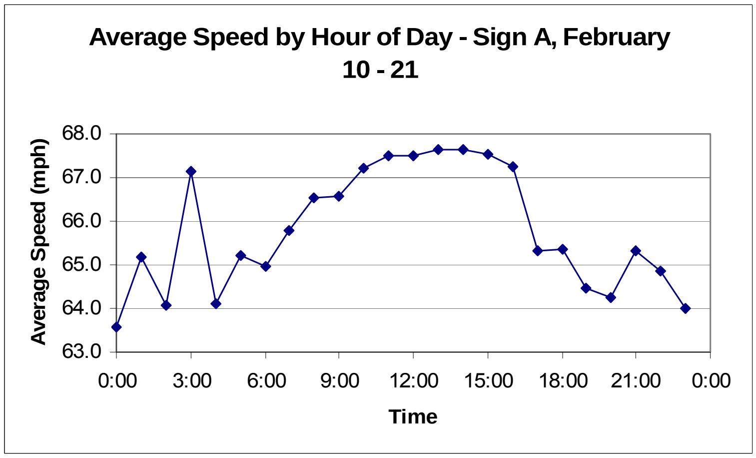

Figure 5: Average Speed by Hour of Day

CONCLUSION

Before this study can continue, the following action items are recommended:

- Repair the camera located at sign D in order to improve the video quality.
- Install an external antenna on sign D's cabinet for the handheld radio to enable the handheld to receive signals when the cabinet door is closed.
- Test that radio transmitting power from the detectors is sufficient to reach the sign receivers.
- Cover up the northernmost sign, sign A. This will enable "before" speed data to be collected.

The sooner these items can be completed, the better. I hope to visit the site to begin collecting data no later than the week of March 19th.

Trapper's Point Animal Detection Site Visit

Prepared by: Steven Vander Giessen (UW)

Date: March 21st, 2007

The following is a summary of the work done by TransCore ITS prior to my arrival:

1. Camera - it appears that vibration moved the focus ring of the camera lens. We refocused, cleaned the lens of the housing and verified that the camera image was good at the end of the cable, as well as the video output of the DVR.

2. Wavetronix - We raised the detector 5 - 5.5 feet and then re-setup the detector and verified working. We noticed that cars are passing on the westbound downhill, and it is showing them in a eastbound lane, as there are 2 EB lanes at this detector. Not sure if this is messing up. Also this is where the climbing lane starts, cars are riding in the middle and being picked up on both lanes. This could be adding a little bit of error.

3. The antenna was installed on the outside of the enclosure. If the handheld is needed. Just unplug the jumper cable and the antenna. This appears to fix the receiving problems.

4. We checked the radio coverage, and it looks like it is fine. I know that we had checked this before as well.

5. It appears that there is an IR scope missing from the farthest west north side post (station 1). Not sure if this was removed by UW or stolen.

6. We noticed a lot (a lot a lot a lot) of deer traffic and the system was going off.

- An external antenna had been added, as requested, to the cabinet at sign C for the handheld receiver. The receiver's reception is much improved. So improved, in fact, that the ticker tape ran out of paper in the few days since the antenna had been installed (Figure 1).

- Jeff Hermreck met me on site to adjust the camera. We zoomed the view out slightly, lowered the view so the horizon is no longer visible, and moved it slightly to the south so that the sensors on the south side of the road are visible. Figure 2 is a shot captured from the camera after these adjustments. A group of three deer can be seen darting in front of a tractor-trailer.

- The camera appears to be slightly out of focus, but this should not be a problem.

Figure 1: Receipt tape billows from Sign D's cabinet

Figure 2: Camera view after adjustment; shows a semi hitting a deer

- The DVR is set up to record between 6 AM and 8PM every day.

- The Dell laptop supplied by WYDOT is attached to the handheld radio and should be recording the same information that the tickertape printer recorded. I don't know if the laptop will be able to handle two or three weeks' worth of data without locking up. If I return to find the laptop locked up, I will reattach the tickertape printer or install another terminal-emulation program.

- Previously reported problems with the southernmost Wavetronix sensor (on Sign D) appear to have been the result of the climbing lane that begins at this location. The sensor automatically and incorrectly sensed that there were two full lanes. This was corrected by manually configuring a single, 20-foot-wide, lane in the southbound direction.

- All Wavetronix sensors appear to be functioning properly.

- The settings on all of the sensors were changed to the following: LEFT 4, RIGHT 4, SEISMIC 5, QUALIFY PERIOD 5 sec. Individual sensors will be adjusted on future trips, based on data collected by the DVR and handheld radio.

- Deer activity was very high. The vast majority of deer crossed halfway between sign D and B, near sensors #14 and 28. All deer were traveling north.

- The system appears to be detecting deer reliably; the number of false negatives appears to be low. A few sensors, #11 and 27 for instance, appear to be causing the majority of the false positives.

- The northernmost sign, Sign A, still needs to be covered up.

TRAPPER'S POINT SITE VISIT REPORT

Prepared By: Steven Vander Giessen (UW)

Date Visited: April 10, 2007

Arrived at 9:30AM. Began to download from DVR and speed sensor at sign D. Returned several times, finally returned at 12:00PM and found that the speed sensor computer had downloaded approximately 60% of the total. The DVR computer had downloaded about 2.5 gigs, with plenty more sure to go. We decided that 60% (10,000 entries) would be enough data from the speed sensor. We also decided that it is infeasible to download video from the DVR for analysis in the office. Instead, we decided to analyze the data in the field. Using the data collected by the laptop hooked to the handheld radio (due to an unforseen limitation of Hyper Terminal, only records from 4/8 to 4/10 were collected), we could bring up the video associated with those times and determine whether deer were present, all while in the field.

Sensors #1-18, #25-30, and #32 are within the camera's field of view. Hits on these sensors were compared with video recorded by the DVR. Approximately 56% of the hits recorded by the handheld came from sensor #1. We will correct this.

As of 4/10/06, the handheld radio was approximately 2 minutes slow compared to the time from the DVR. Therefore, we can assume that the time that the sensor was hit, based on the time from the DVR, is between 0 and 3 minutes ahead of the time reported by the handheld. We listed all of the data from the handheld between 4/8 and 4/10 in an Excel spreadsheet. We eliminated data from sensors that are not included in the ranges 1-18, 25-30, and 32 since these sensors are not visible from the camera. We then eliminated hits that occured between 20:00 and 6:00, since the DVR is not recording during this time. This resulted in 195 sensor hits. Downloading 3 minutes of video for all 195 hits would take more time than is feasible in the field, in the snow. The data was then separated by sensor number and randomly sorted within each sensor. Video from the top five hits on each sensor was then downloaded, ensuring that statistics could be calculated for every sensor that witnessed a hit during the study period. This will check for false positives.

42% of the hits on sensor #1 occured between 7:00 and 7:59AM. 74% of the hits on sensor #1 occured between 6:00AM and 8:59AM. This sensor faces the east. (These statistics are somewhat skewed; data from April 8th is incomplete and begins around 15:00) This could be caused by the morning sun or a rush of morning traffic, or both. Morning traffic could trip the seismic sensors and the sun could trip the IR sensors, within the system's qualify period. Therefore, we lowered the qualify period from 5 seconds to 2 seconds. We had to leave shortly afterwards and were not able to verify whether this new setting had an effect.

To test for false negatives, we randomly selected a half-hour period between 7:00 & 9:00 and 15:00 & 17:00 on April 9th, the only day for which we had complete data. These resulted in the periods 8:01-8:31 and 15:44-16:14. We downloaded video corresponding to these two half-hour periods with the intention of comparing it to data collected from the handheld later.

The Wavetronix sensor at Sign D was approximately one hour ahead of the handheld radio. (The sensor read 17:12, the handheld read 16:12, the actual time was 16:12) The sensor had created a new lane a hundred feet from the farthest edge of the road, likely due to a vehicle with a high profile. This area was excluded, so the sensor cannot make any more new lanes. The sensor at Sign A was behaving properly and the time was correct. Both lanes are activated on this sensor, making this the only sensor that will collect data on northbound vehicles. This will be useful to correlate traffic volumes to sensor hits. The time on sign B was also an hour behind and was corrected. We left the site at 5:15.

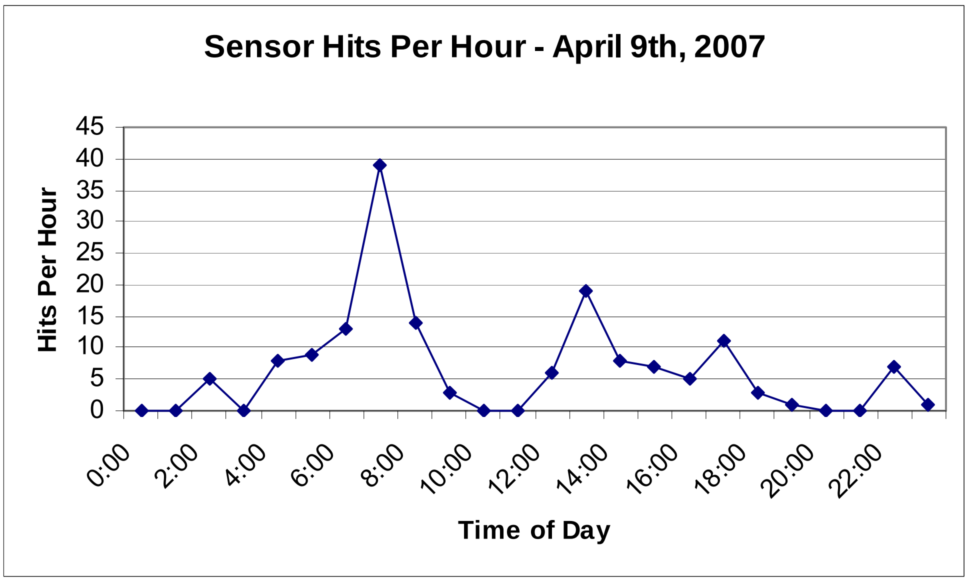

Figure 1: Sensor Hits Per Hour

Since data from the handheld radio was only available for portions of April 8th & 10th and the whole day of April 9th, our analysis options are limited at this point. The issue with Hyper Terminal has been resolved; data collection should go smoothly on my next visit. The above graph illustrates the number of sensor hits per hour on April 9th. The handheld radio received telemetry from 159 individual sensor events. There was a peak of 39 hits during the hour between 7:00 and 8:00, with several other peaks occurring at 13:00 (19 hits), 17:00 (11 hits), and 22:00 (7 hits). At first glance, it appears that the data follow a cyclical trend, with peaks occurring every four hours or so. Without additional data we cannot conclude that this is due to anything other than the result of random chance.

Traffic, especially heavy trucks, have been observed causing false positives. Can traffic volume have an effect on the number of hits observed during an hour? The graph below shows the traffic volume per hour of April 9th. The day's peak occurred during the hour between 7:00 and 8:00, with 150 vehicles passing Sign B during that time. This hour also witnessed the highest number of sensor hits, too, according to Figure 1. The remainder of Figure 2 shows that the traffic volume hovered between 80 and 100 vehicles per hour until 18:00, when the volume drops dramatically from 91 between 17:00 & 18:00 to only 54 vehicles between 18:00 & 19:00. This does not appear to correspond with the local maximum at 17:00 in Figure 1.

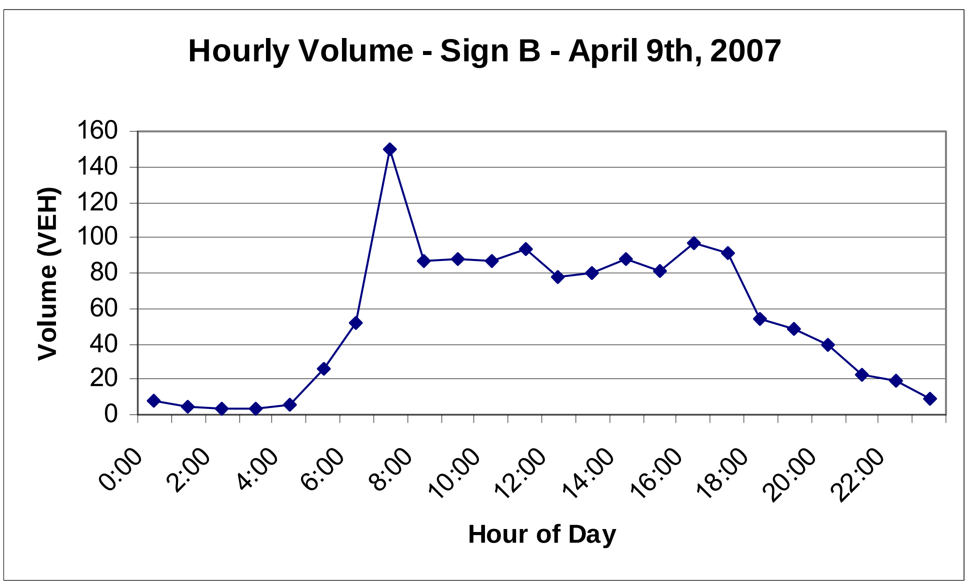

Figure 2: Hourly Volume

The time of day is another factors that has potential to cause false positives. The morning sun stares straight into IR scopes that face east just as the setting sun shines directly towards west-facing scopes. Data from April 9th was separated by whether the sensor uses west-facing or east-facing IR scopes and the number of sensor hits by each orientation was plotted, shown in Figure 3. Much of the data is overwhelmed by data from sensor #1, but both orientations show a spike in the morning hours of the day and a slight peak near the end of the day. These results from April 9th alone are inconclusive. More data is necessary to determine whether time of day actually causes false positives.

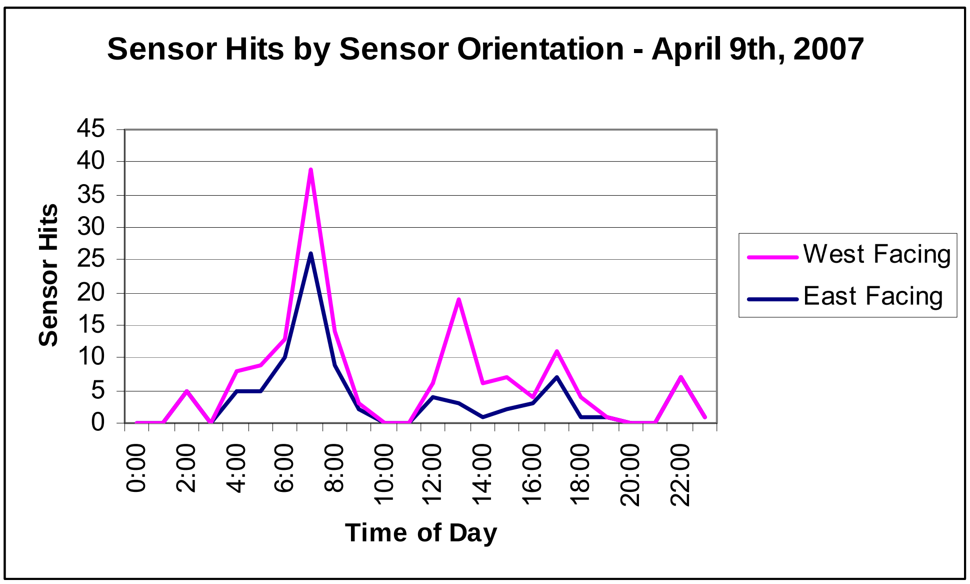

Figure3: Sensor Hits by Sensor Orientation

Trapper's Point Animal Detection Site Visit

Prepared by: William N. Winkler (UW)
Date: September 29th & 30th, 2007

Alan Moore and I made our first visit to the Trappers Point Site, arriving around 10:30 in the morning. Our goal for this trip was to get familiarized with the system and download detection data being collected by the HyperTerminal and the speed sensors. To do this we were following the document "INSTRUCTIONS FOR DATA COLLECTION AT TRAPPERS POINT", provided by Steven Vander Giessen. Another main purpose of the visit was to ensure that data was being collected properly since a second site visit was planned for 3 weeks following.

Before leaving Laramie we were informed that the animal detection system was in the process of being tested and calibrated by the Wyoming Department of Transportation. Upon arrival we found the main cabinet containing the laptop and the hand held radio. We found that the pocket PC was missing and assumed it was removed by the workers from WYDOT. We were able to successfully obtain data from the HyperTerminal and all three speed sensors. The data we collected started at 10:00 am on the 28th and ended at 10:00 am on the 29th. The reason we didn't collect more data was that when the system was shut down for its annual maintenance it was not reset until about the 28th of September so only limited data was available. Also we had to make sure that the data from the HyperTerminal matched that from the DVR.

Along with the data from September we also found a large portion of data still in the HyperTerminal from May of 2007. We gathered this data even though we did not have DVR recordings that corresponded. We were told that there was video data collected over the summer and we wanted to see if it would match up.

The only problem that we encountered on this trip was resetting the DX-1000 DVR when replacing the DX-4000. This was our first time setting this equipment up and was confusing because it doesn't provide confirmation that it is recording.

Observations:

While in the area, we did not see a lot of animal movement but were able to observe as a herd of antelope crossed the road from the West to the East above the stock pass and Sign E (See figure 1). During this time there were no detections made by the sensors. This left the question of whether or not the sensors above the stock pass were activated.

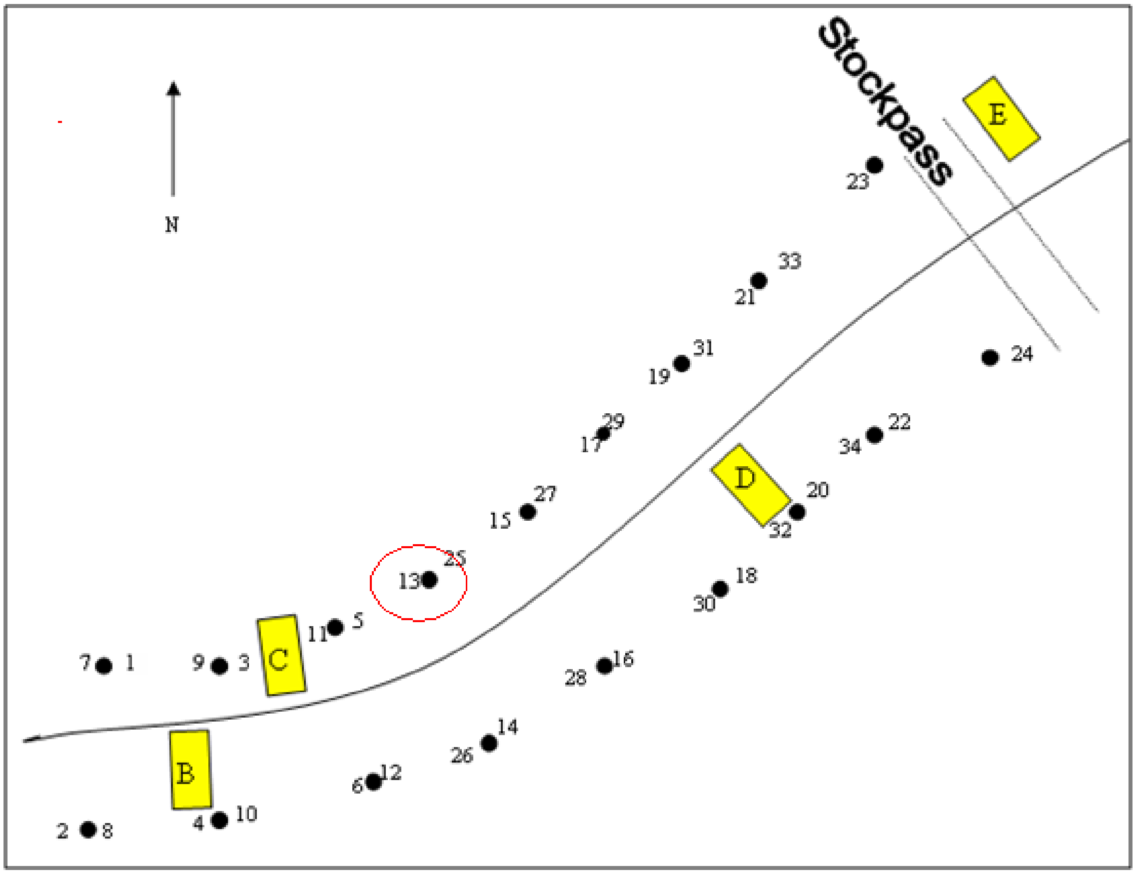

Figure 1: Site Layout

Another observation that we made was that one sensor was being activated far more than any other in the area. Sensor 13 was set off as frequently as once or twice every couple of minutes.

Data Collected:

- Hyper Terminal Detection Data: 2007.09.28 10:06:38 - 2007.09.29 10:47:03
- Speed Sensor Data (all three sensors): 2007.09.28 10:06:38 - 2007.09.29 10:47:03
- DVR Data: 2007.09.28 10:06:38 - 2007.09.29 10:47:03

Trapper's Point Animal Detection Site Visit
Prepared by: William N. Winkler (UW)
Date: October 20th & 21st, 2007

The goals for our second trip to the Trappers Point Site were to collect as much data from both the HyperTerminal and the speed sensors as possible. Then we were going to remove the DX-1000 DVR to bring it back to Laramie. This would then free up a DVR for other research.

When we first arrived to the site we noticed that the Wyoming Department of Transportation had returned the Pocket PC. It also appeared that they reset the HyperTerminal. I assume they reset the HyperTerminal because there were adjustments made to detector 13. This time there were no detections made from this sensor which is a major change from our September visit. This leaves me to believe that the WYDOT personnel adjusted the sensitivity on this detector (It was later confirmed that this sensor was deactivated by WYDOT).

We tested each of the signs with the hand held radio and each one was activated and functioned properly to our motions. Then to determine how much data we would be collecting, we hooked up the DVR to the laptop and found out that it had frozen around the 18th of October. We collected data from the 14th to the 18th of October and then obtained the data from the speed sensors that corresponded to that same time period.

Because the DVR stopped recording and we did not gather as much data as we expected we decided to reset it and leave it to pick up on a later site visit. Instead of bringing both of the DVR's back to Laramie we brought back the newer, model which we figured would be easier to use for the other site applications.

When first looking over the data that we collected from the HyperTerminal it appeared that there were far less detections made. Compared to the September visit, there were far less frequent false detections made by sensor 13 and this should produce better data.

This trip, we also returned to the site for an hour at night from about 8:45pm to 9:45pm to observe while using a night vision scope. The night vision was very limited for observations because every time a vehicle came up the roadway there was no visibility. Still we did observe an animal, likely a coyote, cross the road directly in front of us so it was effective for a limited range. However no signs were activated.

Site Conditions:

This trip was much colder and we had frequent snow flurries while we were waiting for the data to download. Even with the larger vehicle and four wheel drive we did not feel comfortable driving into the ditch until the middle of the day. This did not slow us down too much because we were able to gather data without driving right to the signs. We just had to make sure the snow let up long enough to let us use the laptop at the signs.

Observations:

This trip had a lot of wildlife movement which we observed. The first occurrence we observed was four mule deer crossing in front of the south facing sign C. They crossed from east to west and no detection was made until they had completely crossed the road. A semi truck narrowly missed hitting all four deer. The area they walked out was right about where

sensor 13 is located and this is why I feel there was not a detection made on the east side of the road (Later confirmed that sensor 13 had been taken offline by WYDOT).
Not long after the deer crossing we watched as approximately 200 antelope crossed the road higher on the hill just south of sign D. There were not detections made during this crossing and there was an animal found dead later when we were returning to town.

Figure 1: Antelope Hit While Crossing

While returning later that night we witnessed the system working perfectly. We were approaching sign D and the lights started to flash. We slowed and so did the oncoming traffic while a mule deer crossed, east to west, directly in front of us just north of sign D.
We also observed a deer crossing about 50 yards to the north of sign D while using the night vision scope. This deer traveled east to west and there were no detections made.
Data Collected:

- Hyper Terminal Detection Data: 2007.10.14 08:12:53 - 2007.10.18 08:34:18
- Speed Sensor Data (all three sensors): 2007.10.14 08:12:53 - 2007.10.18 08:34:18
- DVR Data: 2007.10.14 08:12:53 - 2007.10.18 08:34:18

Trapper's Point Animal Detection Site Visit
Prepared by: William N. Winkler (UW)
Date: April 5th & 6th, 2008

The goals for this trip to the Trappers Point Site were to collect data from the HyperTerminal and at least four days of matching data from each of the three speed sensors. We planned on replacing the DX-1000 DVR with the DX-4000 DVR and remove the video data that was collected.

Upon arrival signs A, B, and D, were all tested to ensure that they were still operating. After testing the signs Alan Moore and I, collected all of the data in the HyperTerminal that ranged from Sept. 28th to April 5th. Since WYDOT personnel had just visited the site to test the system calibration and sensitivity, we decided to collect the most recent data from the speed sensors. The data that was collected from the speed sensors ranged from April 2nd to April 5th. The four day time period was chosen because of the amount of time it takes to download data from each of the speed sensors.

Site Conditions:

This trip to Pinedale was the conditions were warmer than previous trips with the sun out most of the day but the temperature was still relatively cold due to high winds. The site was dry and easy to access for data collection. We found that the easiest way to keep the laptop charged while downloading is to plug it into the power strips located in each cabinet. This also helped with the speed of the downloading process.

Observations:

This trip was planned just two weeks after a WYDOT personnel trip to ensure the system was operating correctly. It was obvious that the sensitivity of the system had been adjusted because there were very few false positive detection. In the past the signs were tripped repeatedly while we were on site but during this trip the signs only flash one or two times. There was very little animal movement along the roadway this trip. In fact we didn't see any animals cross the road or come close to the roadway while we were on site. One doe deer was found dead on the shoulder of the road, but it appeared to have been there for a few days.

Data Collected:

- Hyper Terminal Detection Data: 09/28/2007 15:36:46 - 04/05/2008 12:40:58
- Speed Sensor Data (all three sensors): 04/02/2008 11:00:00 - 04/05/2008 11:00:00
- DVR Data: 03/21/2008 11:00:00 04/05/2008

Next Planned Visit:

It is planned to go back to the Trapper's Point Site May 8th to collect one final set of data for the Spring season.

Trapper's Point Animal Detection Site Visit

Prepared by: William N. Winkler (UW)
Date: May 13th, 2008

This trip to Trapper's Point we planned to collect as much data as time would allow and to attempt to recover any data that was lost from the previous trip due to a hard drive failure. The DX1000 DVR was not brought to swap with the DX4000 because it was found after the previous visit that the DX1000 was beginning to have hard drive problems and needs to be repaired before being used. At this time there is no DVR in use at the Trapper's Point site.
The first task was to test the signs and noticed right away that Sign D was not responding to detections. When the HyperTerminal program was opened we saw that there were no detections being recorded. The detections had stopped between our March visit and this visit.
After finding out that the HyperTerminal was malfunctioning we contacted Dr. Young and the Earl LaVake from WYDOT. Earl informed us that the system had been malfunctioning for a few weeks. He was working on replacing the radios that transmit the detections to the HyperTerminal. Because of this we were unable to collect correlating data from two of the three speed sensors.
We gathered two periods of HyperTerminal data and were able to correlate both of these periods with data from the speed sensor on Sign B. The other two speed sensors gave us an error message when we tried to record correlating data because the time periods we were looking for were no longer stored in the hard drive.
The following days were available for each of the three speed sensors.

Timelines: Sign A – 4/28/08 to 5/13/08
Sign B – 4/20/08 to 5/13/08
Sign C – 4/28/08 to 5/13/08

Observations:
We saw very little animal movement and did not see any animals cross the road in that section of highway during our visits but the signs were activated multiple times.

Data Collected:
Hyper Terminal Detection Data:
Begin: 04/21/08 – 08:14:47 End: 04/23/08 – 15:51:54
Begin: 04/25/08 – 21:01:10 End: 04/26/08 – 08:49:53
Speed Sensor Data: 2008-04-21 15:51:10 to 2008-04-23 08:15:00
2008-04-25 1:01:10 to 2008-04-26 08:49:50

DVR Data: 6am to 9pm for 5/08/08 to 5/12/08

APPENDIX B

DETECTOR RECORDS

- **FROM 04/08/07 THROUGH 04/10/07**
- **FROM 04/10/07 THROUGH 04/12/07**
- **FROM 04/26/07 THROUGH 05/16/07**

2007.04.08 15:58:33 0001 QUAL/PED 51
2007.04.08 16:00:03 0011 QUAL/PED 02
2007.04.08 16:07:54 0011 QUAL/PED 03
2007.04.08 16:18:23 0011 QUAL/PED 04
2007.04.08 16:18:24 0005 QUAL/PED 38
2007.04.08 16:26:20 0001 QUAL/PED 52 ?
2007.04.08 16:34:40 0001 QUAL/PED 53 61
2007.04.08 16:34:50 0011 QUAL/PED 05 10
2007.04.08 16:34:51 0005 QUAL/PED 39 11
2007.04.08 16:35:13 0018 QUAL/PED 31 12
2007.04.08 16:42:58 0001 QUAL/PED 54 13 ?
2007.04.08 16:57:28 0001 QUAL/PED 55/PED 46 ?
2007.04.08 17:27:50 0001 QUA
2007.04.08 17:32:13 0001
2007.04.08 17:34:41 0001 QUAL/PED 58 ?
2007.04.08 17:34:41 0007 Event 104 39 ?B6 ?
2007.
2007.04.08 18:06:22 0011 QUAL/PED 0649 ?
2007.
2007.04.08 18:06:23 0005 QUAL/PED 40ED 18
2007.
2007.04.08 18:17:10 0001 QUAL/PED 59ED 63
2007.
2007.04.08 18:44:36 0011 QUAL/PED 07ED 23
2007.
2007.04.08 19:30:46 0028 QUAL/PED 45ED 00
2007.
2007.04.08 19:39:59 0001 QUAL/PED 60ED 29 ?
2007.
2007.04.08 20:16:39 0001 QUAL/PED 61AL/PED 01
2007.
2007.04.08 20:40:03 0011 QUAL/PED 08AL/PED 02
2007.
2007.04.08 21:01:11 0001 QUAL/PED 62AL/PED 03
2007.
2007.04.08 22:11:38 0001 QUAL/PED 00AL/PED 04
2007.
2007.04.08 22:19:37 0001 QUAL/PED 01AL/PED 05
2007.
2007.04.08 22:27:59 00
2007.04.09 02:45:23 0001 QUAL/PED 09 56
2007.04.09 02:46:31 0001 00
2007.04.09 02:47:17 0001 QUAL/PED 11 ?
2007.04.09 02:47:30 0001 QUAL/PED 12 17
2007.04.09 04:03:42 0001 QUAL/PED 13 18
2007.04.09 04:46:39 0001 QUAL/PED 14 19
2007.04.09 04:52:38 0001 QUAL/PED 15 ?20
2007.04.09 04:54:52 0016 QUAL/PED 38 20
2007.04.09 04:57:13 0034 QUAL/PED 30 21
2007.04
2007.04.09 04:57:34 0021 QUAL/PED 16 22
2007.04.08 16:0
2007.04.09 04:57:44 0021 QUAL/PED 17 ?09
2007.04.08 16:18:23 001

2007.04.09 05:10:07 0001 QUAL/PED 16 06
2007.04.08 16:18:24 0005 QUAL/P
2007.04.09 05:12:15 0021 QUAL/PED 18 14 ?2007.04.08 16:26:20 0001 QUAL/PED 52 ?
2007.04.09 05:13:51 0001 QUAL/PED 18/PED 07 16:34:40 0001 QUAL/PED 53 61
2007.04.09 05:13:52 0199 QUAL/PED 46 ?ED 150 0011 QUAL/PED 05 10
200
2007.04.09 05:41:15 002 0:34:51 0005 QUAL/PED 39
2007.04.09 05:46:43 0001 QUAL/PED 20 ?
2007.04.08 16:35:13 0018 QUAL/PED
2007.04.09 05:51:49 0021 QUAL/PED 21 52
2007.04.08 16:42:58 0001 QUAL/PED
2007.04.09 05:57:32 0001 QUAL/PED 21 21
2007.04.08 16:57:28 0001 QUAL/
2007.04.09 06:04:42 0021 QUAL/PED 22 ?26
2007.04.08 17:27:5
2007.04.09 06:30:49 0001 QUAL/PED 279 QUAL/PED 23 ?
2007.
2
20004.
2007.04.09 06:31:07 0001 QUAL/PED 28 0019 QUAL 54
2007.
2007.04.08 20:16:
200001
2007.04.09 06:31:49 002
2007.04.09 06:38:40 0016 QUAL/PED 39/PED 2220:40:03 0011 QUAL/PED 08AL/PED 02
2007.04.09 06:38:57 0027
2007.
2007.04.
2007.04.09 06:46:20 0021 QUAL/PED 24/PED 25
2007.04.09 02:47:17 0001 QUAL/PED 11 ?
2007.04.09 06:49:09 0001 QUAL/PED 32/PED 3902:47:30 0001 QUAL/PED 12 17
2007.04.09 06:49:36 0001 QUAL/PED 33/PED 26 0001 QUAL/PED 13 18
2007.04.09 06:55:10 0001 53 004:46:39 0001 QUAL/PED 14 1
2007.04.09 06:58:54 0001 QUAL/PED 35 ?B
2007.04.09 04:52:38 0001 QUAL/PED 15
2007.04.09 07:02:18 0001 QUAL/PED 36ED 16 ?007.04.09 04:54:52 0016 QUAL/PED 38 20
2007.04.09 07:04:17 0001 QUAL/PED

2007.04.09 07:09:45 0011 QUAL/PED 10 0011 QUAL/PED 21D 18 14 ?

2007.04.09 07:09:46 0005 QUAL/PED 42 0005 QUAL/PED 07
2007.04.09 05:13:52
2007.04.09 07:09:48 0001 QUAL/PED 41 0001 QUAL/PED 19
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2007.04.09 05:41:15 002 0
2007.04.09 07:10:34 0021 QUAL/PED 25 0001 QUAL/PED 20?
2007.04.09 05:
2007.04.09 07:12:16 0001 QUAL/PED 43 0001 QUAL/PED 21
2007.04.09 05:57:32 0001 QUAL/PED 21 21
2007.04.09 07:13:46 0001 QUAL/PED 44 0001 QUAL/PED 224:42 0021 QUAL/PED 22 ?26
2007.04.09 07:23:01 0033 QUAL/PED 28 51 28
2007.04.09 07:23:05 0034 QUAL/PED 31 59L/PED 48 ?01AL 22 ?
2007.04.09 07:23:10 0021 QUAL/PED 29 33
2007.04.09 06:30:49 0001 QUAL/PED 279

2007.04.09 07:24:25 0001 QUAL/PED 49 30
200
2007.04
2007.04.09 07:24:47 0021 QUAL/PED 30 34   54
2007.04.09 07:25:13 0009 QUAL/PED 50 ?3531:49 002
2007.04.
2006:3
2007.04.09 07:25:59 0011 QUAL/PED 11
2007.0
2007.04.09 07:26:00
2007.04.09 06:40:36 0001 QU
2007.04.09 07:32:47 0001 QUAL/PED 58 ?45
2007.04.09 06:43:36
2007.04.09 07:33:40 0001 QUAL/PED 59 50
2007.04.09
2007.04.09 07:34:03 0001 QUAL/PED 60 17
200
2007.04.09 07:34:32 0023 QUAL/PED 39 18
2007.04.09 07:34:51 0001 QUAL/PED 61 51/PED 26
2007.04.09 07:35:29 0001 QUAL/PED 62 52
2007.04.09
2007.04.09 07:35:30 0023 QUAL/PED 51 ?53
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2007.04.09 07:39:36 0001 QUAL/PED 0004:17 0001 QUAL/PED
2007.04.09 07:42:34 0001 QUAL/PED 03 51UAL/PED 21
2007.04.09 07:43:53 0001 QUAL/PED 04 ?27:46 0005 QUAL/PED 42 0005 QUAL/PED 07
2007.04.09 07:44:11 0001 QUAL/PED 05 34
2007.04.09 07:09:48 0001 QUAL
2007.04.09 07:44:45 0021 QUAL/PED 34 58
2
2007.04.09 07:45:16 0001 QUAL/PED 06 05QUAL/PED 20
2007.04.09 07:46:06 0001 QUAL/PED 07 592:16 0001 QUAL/PED 43 0001 QUAL/PED 21
2007.04.09 07:47:29 0021 QUAL/PED 35 48
2007.04.09 07:13:46 0001 QUA
2007.04.09 07:48:34 0001 02
2007.04.09 07:48:35 0007 QUAL/PED 53
2007.04.09 07:55:08 0001 QUAL/PED 13 ?01 0033 QUAL/PED 28 51
2007.04.09 07:55:49 0001 QUAL/PED 14 633:05 0034 QUAL/PED 31 59
2007.04.09 07:59:01 0001 QUAL/PED 15 613:10 0021 QUAL/PED 29 33
2007.04.09 08:02:47 0001 QUAL/PED 16 044:25 0001 QUAL/PED 49 30
2007.04.09 08:03:06 0001 QUAL/PED 17 314:47 0021 QUAL/PED 30 34
2007.04.09 08:05:15 0034 QUAL/PED 32 055:13 0009 QUAL/PED 50 ?35
2007.04.09 08:05:23 0011 QUAL/PED 13 3209 07:25:59 0011 QUAL/PED 11
2007.04.09 08:05:26 0021 020
2007.04.09 07:26:00
2007.04.09 08:12:18 0001 QUAL/PED 201 QUAL/PED 52
2007.04.09 08:13:00 0001 Event 56 21 ?5 000
2007.04.09
20032:
2007.04.09 08:13:33 0001 QUAL/PED 22
2007.04.0
200:32

2007.04.09 08:19:04 0001 QUAL/PED 23
2007.04.
2007:3
2007.04.09 08:21:20 0001 QUAL/PED 24
2007.04
20007:
2007.04.09 08:34:19 0001 QUAL/PED 25
2007.0
200 07
2007.04.09 08:43:38 0001 QUAL/PED 26
2007.
2009 0
2007.04.09 08:46:55 0011 QUAL/PED 14
2007
20009
2007.04.09 08:54:07 0011 QUAL/PED 15
200
200.09
2007.04.09 09:00:06 0001 QUAL/PED 27
20
200
20
2007.04.09 09:07:48 0001 QUAL/PED 28
2007.04.09 07:39:36 0001 QUAL/
200 00
2007.04.09 09:22:16 0011

2007.04.09 12:17:48 0011 QUAL/PED 22
2007.
2007.04.09 12:26:05 0001 QUAL/PED 36 ?
2
2007.04.09 12:26:06 0007 QUAL/PED 57 01
2
2007.04.09 12:27:14 0001 QUAL/PED 37 02
2
2007.04.09 12:41:33 0001 QUAL/PED 38 03
2007.04.09 07:48:35 0007 QUAL
2007.04.09 12:48:16 000

200
2007.04.09 13:15:04 0021 QUAL/PED 39
2007.04.09 13:28:50 0023 QUAL/PED 40 63
2007.04.09 13:28:57 0001 QUAL/PED 41/PED 15 61
2007.04.09 13:29:46 0006 QUAL/PED 45 ?1 QUAL/PED 16 04
2007.04.09 13:32:28 0026 QUAL/PED 03 52001 QUAL/PED 17 31
2007.04.09 13:38:01 0011 QUAL/PED 26 20034 QUAL/PED 32 05
2007.04.09 13:38:02 0005 QUAL/PED 49 53011 QUAL/PED 13 32
2007.04.09 13:38:15 0013 QUAL/PED 54 21021 02

2007.04.09 0
2007.04.09 13:39:22 0023 QUAL 41 57
200
2007.04.09 08
2007.04.09 13:39:54 0011 01

2007.04.09 13:41:41 0011 QUAL/PED 29 ?UAL/PED 24
2007.04.09 13:42:09 0019 QUAL   30 04QUAL/PED 25
2007.04.09 13:42:40 0023 QUAL   42 05UAL/PED 26
2007.04.09 13:43:52 0007 STATUS   58 ?48AL/PED 14
200

2007.04.09 13:44:46 0023 QUAL   43ED 15
200

2007.04.09 13:49:06 0019 QUAL   31ED 27
200

2007.04.09 13:50:32 0011 QUAL/PED 30ED 28
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2007.04.09 13:50:33 0005 QUA11
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2007.04.11 18:41:22 0005 QUAL/PED 00	2007.04.11 23:17:44 0030 QUAL/PED 45
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2007.04.11 18:54:51 0011 QUAL/PED 02	2007.04.11 23:22:05 0022 QUAL/PED 32
2007.04.11 18:54:51 0005 QUAL/PED 02	2007.04.11 23:22:15 0022 QUAL/PED 33
2007.04.11 23:22:40 0022 QUAL/PED 34	2007.04.12 07:19:55 0021 QUAL/PED 49
2007.04.11 23:23:21 0022 QUAL/PED 35	2007.04.12 07:20:36 0011 QUAL/PED 18
2007.04.11 23:23:32 0022 QUAL/PED 36	2007.04.12 07:21:59 0001 QUAL/PED 14
2007.04.11 23:23:51 0022 QUAL/PED 37	2007.04.12 07:23:18 0001 QUAL/PED 15
2007.04.11 23:24:48 0022 QUAL/PED 38	2007.04.12 07:26:08 0001 QUAL/PED 16
2007.04.11 23:27:49 0001 QUAL/PED 56	2007.04.12 07:27:38 0001 QUAL/PED 17
2007.04.11 23:37:28 0028 QUAL/PED 53	2007.04.12 07:28:44 0011 QUAL/PED 19
2007.04.11 23:44:33 0028 QUAL/PED 54	2007.04.12 07:28:49 0001 QUAL/PED 18
2007.04.11 23:52:01 0011 QUAL/PED 08	2007.04.12 07:31:07 0001 QUAL/PED 19
2007.04.11 23:55:50 0016 QUAL/PED 45	
2007.04.11 23:58:00 0016 QUAL/PED 46	
2007.04.11 23:59:05 0016 QUAL/PED 47	
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2007.04.12 02:33:52 0016 QUAL/PED 50	
2007.04.12 02:35:34 0016 QUAL/PED 51	
2007.04.12 02:39:24 0016 QUAL/PED 52	
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2007.04.12 05:04:13 0013 QUAL/PED 04	
2007.04.12 05:06:06 0026 QUAL/PED 19	

2007.04.12 05:08:29 0026 QUAL/PED 20 2007.04.12 05:19:17 0026 QUAL/PED 21 2007.04.12 05:21:59 0001 QUAL/PED 57 2007.04.12 05:22:04 0026 QUAL/PED 22 2007.04.12 05:52:29 0011 QUAL/PED 09 2007.04.12 05:52:30 0005 QUAL/PED 12 2007.04.12 05:52:36 0001 QUAL/PED 58 2007.04.12 05:52:37 0007 QUAL/PED 04 2007.04.12 06:01:02 0027 QUAL/PED 22 2007.04.12 06:22:25 0001 QUAL/PED 59 2007.04.12 06:27:04 0001 QUAL/PED 60 2007.04.12 06:27:36 0011 QUAL/PED 10 2007.04.12 06:27:40 0001 QUAL/PED 61 2007.04.12 06:30:16 0011 QUAL/PED 11 2007.04.12 06:31:16 0001 QUAL/PED 62 2007.04.12 06:33:02 0001 QUAL/PED 63 2007.04.12 06:33:03 0007 QUAL/PED 14 2007.04.12 06:36:09 0001 QUAL/PED 00 2007.04.12 06:36:10 0011 QUAL/PED 12 2007.04.12 06:36:19 0001 QUAL/PED 01 2007.04.12 06:37:00 0001 QUAL/PED 02 2007.04.12 06:37:01 0007 QUAL/PED 11 2007.04.12 06:40:34 0011 QUAL/PED 13 2007.04.12 06:40:35 0005 QUAL/PED 13 2007.04.12 06:43:25 0001 QUAL/PED 03 2007.04.12 06:56:59 0022 QUAL/PED 39 2007.04.12 07:01:01 0011 QUAL/PED 14 2007.04.12 07:01:03 0001 QUAL/PED 05 2007.04.12 07:02:32 0001 QUAL/PED 06 2007.04.12 07:02:50 0011 QUAL/PED 15	

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2007.04.26 17:48:59 0032 QUAL/PED 40	2007.04.27 10:24:04 0016 QUAL/PED 09
2007.04.26 18:25:52 0026 QUAL/PED 12	2007.04.27 10:24:17 0016 QUAL/PED 10
2007.04.26 18:27:15 0013 QUAL/PED 06	2007.04.27 10:24:23 0027 QUAL/PED 11
2007.04.26 18:27:17 0026 QUAL/PED 13	2007.04.27 10:54:48 0001 QUAL/PED 16
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2007.04.26 18:53:05 0001 QUAL/PED 06	2007.04.27 11:26:37 0016 QUAL/PED 11
2007.04.26 18:55:31 0026 QUAL/PED 14	2007.04.27 11:26:54 0027 QUAL/PED 12
2007.04.26 18:59:59 0032 QUAL/PED 41	2007.04.27 11:28:44 0018 QUAL/PED 58
2007.04.26 19:01:06 0032 QUAL/PED 42	2007.04.27 12:00:59 0013 QUAL/PED 08
2007.04.26 19:13:58 0032 QUAL/PED 43	2007.04.27 14:24:06 0001 QUAL/PED 18
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2007.04.26 19:14:24 0032 QUAL/PED 45	2007.04.27 15:07:13 0011 QUAL/PED 06
2007.04.26 19:17:14 0032 QUAL/PED 46	2007.04.27 15:29:53 0011 QUAL/PED 07
2007.04.26 19:18:06 0032 QUAL/PED 47	2007.04.27 16:00:39 0011 QUAL/PED 08
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2007.04.27 00:06:43 0021 QUAL/PED 15	2007.04.27 16:28:03 0001 QUAL/PED 21
2007.04.27 00:40:16 0034 QUAL/PED 54	2007.04.27 17:48:44 0011 QUAL/PED 09
2007.04.27 00:40:27 0034 QUAL/PED 55	2007.04.27 17:58:20 0001 QUAL/PED 22
2007.04.27 00:42:53 0021 QUAL/PED 16	2007.04.27 18:05:52 0001 QUAL/PED 23
2007.04.27 00:43:40 0021 QUAL/PED 17	2007.04.27 18:09:33 0001 QUAL/PED 24

2007.04.27 00:58:50 0021 QUAL/PED 18	2007.04.27 18:31:53 0001 QUAL/PED 25
2007.04.27 01:00:38 0034 QUAL/PED 56	2007.04.27 18:40:28 0001 QUAL/PED 26
2007.04.27 01:05:03 0033 QUAL/PED 63	2007.04.27 19:12:32 0013 QUAL/PED 09
2007.04.27 04:09:09 0018 QUAL/PED 45	2007.04.27 21:08:32 0021 QUAL/PED 20
2007.04.27 04:09:24 0018 QUAL/PED 46	2007.04.27 22:20:36 0011 QUAL/PED 10
2007.04.27 04:09:41 0018 QUAL/PED 47	2007.04.27 22:47:05 0021 QUAL/PED 21
2007.04.27 04:11:35 0018 QUAL/PED 48	2007.04.28 04:51:19 0016 QUAL/PED 12
2007.04.27 04:12:13 0018 QUAL/PED 49	2007.04.28 04:51:53 0027 QUAL/PED 13
2007.04.27 04:12:44 0018 QUAL/PED 50	2007.04.28 06:01:35 0022 QUAL/PED 08
2007.04.27 04:13:00 0018 QUAL/PED 51	2007.04.28 06:42:08 0021 QUAL/PED 22
2007.04.27 04:13:23 0018 QUAL/PED 52	2007.04.28 06:43:38 0018 QUAL/PED 59
2007.04.27 04:13:27 0030 QUAL/PED 51	2007.04.28 06:47:27 0001 QUAL/PED 27
2007.04.27 04:13:39 0018 QUAL/PED 53	2007.04.28 07:00:48 0032 QUAL/PED 48
2007.04.27 04:15:55 0018 QUAL/PED 54	2007.04.28 07:03:37 0019 QUAL/PED 42
2007.04.27 04:16:31 0018 QUAL/PED 55	2007.04.28 07:32:59 0001 QUAL/PED 28
2007.04.27 06:05:57 0011 QUAL/PED 02	2007.04.28 07:41:31 0026 QUAL/PED 16
2007.04.27 06:34:41 0007 QUAL/PED 53	2007.04.28 07:41:32 0012 QUAL/PED 60
2007.04.27 06:41:30 0018 QUAL/PED 56	2007.04.28 07:41:42 0012 QUAL/PED 61
2007.04.27 06:41:32 0030 QUAL/PED 52	2007.04.28 07:42:56 0026 QUAL/PED 17
2007.04.27 06:41:36 0016 QUAL/PED 07	2007.04.28 07:43:01 0012 QUAL/PED 62
2007.04.27 06:41:37 0028 QUAL/PED 04	2007.04.28 07:43:06 0026 QUAL/PED 18
2007.04.27 06:42:22 0016 QUAL/PED 08	2007.04.28 07:43:18 0005 QUAL/PED 02
2007.04.27 06:43:05 0018 QUAL/PED 57	2007.04.28 07:44:00 0006 QUAL/PED 21
2007.04.27 06:45:09 0001 QUAL/PED 07	2007.04.28 07:49:13 0007 QUAL/PED 57
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2007.04.27 07:27:23 0001 QUAL/PED 09	2007.04.28 09:58:18 0013 QUAL/PED 11
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2007.04.27 07:41:35 0023 QUAL/PED 43	2007.04.28 12:33:11 0001 QUAL/PED 29

2007.04.27 07:51:04 0001 QUAL/PED 11	2007.04.28 12:33:17 0011 QUAL/PED 12
2007.04.27 07:51:04 0007 QUAL/PED 55	2007.04.28 13:37:27 0030 QUAL/PED 53
2007.04.27 07:54:15 0001 QUAL/PED 12	2007.04.28 13:37:36 0030 QUAL/PED 54
2007.04.27 08:53:20 0013 QUAL/PED 07	2007.04.28 13:37:47 0017 QUAL/PED 62
2007.04.27 09:44:38 0012 QUAL/PED 59	2007.04.28 13:43:52 0011 QUAL/PED 13
2007.04.27 09:44:39 0006 QUAL/PED 19	2007.04.28 13:46:30 0019 QUAL/PED 43
2007.04.27 09:44:45 0026 QUAL/PED 15	2007.04.28 14:30:07 0001 QUAL/PED 30
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2007.04.28 16:51:30 0021 QUAL/PED 24	2007.04.30 08:59:25 0017 QUAL/PED 01
2007.04.28 18:09:04 0011 QUAL/PED 16	2007.04.30 09:18:38 0016 QUAL/PED 19
2007.04.29 05:45:20 0034 QUAL/PED 57	2007.04.30 09:18:51 0016 QUAL/PED 20
2007.04.29 05:45:31 0021 QUAL/PED 25	2007.04.30 09:19:03 0016 QUAL/PED 21
2007.04.29 06:52:54 0018 QUAL/PED 60	2007.04.30 09:19:11 0027 QUAL/PED 18
2007.04.29 07:46:41 0019 QUAL/PED 44	2007.04.30 10:41:00 0001 QUAL/PED 37
2007.04.29 08:16:25 0013 QUAL/PED 13	2007.04.30 11:33:26 0011 QUAL/PED 20
2007.04.29 08:43:39 0021 QUAL/PED 26	2007.04.30 11:36:16 0023 QUAL 53
2007.04.29 11:19:28 0021 QUAL/PED 27	2007.04.30 11:49:15 0023 QUAL 54
2007.04.29 11:36:48 0016 QUAL/PED 14	2007.04.30 12:08:49 0028 QUAL/PED 07
2007.04.29 11:36:50 0028 QUAL/PED 05	2007.04.30 12:09:02 0028 QUAL/PED 08
2007.04.29 11:37:15 0016 QUAL/PED 15	2007.04.30 12:18:47 0030 QUAL/PED 59
2007.04.29 11:37:38 0016 QUAL/PED 16	2007.04.30 12:18:57 0030 QUAL/PED 60
2007.04.29 11:38:16 0017 QUAL/PED 63	2007.04.30 12:34:47 0011 QUAL/PED 21
2007.04.29 12:02:58 0013 QUAL/PED 14	2007.04.30 12:55:33 0021 QUAL/PED 38
2007.04.29 12:03:27 0023 QUAL 47	2007.04.30 13:52:10 0001 QUAL/PED 38
2007.04.29 12:10:33 0033 QUAL/PED 01	2007.04.30 14:29:47 0023 QUAL 55

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2007.04.29	12:29:35	0021	QUAL/PED	29	
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2007.04.29	14:11:25	0023	QUAL	51	
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2007.04.29	20:07:20	0034	QUAL/PED	59	
2007.04.29	20:07:25	0021	QUAL/PED	34	
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2007.05.01	06:37:32	0018	QUAL/PED	63	
2007.05.01	06:54:51	0001	QUAL/PED	42	
2007.05.01	07:20:33	0001	QUAL/PED	43	
2007.05.01	07:28:50	0012	QUAL/PED	63	

2007.04.30 06:54:45 0011 QUAL/PED 19	2007.05.01 08:00:00 0013 QUAL/PED 19
2007.04.30 06:55:42 0018 QUAL/PED 62	2007.05.01 08:37:19 0001 QUAL/PED 44
2007.04.30 07:18:02 0034 QUAL/PED 63	2007.05.01 09:00:49 0016 QUAL/PED 24
2007.04.30 07:21:35 0001 QUAL/PED 33	2007.05.01 09:00:52 0027 QUAL/PED 21
2007.04.30 07:23:50 0001 QUAL/PED 34	2007.05.01 09:20:57 0001 QUAL/PED 45
2007.04.30 07:47:34 0022 QUAL/PED 09	2007.05.01 09:38:14 0001 QUAL/PED 46
2007.04.30 07:56:05 0030 QUAL/PED 55	2007.05.01 10:25:20 0001 QUAL/PED 47
2007.04.30 07:56:07 0016 QUAL/PED 17	2007.05.01 11:07:14 0021 QUAL/PED 41
2007.04.30 07:56:17 0016 QUAL/PED 18	2007.05.01 11:08:04 0001 QUAL/PED 48
2007.04.30 07:56:27 0027 QUAL/PED 16	2007.05.01 11:29:27 0011 QUAL/PED 29
2007.04.30 08:14:49 0007 QUAL/PED 60	2007.05.01 12:11:28 0001 QUAL/PED 49
2007.04.30 08:26:16 0001 QUAL/PED 36	2007.05.01 12:24:11 0021 QUAL/PED 42
2007.04.30 08:58:43 0030 QUAL/PED 56	2007.05.01 13:12:46 0021 QUAL/PED 43
2007.04.30 08:58:52 0030 QUAL/PED 57	2007.05.01 13:13:14 0021 QUAL/PED 44
2007.04.30 08:59:00 0027 QUAL/PED 17	2007.05.01 13:56:24 0001 QUAL/PED 50
2007.04.30 08:59:15 0030 QUAL/PED 58	2007.05.01 14:04:02 0011 QUAL/PED 30
2007.05.01 14:40:38 0021 QUAL/PED 45	2007.05.02 18:28:49 0006 QUAL/PED 25
2007.05.01 16:30:32 0011 QUAL/PED 31	2007.05.02 18:29:09 0006 QUAL/PED 26
2007.05.01 16:40:04 0021 QUAL/PED 46	2007.05.02 19:57:31 0011 QUAL/PED 44
2007.05.01 16:40:05 0033 QUAL/PED 02	2007.05.02 20:36:07 0011 QUAL/PED 45
2007.05.01 16:54:08 0001 QUAL/PED 51	2007.05.02 20:47:54 0011 QUAL/PED 46
2007.05.01 17:31:16 0001 QUAL/PED 52	2007.05.03 00:01:10 0006 QUAL/PED 27
2007.05.01 18:00:58 0011 QUAL/PED 32	2007.05.03 00:01:19 0006 QUAL/PED 28
2007.05.01 18:11:32 0021 QUAL/PED 47	2007.05.03 00:01:53 0011 QUAL/PED 47
2007.05.01 18:24:46 0011 QUAL/PED 33	2007.05.03 06:21:31 0001 QUAL/PED 04
2007.05.01 18:32:35 0001 QUAL/PED 53	2007.05.03 06:33:24 0011 QUAL/PED 48
2007.05.01 18:38:35 0019 QUAL/PED 47	2007.05.03 07:27:27 0011 QUAL/PED 49
2007.05.01 19:06:12 0032 QUAL/PED 50	2007.05.03 07:27:27 0005 QUAL/PED 06
2007.05.01 20:48:09 0018 QUAL/PED 00	2007.05.03 07:58:16 0021 QUAL/PED 51
2007.05.01 20:49:11 0001 QUAL/PED 54	2007.05.03 08:19:36 0021 QUAL/PED 52

2007.05.01 20:49:23 0018 QUAL/PED 01	2007.05.03 08:19:36 0033 QUAL/PED 03
2007.05.01 20:52:22 0030 QUAL/PED 61	2007.05.03 08:25:11 0011 QUAL/PED 50
2007.05.01 20:52:38 0030 QUAL/PED 62	2007.05.03 08:53:37 0021 QUAL/PED 53
2007.05.01 20:53:16 0017 QUAL/PED 02	2007.05.03 09:50:45 0011 QUAL/PED 51
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2007.05.02 01:42:49 0016 QUAL/PED 25	2007.05.03 10:55:19 0011 QUAL/PED 52
2007.05.02 01:43:45 0027 QUAL/PED 22	2007.05.03 10:59:27 0011 QUAL/PED 53
2007.05.02 01:55:35 0019 QUAL/PED 48	2007.05.03 12:40:02 0016 QUAL/PED 28
2007.05.02 05:39:52 0011 QUAL/PED 35	2007.05.03 12:40:13 0027 QUAL/PED 23
2007.05.02 06:33:42 0016 QUAL/PED 26	2007.05.03 13:15:31 0011 QUAL/PED 54
2007.05.02 06:33:45 0028 QUAL/PED 10	2007.05.03 13:16:38 0001 QUAL/PED 06
2007.05.02 06:35:07 0016 QUAL/PED 27	2007.05.03 13:23:13 0001 QUAL/PED 07
2007.05.02 06:38:41 0018 QUAL/PED 02	2007.05.03 13:45:11 0001 QUAL/PED 08
2007.05.02 07:05:09 0001 QUAL/PED 55	2007.05.03 14:04:11 0001 QUAL/PED 09
2007.05.02 07:28:57 0193 QUAL/PED 56 ?	2007.05.03 14:07:53 0011 QUAL/PED 55
2007.05.02 07:29:29 0011 QUAL/PED 36	2007.05.03 15:07:56 0001 QUAL/PED 10
2007.05.02 07:49:24 0001 QUAL/PED 59 ?	2007.05.03 16:33:04 0021 QUAL/PED 54
2007.05.02 08:13:13 0011 QUAL/PED 37	2007.05.03 16:33:40 0011 QUAL/PED 56
2007.05.02 08:37:16 0011 QUAL/PED 38	2007.05.03 16:45:26 0001 QUAL/PED 11
2007.05.02 08:54:58 0032 QUAL/PED 51	2007.05.03 17:10:27 0001 QUAL/PED 12 ?
2007.05.02 09:10:20 0001 QUAL/PED 58	2007.05.03 17:26:23 0001 QUAL/PED 13
2007.05.02 09:26:43 0001 QUAL/PED 59	2007.05.03 17:52:23 0019 QUAL 49
2007.05.02 09:50:43 0013 QUAL/PED 20	2007.05.03 18:08:20 0001 QUAL/PED 14
2007.05.02 12:05:22 0001 QUAL/PED 60	2007.05.03 18:31:48 0001 QUAL/PED 15
2007.05.02 12:16:19 0011 QUAL/PED 39	2007.05.03 18:56:36 0001 QUAL/PED 16
2007.05.02 12:21:47 0001 QUAL/PED 61	2007.05.03 19:03:35 0011 QUAL/PED 57
2007.05.02 12:43:01 0011 QUAL/PED 40	2007.05.03 19:29:26 0016 QUAL/PED 29
2007.05.02 13:04:09 0001 QUAL/PED 62	2007.05.03 19:29:33 0027 QUAL/PED 24
2007.05.02 13:51:01 0013 QUAL/PED 21	2007.05.03 19:43:55 0032 QUAL/PED 52
2007.05.02 14:29:34 0001 QUAL/PED 63	2007.05.03 19:59:58 0032 QUAL/PED 53

2007.05.02 14:46:02 0011 QUAL/PED 41	2007.05.03 20:00:16 0026 STATUS 24 ?
2007.05.02 15:07:23 0001 QUAL/PED 00	2007.05.03 22:38:45 0013 QUAL/PED 24
2007.05.02 15:09:06 0011 QUAL/PED 42	2007.05.04 00:12:17 0021 QUAL/PED 55
2007.05.02 15:19:05 0021 QUAL/PED 48	2007.05.04 04:22:02 0016 QUAL/PED 30
2007.05.02 15:57:51 0026 QUAL/PED 23	2007.05.04 04:22:36 0016 QUAL/PED 31
2007.05.02 15:57:53 0012 QUAL/PED 00	2007.05.04 04:23:10 0027 QUAL/PED 25
2007.05.02 15:58:29 0012 QUAL/PED 01	2007.05.04 04:23:23 0027 QUAL/PED 26
2007.05.02 15:58:37 0006 QUAL/PED 22	2007.05.04 05:21:46 0001 QUAL/PED 17
2007.05.02 15:59:02 0012 QUAL/PED 02	2007.05.04 05:35:31 0016 QUAL/PED 32
2007.05.02 15:59:02 0006 QUAL/PED 23	2007.05.04 05:35:53 0027 QUAL/PED 27
2007.05.02 16:01:12 0002 QUAL/PED 21	2007.05.04 05:43:30 0001 QUAL/PED 18
2007.05.02 16:02:40 0001 QUAL/PED 01	2007.05.04 06:24:29 0032 QUAL/PED 54
2007.05.02 16:25:00 0021 QUAL/PED 49	2007.05.04 06:24:41 0018 QUAL/PED 03
2007.05.02 16:48:18 0021 QUAL/PED 50	2007.05.04 06:25:13 0016 QUAL/PED 33
2007.05.02 16:52:50 0001 QUAL/PED 02	2007.05.04 06:25:14 0030 QUAL/PED 63
2007.05.02 17:15:23 0006 QUAL/PED 24	2007.05.04 06:25:40 0027 QUAL/PED 28
2007.05.02 17:28:46 0001 QUAL/PED 03	2007.05.04 06:29:11 0022 QUAL/PED 11
2007.05.02 17:35:44 0013 QUAL/PED 22	2007.05.04 06:34:50 0016 QUAL/PED 34
2007.05.02 18:24:56 0011 QUAL/PED 43	2007.05.04 06:34:51 0028 QUAL/PED 11
2007.05.04 06:34:57 0022 QUAL/PED 12	2007.05.05 06:59:15 0027 QUAL/PED 31
2007.05.04 06:37:37 0018 QUAL/PED 04	2007.05.05 09:34:51 0011 QUAL/PED 00
2007.05.04 06:37:40 0030 QUAL/PED 00	2007.05.05 10:23:58 0001 QUAL/PED 36
2007.05.04 06:40:59 0016 QUAL/PED 35	2007.05.05 10:28:41 0011 QUAL/PED 01
2007.05.04 06:41:15 0033 QUAL/PED 04	2007.05.05 13:40:28 0001 QUAL/PED 38
2007.05.04 07:04:36 0021 QUAL/PED 56	2007.05.05 13:59:29 0011 QUAL/PED 02
2007.05.04 07:04:37 0033 QUAL/PED 05	2007.05.05 14:08:19 0011 QUAL/PED 03
2007.05.04 07:04:56 0001 QUAL/PED 20	2007.05.05 19:39:14 0001 QUAL/PED 39 ?
2007.05.04 07:13:29 0001 QUAL/PED 21	2007.05.05 20:32:05 0011 QUAL/PED 04
2007.05.04 07:20:57 0001 QUAL/PED 22	2007.05.05 21:38:11 0001 QUAL/PED 40
2007.05.04 07:22:40 0018 QUAL/PED 05	2007.05.05 22:20:15 0011 QUAL/PED 05

2007.05.04 07:39:24 0001 QUAL/PED 23	2007.05.05 23:34:30 0033 QUAL/PED 06
2007.05.04 07:44:02 0001 QUAL/PED 24	2007.05.05 23:34:56 0034 QUAL/PED 01
2007.05.04 07:51:02 0001 QUAL/PED 25	2007.05.05 23:38:51 0001 QUAL/PED 41
2007.05.04 07:58:10 0001 QUAL/PED 26	2007.05.06 06:24:00 0001 QUAL/PED 42
2007.05.04 08:16:58 0013 QUAL/PED 25	2007.05.06 10:05:36 0013 QUAL/PED 31
2007.05.04 08:20:28 0001 QUAL/PED 27	2007.05.06 10:19:55 0015 QUAL/PED 01
2007.05.04 08:46:29 0021 QUAL/PED 57	2007.05.06 10:19:56 0027 QUAL/PED 32
2007.05.04 08:54:49 0032 QUAL/PED 55	2007.05.06 11:26:00 0026 QUAL/PED 27
2007.05.04 08:56:28 0027 QUAL/PED 29	2007.05.06 11:31:29 0016 QUAL/PED 40
2007.05.04 09:00:31 0026 QUAL/PED 25	2007.05.06 11:31:45 0016 QUAL/PED 41
2007.05.04 10:03:13 0013 QUAL/PED 26	2007.05.06 11:32:16 0016 QUAL/PED 42
2007.05.04 10:22:20 0034 QUAL/PED 00	2007.05.06 11:40:11 0016 QUAL/PED 43
2007.05.04 10:22:38 0021 QUAL/PED 58	2007.05.06 11:40:56 0016 QUAL/PED 44
2007.05.04 10:49:28 0001 QUAL/PED 28	2007.05.06 11:41:22 0027 QUAL/PED 33
2007.05.04 10:56:37 0001 QUAL/PED 29	2007.05.06 13:12:18 0019 QUAL 51
2007.05.04 11:01:56 0023 SER FAULT 02 ?	2007.05.06 13:13:05 0026 QUAL/PED 28
2007.05.04 11:04:56 0026 QUAL/PED 26	2007.05.06 13:35:03 0023 QUAL 03
2007.05.04 12:23:17 0001 QUAL/PED 30	2007.05.06 13:36:12 0026 QUAL/PED 29
2007.05.04 12:44:10 0028 QUAL/PED 12	2007.05.06 13:36:25 0019 QUAL 52
2007.05.04 12:44:20 0028 QUAL/PED 13	2007.05.06 13:38:09 0019 QUAL 53
2007.05.04 12:44:29 0028 QUAL/PED 14	2007.05.06 13:43:53 0019 QUAL 54
2007.05.04 12:44:39 0028 QUAL/PED 15	2007.05.06 13:46:16 0032 QUAL/PED 58
2007.05.04 12:45:18 0016 QUAL/PED 36	2007.05.06 13:51:01 0023 QUAL 06
2007.05.04 12:57:27 0032 QUAL/PED 56	2007.05.06 14:00:07 0001 QUAL/PED 43
2007.05.04 12:57:57 0019 QUAL/PED 50	2007.05.06 14:10:07 0019 QUAL 55
2007.05.04 12:59:20 0027 QUAL/PED 30	2007.05.06 14:51:59 0021 QUAL/PED 01
2007.05.04 13:01:30 0032 QUAL/PED 57	2007.05.06 15:04:04 0027 QUAL/PED 34
2007.05.04 13:31:43 0001 QUAL/PED 31	2007.05.06 15:16:14 0011 QUAL/PED 06
2007.05.04 14:35:55 0021 QUAL/PED 59	2007.05.06 15:41:36 0027 QUAL/PED 35
2007.05.04 14:41:56 0011 QUAL/PED 58	2007.05.06 15:57:12 0023 QUAL 10

2007.05.04 15:24:32 0001 QUAL/PED 33	2007.05.06 16:09:42 0023 QUAL 11
2007.05.04 15:49:50 0001 QUAL/PED 34	2007.05.06 18:56:11 0021 QUAL/PED 02
2007.05.04 16:12:41 0021 QUAL/PED 60	2007.05.06 20:04:38 0013 QUAL/PED 32
2007.05.04 16:23:04 0011 QUAL/PED 59	2007.05.06 20:05:17 0026 QUAL/PED 30
2007.05.04 16:40:10 0001 QUAL/PED 35	2007.05.06 20:05:33 0032 QUAL/PED 59
2007.05.04 17:06:33 0013 QUAL/PED 27	2007.05.06 20:12:13 0001 QUAL/PED 45
2007.05.04 17:18:51 0013 QUAL/PED 28	2007.05.06 23:03:56 0032 QUAL/PED 60
2007.05.04 17:27:17 0013 QUAL/PED 29	2007.05.06 23:04:14 0032 QUAL/PED 61
2007.05.04 18:15:16 0021 QUAL/PED 61	2007.05.07 07:45:15 0001 QUAL/PED 47
2007.05.04 18:24:38 0016 QUAL/PED 37	2007.05.07 07:47:39 0034 QUAL/PED 02
2007.05.04 18:24:51 0016 QUAL/PED 38	2007.05.07 07:47:59 0021 QUAL/PED 03
2007.05.04 18:25:27 0030 QUAL/PED 01	2007.05.07 08:24:53 0033 QUAL/PED 07
2007.05.04 18:25:41 0017 QUAL/PED 03	2007.05.07 08:34:40 0013 QUAL/PED 33
2007.05.04 18:47:07 0011 QUAL/PED 60	2007.05.07 10:12:42 0001 QUAL/PED 48
2007.05.04 18:52:51 0013 QUAL/PED 30	2007.05.07 10:34:12 0013 QUAL/PED 34
2007.05.04 19:07:10 0011 QUAL/PED 61	2007.05.07 11:01:04 0001 QUAL/PED 49
2007.05.04 19:24:03 0021 QUAL/PED 62	2007.05.07 11:34:53 0034 QUAL/PED 03
2007.05.04 19:57:15 0011 QUAL/PED 62	2007.05.07 11:37:57 0011 QUAL/PED 07
2007.05.04 20:12:26 0021 QUAL/PED 63	2007.05.07 11:39:16 0034 QUAL/PED 04
2007.05.04 20:22:48 0021 QUAL/PED 00	2007.05.07 11:42:28 0016 QUAL/PED 45
2007.05.04 21:31:11 0011 QUAL/PED 63	2007.05.07 11:42:29 0028 QUAL/PED 16
2007.05.05 06:59:06 0016 QUAL/PED 39	2007.05.07 11:42:33 0030 QUAL/PED 02
2007.05.07 11:44:08 0028 QUAL/PED 17	2007.05.08 08:30:47 0025 QUAL/PED 40
2007.05.07 12:16:40 0023 SER FAULT 12 ?	2007.05.08 08:36:46 0013 QUAL/PED 35
2007.05.07 13:01:49 0021 QUAL/PED 04	2007.05.08 08:49:53 0025 QUAL/PED 41
2007.05.07 13:02:59 0021 QUAL/PED 05	2007.05.08 08:58:31 0025 QUAL/PED 42
2007.05.07 13:11:53 0011 QUAL/PED 08	2007.05.08 09:13:48 0025 QUAL/PED 43
2007.05.07 13:23:32 0011 QUAL/PED 09	2007.05.08 09:14:44 0025 QUAL/PED 44
2007.05.07 13:29:54 0001 QUAL/PED 50	2007.05.08 09:17:39 0025 QUAL/PED 45
2007.05.07 14:06:02 0011 QUAL/PED 10	2007.05.08 09:17:58 0025 QUAL/PED 46

2007.05.07 15:53:47 0001 QUAL/PED 51	2007.05.08 09:20:36 0025 QUAL/PED 47
2007.05.07 17:01:17 0011 QUAL/PED 11	2007.05.08 09:22:10 0001 QUAL/PED 59
2007.05.07 17:49:15 0001 QUAL/PED 53	2007.05.08 09:22:57 0025 QUAL/PED 48
2007.05.07 18:19:39 0011 QUAL/PED 12	2007.05.08 09:34:26 0025 QUAL/PED 49
2007.05.07 19:47:32 0033 QUAL/PED 08	2007.05.08 09:53:51 0025 QUAL/PED 50
2007.05.07 19:55:33 0026 QUAL/PED 31	2007.05.08 10:00:08 0025 QUAL/PED 51
2007.05.08 03:40:07 0025 QUAL/PED 00	2007.05.08 10:04:20 0028 QUAL/PED 19
2007.05.08 04:21:51 0025 QUAL/PED 01	2007.05.08 10:05:32 0011 QUAL/PED 14
2007.05.08 04:33:01 0030 QUAL/PED 03	2007.05.08 10:42:29 0025 QUAL/PED 00
2007.05.08 05:18:37 0001 QUAL/PED 54	2007.05.08 10:50:30 0011 QUAL/PED 15
2007.05.08 05:19:57 0025 QUAL/PED 02	2007.05.08 10:58:18 0025 QUAL/PED 01
2007.05.08 05:28:45 0025 QUAL/PED 03	2007.05.08 11:07:49 0025 QUAL/PED 02
2007.05.08 05:33:32 0025 QUAL/PED 04	2007.05.08 11:15:49 0025 QUAL/PED 03
2007.05.08 05:49:01 0025 QUAL/PED 05	2007.05.08 11:32:00 0025 QUAL/PED 04
2007.05.08 05:53:21 0025 QUAL/PED 06	2007.05.08 11:43:36 0025 QUAL/PED 05
2007.05.08 06:02:28 0025 QUAL/PED 07	2007.05.08 11:48:50 0025 QUAL/PED 06
2007.05.08 06:02:39 0025 QUAL/PED 08	2007.05.08 11:59:11 0025 QUAL/PED 07
2007.05.08 06:07:48 0025 QUAL/PED 09	2007.05.08 12:06:23 0025 QUAL/PED 08
2007.05.08 06:20:55 0025 QUAL/PED 10	2007.05.08 12:19:51 0025 QUAL/PED 09
2007.05.08 06:21:12 0025 QUAL/PED 11	2007.05.08 12:20:01 0025 QUAL/PED 10
2007.05.08 06:23:17 0022 QUAL/PED 13	2007.05.08 12:31:15 0011 QUAL/PED 16
2007.05.08 06:24:57 0022 QUAL/PED 14	2007.05.08 12:32:07 0025 QUAL/PED 11
2007.05.08 06:25:43 0016 QUAL/PED 46	2007.05.08 12:38:45 0025 QUAL/PED 12
2007.05.08 06:25:44 0028 QUAL/PED 18	2007.05.08 12:40:42 0025 QUAL/PED 13
2007.05.08 06:25:49 0025 QUAL/PED 12	2007.05.08 12:42:44 0025 QUAL/PED 14
2007.05.08 06:26:28 0025 QUAL/PED 13	2007.05.08 12:46:08 0021 QUAL/PED 06
2007.05.08 06:29:15 0025 QUAL/PED 14	2007.05.08 12:50:40 0025 QUAL/PED 15
2007.05.08 06:34:38 0025 QUAL/PED 15	2007.05.08 12:53:31 0025 QUAL/PED 16
2007.05.08 06:35:14 0025 QUAL/PED 16	2007.05.08 12:54:26 0025 QUAL/PED 17
2007.05.08 06:44:06 0025 QUAL/PED 17	2007.05.08 13:00:29 0021 QUAL/PED 07

2007.05.08 06:45:08 0025 QUAL/PED 18	2007.05.08 13:00:30 0025 QUAL/PED 18
2007.05.08 06:47:35 0025 QUAL/PED 19	2007.05.08 13:05:16 0025 QUAL/PED 19
2007.05.08 06:49:18 0025 QUAL/PED 20	2007.05.08 13:06:03 0025 QUAL/PED 20
2007.05.08 06:52:36 0025 QUAL/PED 21	2007.05.08 13:10:58 0025 QUAL/PED 21
2007.05.08 06:54:11 0025 QUAL/PED 22	2007.05.08 13:13:23 0025 QUAL/PED 22
2007.05.08 06:59:02 0025 QUAL/PED 23	2007.05.08 13:15:40 0025 QUAL/PED 23
2007.05.08 07:01:27 0025 QUAL/PED 24	2007.05.08 13:30:49 0025 QUAL/PED 24
2007.05.08 07:10:37 0001 QUAL/PED 56	2007.05.08 13:33:04 0025 QUAL/PED 25
2007.05.08 07:11:54 0011 QUAL/PED 13	2007.05.08 13:41:42 0025 QUAL/PED 26
2007.05.08 07:12:07 0025 QUAL/PED 25	2007.05.08 13:47:55 0025 QUAL/PED 27
2007.05.08 07:13:32 0025 QUAL/PED 26	2007.05.08 13:49:05 0025 QUAL/PED 28
2007.05.08 07:17:06 0025 QUAL/PED 27	2007.05.08 14:14:09 0025 QUAL/PED 29
2007.05.08 07:19:04 0025 QUAL/PED 28	2007.05.08 14:17:03 0025 QUAL/PED 30
2007.05.08 07:26:11 0025 QUAL/PED 29	2007.05.08 14:18:43 0025 QUAL/PED 31
2007.05.08 07:27:47 0025 QUAL/PED 30	2007.05.08 14:42:11 0021 QUAL/PED 08
2007.05.08 07:31:00 0025 QUAL/PED 31	2007.05.08 14:51:30 0025 QUAL/PED 32
2007.05.08 07:34:14 0025 QUAL/PED 32	2007.05.08 14:51:36 0001 QUAL/PED 60
2007.05.08 07:34:46 0025 QUAL/PED 33	2007.05.08 14:52:59 0025 QUAL/PED 33
2007.05.08 07:44:48 0025 QUAL/PED 34	2007.05.08 14:55:05 0025 QUAL/PED 34
2007.05.08 07:46:11 0025 QUAL/PED 35	2007.05.08 15:13:46 0025 QUAL/PED 35
2007.05.08 07:54:57 0001 QUAL/PED 58	2007.05.08 15:15:11 0025 QUAL/PED 36
2007.05.08 07:58:31 0025 QUAL/PED 36	2007.05.08 15:18:20 0025 QUAL/PED 37
2007.05.08 08:07:56 0025 QUAL/PED 37	2007.05.08 15:21:56 0025 QUAL/PED 38
2007.05.08 08:18:06 0025 QUAL/PED 38	2007.05.08 15:25:35 0025 QUAL/PED 39
2007.05.08 08:28:32 0025 QUAL/PED 39	2007.05.08 15:29:00 0025 QUAL/PED 40
2007.05.08 15:30:53 0025 QUAL/PED 41	2007.05.09 06:10:08 0025 QUAL/PED 27
2007.05.08 15:40:42 0025 QUAL/PED 42	2007.05.09 06:13:10 0018 QUAL/PED 06
2007.05.08 16:04:11 0025 QUAL/PED 43	2007.05.09 06:13:37 0018 QUAL/PED 07
2007.05.08 16:09:59 0025 QUAL/PED 44	2007.05.09 06:16:24 0001 QUAL/PED 00
2007.05.08 16:14:02 0011 QUAL/PED 17	2007.05.09 06:20:52 0025 QUAL/PED 28

2007.05.08 16:18:07 0025 QUAL/PED 45	2007.05.09 06:23:35 0016 QUAL/PED 47
2007.05.08 16:29:50 0025 QUAL/PED 46	2007.05.09 06:23:39 0028 QUAL/PED 20
2007.05.08 16:31:31 0025 QUAL/PED 47	2007.05.09 06:25:29 0016 QUAL/PED 48
2007.05.08 16:32:57 0025 QUAL/PED 48	2007.05.09 06:25:33 0028 QUAL/PED 21
2007.05.08 16:38:11 0025 QUAL/PED 49	2007.05.09 06:26:19 0016 QUAL/PED 49
2007.05.08 16:42:15 0021 QUAL/PED 09	2007.05.09 06:26:22 0028 QUAL/PED 22
2007.05.08 16:44:50 0001 QUAL/PED 61	2007.05.09 06:28:43 0018 QUAL/PED 08
2007.05.08 16:45:04 0025 QUAL/PED 50	2007.05.09 06:30:04 0025 QUAL/PED 29
2007.05.08 16:47:38 0025 QUAL/PED 51	2007.05.09 06:31:14 0025 QUAL/PED 30
2007.05.08 16:47:48 0011 QUAL/PED 18	2007.05.09 06:32:10 0016 QUAL/PED 50
2007.05.08 16:56:44 0025 QUAL/PED 52	2007.05.09 06:32:15 0025 QUAL/PED 31
2007.05.08 17:02:24 0025 QUAL/PED 53	2007.05.09 06:34:04 0025 QUAL/PED 32
2007.05.08 17:08:49 0025 QUAL/PED 54	2007.05.09 06:34:51 0025 QUAL/PED 33
2007.05.08 17:12:39 0025 QUAL/PED 55	2007.05.09 06:43:20 0025 QUAL/PED 34
2007.05.08 17:21:55 0025 QUAL/PED 56	2007.05.09 06:43:58 0025 QUAL/PED 35
2007.05.08 17:27:59 0025 QUAL/PED 57	2007.05.09 06:53:59 0025 QUAL/PED 36
2007.05.08 17:31:39 0025 QUAL/PED 58	2007.05.09 06:55:03 0025 QUAL/PED 37
2007.05.08 17:34:25 0025 QUAL/PED 59	2007.05.09 06:56:35 0025 QUAL/PED 38
2007.05.08 17:38:46 0001 QUAL/PED 62	2007.05.09 06:57:26 0033 QUAL/PED 09
2007.05.08 17:47:50 0025 QUAL/PED 60	2007.05.09 06:57:27 0021 QUAL/PED 13
2007.05.08 17:48:11 0022 QUAL/PED 15	2007.05.09 06:57:58 0011 QUAL/PED 19
2007.05.08 17:52:40 0025 QUAL/PED 61	2007.05.09 07:05:10 0025 QUAL/PED 39
2007.05.08 18:19:29 0025 QUAL/PED 62	2007.05.09 07:24:50 0025 QUAL/PED 40
2007.05.08 18:22:52 0021 QUAL/PED 10	2007.05.09 07:29:47 0001 QUAL/PED 01 ?B
2007.05.08 18:24:17 0025 QUAL/PED 63	2007.05.09 07:32:58 0025 QUAL/PED 41
2007.05.08 18:42:45 0025 QUAL/PED 00	2007.05.09 07:36:37 0025 QUAL/PED 42
2007.05.08 18:44:33 0025 QUAL/PED 01	2007.05.09 07:38:20 0001 QUAL/PED 02
2007.05.08 18:44:49 0025 QUAL/PED 02	2007.05.09 07:38:24 0025 QUAL/PED 43
2007.05.08 18:46:21 0025 QUAL/PED 03	2007.05.09 07:45:50 0011 QUAL/PED 20
2007.05.08 18:47:30 0025 QUAL/PED 04	2007.05.09 07:49:10 0025 QUAL/PED 44

2007.05.08 18:48:33 0025 QUAL/PED 05	2007.05.09 07:54:23 0025 QUAL/PED 45
2007.05.08 18:59:46 0025 QUAL/PED 06	2007.05.09 07:57:47 0025 QUAL/PED 46
2007.05.08 19:25:34 0021 QUAL/PED 11	2007.05.09 08:05:30 0025 QUAL/PED 47
2007.05.08 19:38:27 0025 QUAL/PED 07	2007.05.09 08:16:12 0025 QUAL/PED 48
2007.05.08 19:45:18 0025 QUAL/PED 08	2007.05.09 08:23:10 0025 QUAL/PED 49
2007.05.08 19:45:26 0030 QUAL/PED 04	2007.05.09 08:27:56 0025 QUAL/PED 50
2007.05.08 19:53:01 0025 QUAL/PED 09	2007.05.09 08:31:23 0025 QUAL/PED 51
2007.05.08 19:55:30 0013 QUAL/PED 36	2007.05.09 08:41:56 0025 QUAL/PED 52
2007.05.08 20:14:08 0001 QUAL/PED 63	2007.05.09 09:34:50 0025 QUAL/PED 53
2007.05.08 20:39:17 0025 QUAL/PED 10	2007.05.09 09:56:13 0025 QUAL/PED 54
2007.05.08 20:59:28 0025 QUAL/PED 11	2007.05.09 09:56:31 0025 QUAL/PED 55
2007.05.08 21:20:46 0021 QUAL/PED 12	2007.05.09 10:05:20 0025 QUAL/PED 56
2007.05.08 22:34:12 0025 QUAL/PED 12	2007.05.09 10:09:40 0025 QUAL/PED 57
2007.05.08 23:35:44 0025 QUAL/PED 13	2007.05.09 10:12:57 0025 QUAL/PED 58
2007.05.09 00:16:25 0025 QUAL/PED 14	2007.05.09 10:28:35 0025 QUAL/PED 59
2007.05.09 00:56:19 0025 QUAL/PED 15	2007.05.09 10:32:39 0025 QUAL/PED 60
2007.05.09 01:27:15 0030 QUAL/PED 05	2007.05.09 10:38:46 0025 QUAL/PED 61
2007.05.09 02:38:42 0025 QUAL/PED 16	2007.05.09 10:45:59 0025 QUAL/PED 62
2007.05.09 03:06:53 0025 QUAL/PED 17	2007.05.09 10:52:02 0025 QUAL/PED 63
2007.05.09 05:05:37 0025 QUAL/PED 18	2007.05.09 10:58:21 0021 QUAL/PED 14
2007.05.09 05:06:32 0025 QUAL/PED 19	2007.05.09 11:13:23 0025 QUAL/PED 00
2007.05.09 05:36:57 0025 QUAL/PED 20	2007.05.09 11:26:00 0025 QUAL/PED 01
2007.05.09 05:37:05 0025 QUAL/PED 21	2007.05.09 11:33:04 0025 QUAL/PED 02
2007.05.09 05:45:51 0025 QUAL/PED 22	2007.05.09 11:40:09 0021 QUAL/PED 15
2007.05.09 05:54:35 0025 QUAL/PED 23	2007.05.09 11:41:31 0025 QUAL/PED 03
2007.05.09 06:01:39 0025 QUAL/PED 24	2007.05.09 11:43:11 0025 QUAL/PED 04
2007.05.09 06:05:14 0025 QUAL/PED 25	2007.05.09 12:00:30 0025 QUAL/PED 05
2007.05.09 06:06:15 0025 QUAL/PED 26	2007.05.09 12:26:35 0025 QUAL/PED 06
2007.05.09 12:30:06 0025 QUAL/PED 07	2007.05.09 16:53:45 0025 QUAL/PED 53
2007.05.09 12:32:22 0025 QUAL/PED 08	2007.05.09 17:03:36 0025 QUAL/PED 54

2007.05.09 12:37:40 0025 QUAL/PED 09	2007.05.09 17:04:07 0025 QUAL/PED 55
2007.05.09 12:45:00 0025 QUAL/PED 10	2007.05.09 17:05:24 0025 QUAL/PED 56
2007.05.09 12:47:29 0025 QUAL/PED 11	2007.05.09 17:11:05 0025 QUAL/PED 57
2007.05.09 12:55:15 0025 QUAL/PED 12	2007.05.09 17:33:08 0025 QUAL/PED 58
2007.05.09 13:00:14 0025 QUAL/PED 13	2007.05.09 17:36:19 0025 QUAL/PED 59
2007.05.09 13:04:32 0021 QUAL/PED 16	2007.05.09 17:39:24 0025 QUAL/PED 60
2007.05.09 13:06:02 0023 QUAL 27 ?	2007.05.09 17:40:19 0025 QUAL/PED 61
2007.05.09 13:06:20 0025 QUAL/PED 14	2007.05.09 17:48:06 0025 QUAL/PED 62
2007.05.09 13:11:43 0025 QUAL/PED 15	2007.05.09 17:54:24 0025 QUAL/PED 63
2007.05.09 13:12:34 0025 QUAL/PED 16	2007.05.09 18:02:37 0025 QUAL/PED 00
2007.05.09 13:14:45 0025 QUAL/PED 17	2007.05.09 18:02:48 0025 QUAL/PED 01
2007.05.09 13:28:09 0025 QUAL/PED 18	2007.05.09 18:07:35 0025 QUAL/PED 02
2007.05.09 13:31:05 0013 QUAL/PED 37	2007.05.09 18:12:45 0025 QUAL/PED 03
2007.05.09 13:31:05 0026 QUAL/PED 32	2007.05.09 18:22:04 0001 QUAL/PED 08
2007.05.09 13:33:16 0032 QUAL/PED 62	2007.05.09 18:23:37 0025 QUAL/PED 04
2007.05.09 13:37:06 0025 QUAL/PED 19	2007.05.09 18:54:09 0011 QUAL/PED 25
2007.05.09 13:49:42 0025 QUAL/PED 20	2007.05.09 18:55:32 0025 QUAL/PED 05
2007.05.09 13:50:09 0025 QUAL/PED 21	2007.05.09 19:08:14 0011 QUAL/PED 26
2007.05.09 13:52:02 0011 QUAL/PED 21	2007.05.09 19:30:44 0025 QUAL/PED 06
2007.05.09 13:56:24 0025 QUAL/PED 22	2007.05.09 19:32:11 0025 QUAL/PED 07
2007.05.09 13:56:39 0011 QUAL/PED 22	2007.05.09 19:37:54 0014 QUAL/PED 23
2007.05.09 13:58:16 0013 QUAL/PED 38	2007.05.09 19:38:35 0025 QUAL/PED 08
2007.05.09 14:01:54 0027 QUAL/PED 36	2007.05.09 19:43:25 0025 QUAL/PED 09
2007.05.09 14:07:22 0025 QUAL/PED 23	2007.05.09 19:45:05 0025 QUAL/PED 10
2007.05.09 14:09:47 0025 QUAL/PED 24	2007.05.09 19:49:05 0025 QUAL/PED 11
2007.05.09 14:14:11 0001 QUAL/PED 04	2007.05.09 19:51:07 0013 QUAL/PED 39
2007.05.09 14:14:32 0025 QUAL/PED 25	2007.05.09 19:57:11 0025 QUAL/PED 12
2007.05.09 14:23:01 0019 QUAL 56	2007.05.09 20:04:33 0013 QUAL/PED 40
2007.05.09 14:23:11 0025 QUAL/PED 26	2007.05.09 20:07:17 0026 QUAL/PED 33
2007.05.09 14:27:24 0025 QUAL/PED 27	2007.05.09 20:07:19 0025 QUAL/PED 13

2007.05.09 14:29:23 0025 QUAL/PED 28	2007.05.09 20:13:34 0025 QUAL/PED 14
2007.05.09 14:35:34 0025 QUAL/PED 29	2007.05.09 20:17:52 0025 QUAL/PED 15
2007.05.09 14:45:42 0025 QUAL/PED 30	2007.05.09 20:19:14 0025 QUAL/PED 16
2007.05.09 14:49:00 0001 QUAL/PED 05	2007.05.09 20:22:53 0025 QUAL/PED 17
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2007.05.09 14:58:11 0025 QUAL/PED 32	2007.05.09 20:43:02 0025 QUAL/PED 19
2007.05.09 15:22:46 0025 QUAL/PED 33	2007.05.09 21:13:25 0011 QUAL/PED 27
2007.05.09 15:29:40 0025 QUAL/PED 34	2007.05.09 21:13:34 0025 QUAL/PED 20
2007.05.09 15:40:08 0025 QUAL/PED 35	2007.05.09 21:14:02 0025 QUAL/PED 21
2007.05.09 15:47:13 0025 QUAL/PED 36	2007.05.09 21:14:29 0025 QUAL/PED 22
2007.05.09 15:48:47 0001 QUAL/PED 06	2007.05.09 21:16:20 0025 QUAL/PED 23
2007.05.09 15:48:52 0011 QUAL/PED 23	2007.05.09 22:31:06 0025 QUAL/PED 24
2007.05.09 15:49:40 0025 QUAL/PED 37	2007.05.09 22:40:20 0011 QUAL/PED 28
2007.05.09 15:59:18 0025 QUAL/PED 38	2007.05.10 03:53:14 0025 QUAL/PED 25
2007.05.09 15:59:40 0001 QUAL/PED 07	2007.05.10 04:47:09 0025 QUAL/PED 26
2007.05.09 16:00:07 0022 QUAL/PED 16	2007.05.10 04:49:09 0025 QUAL/PED 27
2007.05.09 16:00:38 0025 QUAL/PED 39	2007.05.10 05:09:01 0025 QUAL/PED 28
2007.05.09 16:07:40 0025 QUAL/PED 40	2007.05.10 05:20:08 0025 QUAL/PED 29
2007.05.09 16:12:31 0025 QUAL/PED 41	2007.05.10 05:21:39 0001 QUAL/PED 09
2007.05.09 16:15:51 0025 QUAL/PED 42	2007.05.10 05:45:25 0025 QUAL/PED 30
2007.05.09 16:20:04 0025 QUAL/PED 43	2007.05.10 05:48:35 0025 QUAL/PED 31
2007.05.09 16:20:39 0025 QUAL/PED 44	2007.05.10 05:51:48 0025 QUAL/PED 32
2007.05.09 16:21:10 0025 QUAL/PED 45	2007.05.10 05:52:55 0025 QUAL/PED 33
2007.05.09 16:28:27 0025 QUAL/PED 46	2007.05.10 05:54:36 0025 QUAL/PED 34
2007.05.09 16:36:09 0025 QUAL/PED 47	2007.05.10 06:00:18 0025 QUAL/PED 35
2007.05.09 16:36:29 0025 QUAL/PED 48	2007.05.10 06:04:28 0025 QUAL/PED 36
2007.05.09 16:40:36 0025 QUAL/PED 49	2007.05.10 06:05:37 0025 QUAL/PED 37
2007.05.09 16:47:15 0025 QUAL/PED 50	2007.05.10 06:11:58 0001 QUAL/PED 10
2007.05.09 16:51:53 0025 QUAL/PED 51	2007.05.10 06:15:00 0025 QUAL/PED 38
2007.05.09 16:52:02 0025 QUAL/PED 52	2007.05.10 06:19:21 0025 QUAL/PED 39

2007.05.09 16:52:42 0011 QUAL/PED 24	2007.05.10 06:23:02 0016 QUAL/PED 51
2007.05.10 06:23:03 0028 QUAL/PED 23	2007.05.10 12:14:53 0025 QUAL/PED 21
2007.05.10 06:27:54 0016 QUAL/PED 52	2007.05.10 12:18:46 0025 QUAL/PED 22
2007.05.10 06:29:52 0025 QUAL/PED 40	2007.05.10 12:44:05 0021 QUAL/PED 19
2007.05.10 06:30:30 0027 QUAL/PED 37	2007.05.10 12:45:11 0001 QUAL/PED 11
2007.05.10 06:30:33 0018 QUAL/PED 09	2007.05.10 12:48:56 0025 QUAL/PED 23
2007.05.10 06:30:55 0025 QUAL/PED 41	2007.05.10 13:01:15 0025 QUAL/PED 24
2007.05.10 06:35:08 0025 QUAL/PED 42	2007.05.10 13:05:23 0025 QUAL/PED 25
2007.05.10 06:35:37 0025 QUAL/PED 43	2007.05.10 13:15:28 0014 QUAL/PED 24
2007.05.10 06:37:12 0025 QUAL/PED 44	2007.05.10 13:24:53 0011 QUAL/PED 33
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2007.05.10 06:48:11 0025 QUAL/PED 45	2007.05.10 13:26:10 0025 QUAL/PED 26
2007.05.10 06:55:41 0025 QUAL/PED 46	2007.05.10 13:30:05 0025 QUAL/PED 27
2007.05.10 07:11:46 0025 QUAL/PED 47	2007.05.10 13:34:07 0025 QUAL/PED 28
2007.05.10 07:16:11 0025 QUAL/PED 48	2007.05.10 13:40:26 0014 QUAL/PED 25
2007.05.10 07:26:08 0013 QUAL/PED 41	2007.05.10 13:40:26 0025 QUAL/PED 29
2007.05.10 07:29:14 0025 QUAL/PED 49	2007.05.10 13:40:35 0027 QUAL/PED 38
2007.05.10 07:34:47 0025 QUAL/PED 50	2007.05.10 13:41:04 0019 QUAL 57
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2007.05.10 07:47:55 0025 QUAL/PED 52	2007.05.10 13:47:39 0019 QUAL 58
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2007.05.10 08:05:22 0025 QUAL/PED 54	2007.05.10 13:57:35 0021 QUAL/PED 21
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2007.05.10 08:22:09 0025 QUAL/PED 56	2007.05.10 14:13:20 0025 QUAL/PED 35
2007.05.10 08:28:55 0025 QUAL/PED 57	2007.05.10 14:14:03 0025 QUAL/PED 36
2007.05.10 08:28:56 0013 QUAL/PED 42	2007.05.10 14:22:02 0025 QUAL/PED 37
2007.05.10 08:33:45 0025 QUAL/PED 58	2007.05.10 14:30:26 0025 QUAL/PED 38
2007.05.10 08:33:46 0013 QUAL/PED 43	2007.05.10 14:38:52 0025 QUAL/PED 39

2007.05.10 08:36:08 0025 QUAL/PED 59	2007.05.10 14:41:17 0025 QUAL/PED 40
2007.05.10 08:37:56 0025 QUAL/PED 60	2007.05.10 14:48:52 0032 QUAL/PED 63
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2007.05.10 10:03:54 0011 QUAL/PED 31	2007.05.10 15:39:36 0025 QUAL/PED 50
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2007.05.10 11:16:00 0025 QUAL/PED 13	2007.05.10 16:53:17 0025 QUAL/PED 55
2007.05.10 11:18:03 0025 QUAL/PED 14	2007.05.10 16:55:05 0025 QUAL/PED 56
2007.05.10 11:20:21 0025 QUAL/PED 15	2007.05.10 16:55:20 0011 QUAL/PED 36
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2007.05.10 12:00:44 0025 QUAL/PED 17	2007.05.10 17:05:55 0025 QUAL/PED 58

2007.05.10 12:01:41 0025 QUAL/PED 18	2007.05.10 17:18:16 0011 QUAL/PED 37
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2007.05.10 12:13:17 0025 QUAL/PED 20	2007.05.10 17:23:22 0025 QUAL/PED 60
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2007.05.10 17:29:38 0001 QUAL/PED 14	2007.05.11 06:36:59 0025 QUAL/PED 44
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2007.05.10 17:55:03 0011 QUAL/PED 38	2007.05.11 06:46:23 0025 QUAL/PED 47
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2007.05.10 18:05:27 0001 QUAL/PED 16	2007.05.11 07:14:48 0025 QUAL/PED 50
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2007.05.10 18:19:27 0001 QUAL/PED 17	2007.05.11 07:44:28 0025 QUAL/PED 55
2007.05.10 18:21:43 0025 QUAL/PED 05	2007.05.11 07:44:30 0013 QUAL/PED 49
2007.05.10 18:28:00 0025 QUAL/PED 06	2007.05.11 07:54:44 0025 QUAL/PED 56
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2007.05.10 19:12:03 0011 QUAL/PED 39	2007.05.11 08:17:27 0013 QUAL/PED 50
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2007.05.10 20:18:11 0025 QUAL/PED 12	2007.05.11 08:42:47 0025 QUAL/PED 63
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2007.05.10 21:40:16 0013 QUAL/PED 47	2007.05.11 09:17:32 0025 QUAL/PED 04
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2007.05.10 22:01:40 0025 QUAL/PED 17	2007.05.11 09:20:33 0025 QUAL/PED 06
2007.05.10 22:10:44 0025 QUAL/PED 18	2007.05.11 09:21:49 0025 QUAL/PED 07
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2007.05.11 06:06:22 0025 QUAL/PED 37	2007.05.11 11:03:51 0025 QUAL/PED 26
2007.05.11 06:13:22 0025 QUAL/PED 38	2007.05.11 11:09:30 0025 QUAL/PED 27
2007.05.11 06:19:11 0025 QUAL/PED 39	2007.05.11 11:16:09 0025 QUAL/PED 28

2007.05.11 06:19:13 0013 QUAL/PED 48	2007.05.11 11:18:50 0025 QUAL/PED 29
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2007.05.11 06:27:47 0025 QUAL/PED 41	2007.05.11 11:46:34 0011 QUAL/PED 42
2007.05.11 06:29:37 0025 QUAL/PED 42	2007.05.11 11:47:40 0025 QUAL/PED 33
2007.05.11 06:34:12 0025 QUAL/PED 43	2007.05.11 11:50:54 0021 QUAL/PED 29
2007.05.11 11:59:01 0025 QUAL/PED 34	2007.05.11 17:25:23 0025 QUAL/PED 16
2007.05.11 12:07:27 0025 QUAL/PED 35	2007.05.11 17:53:41 0011 QUAL/PED 47
2007.05.11 12:11:33 0025 QUAL/PED 36	2007.05.11 17:55:58 0025 QUAL/PED 17
2007.05.11 12:16:29 0025 QUAL/PED 37	2007.05.11 17:57:24 0025 QUAL/PED 18
2007.05.11 12:23:31 0025 QUAL/PED 38	2007.05.11 17:57:26 0011 QUAL/PED 48
2007.05.11 12:26:07 0025 QUAL/PED 39	2007.05.11 17:57:54 0025 QUAL/PED 19
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2007.05.11 12:50:54 0025 QUAL/PED 43	2007.05.11 18:15:02 0025 QUAL/PED 22
2007.05.11 13:08:21 0001 QUAL/PED 22	2007.05.11 18:16:32 0025 QUAL/PED 23
2007.05.11 13:10:33 0025 QUAL/PED 44	2007.05.11 18:22:37 0025 QUAL/PED 24
2007.05.11 13:12:06 0025 QUAL/PED 45	2007.05.11 18:44:01 0025 QUAL/PED 25
2007.05.11 13:12:18 0025 QUAL/PED 46	2007.05.11 18:48:54 0021 QUAL/PED 35
2007.05.11 13:13:35 0025 QUAL/PED 47	2007.05.11 18:51:52 0025 QUAL/PED 26
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2007.05.11 13:40:19 0025 QUAL/PED 51	2007.05.11 19:52:40 0025 QUAL/PED 28
2007.05.11 13:49:50 0025 QUAL/PED 52	2007.05.11 19:56:44 0032 QUAL/PED 01
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2007.05.11 13:59:55 0025 QUAL/PED 54	2007.05.11 20:30:16 0022 QUAL/PED 18

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2007.05.11 14:23:26 0025 QUAL/PED 56	2007.05.11 22:03:52 0025 QUAL/PED 31
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2007.05.11 14:34:30 0011 QUAL/PED 44	2007.05.11 23:23:54 0025 QUAL/PED 35
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2007.05.11 15:29:05 0025 QUAL/PED 01	2007.05.12 05:35:51 0025 QUAL/PED 41
2007.05.11 15:30:36 0021 QUAL/PED 32	2007.05.12 06:05:52 0025 QUAL/PED 42
2007.05.11 15:33:28 0025 QUAL/PED 02	2007.05.12 06:22:18 0025 QUAL/PED 43
2007.05.11 15:35:37 0025 QUAL/PED 03	2007.05.12 06:31:40 0025 QUAL/PED 44
2007.05.11 15:36:24 0025 QUAL/PED 04	2007.05.12 06:32:21 0025 QUAL/PED 45
2007.05.11 15:47:44 0011 QUAL/PED 46	2007.05.12 06:48:48 0025 QUAL/PED 46
2007.05.11 15:49:19 0025 QUAL/PED 05	2007.05.12 07:01:25 0032 QUAL/PED 04
2007.05.11 15:53:20 0025 QUAL/PED 06	2007.05.12 07:09:42 0025 QUAL/PED 47
2007.05.11 15:57:46 0025 QUAL/PED 07	2007.05.12 07:17:29 0021 QUAL/PED 37
2007.05.11 16:15:30 0025 QUAL/PED 08	2007.05.12 07:17:35 0025 QUAL/PED 48

2007.05.11 16:24:56 0021 QUAL/PED 33	2007.05.12 07:20:12 0025 QUAL/PED 49
2007.05.11 16:27:17 0025 QUAL/PED 09	2007.05.12 07:28:43 0025 QUAL/PED 50
2007.05.11 16:31:32 0025 QUAL/PED 10	2007.05.12 07:34:15 0025 QUAL/PED 51
2007.05.11 16:34:20 0025 QUAL/PED 11	2007.05.12 07:39:04 0021 QUAL/PED 38
2007.05.11 16:44:21 0025 QUAL/PED 12	2007.05.12 07:45:31 0021 QUAL/PED 39
2007.05.11 16:46:00 0001 QUAL/PED 24	2007.05.12 07:48:45 0025 QUAL/PED 52
2007.05.11 16:57:05 0025 QUAL/PED 13	2007.05.12 07:50:16 0025 QUAL/PED 53
2007.05.11 17:09:42 0025 QUAL/PED 14	2007.05.12 07:53:49 0025 QUAL/PED 54
2007.05.11 17:12:46 0021 QUAL/PED 34	2007.05.12 07:56:07 0021 QUAL/PED 40
2007.05.11 17:15:41 0025 QUAL/PED 15	2007.05.12 08:12:21 0021 QUAL/PED 41
2007.05.12 08:22:25 0025 QUAL/PED 55	2007.05.12 14:29:52 0025 QUAL/PED 39
2007.05.12 08:33:28 0025 QUAL/PED 56	2007.05.12 14:33:41 0025 QUAL/PED 40
2007.05.12 08:34:11 0025 QUAL/PED 57	2007.05.12 14:37:13 0011 QUAL/PED 55
2007.05.12 08:35:08 0013 QUAL/PED 53	2007.05.12 14:48:07 0025 QUAL/PED 41
2007.05.12 08:48:45 0025 QUAL/PED 58	2007.05.12 14:58:23 0025 QUAL/PED 42
2007.05.12 08:59:22 0025 QUAL/PED 59	2007.05.12 15:14:51 0025 QUAL/PED 43
2007.05.12 09:03:42 0011 QUAL/PED 53	2007.05.12 15:29:24 0025 QUAL/PED 44
2007.05.12 09:05:05 0025 QUAL/PED 60	2007.05.12 15:35:21 0025 QUAL/PED 45
2007.05.12 09:07:03 0025 QUAL/PED 61	2007.05.12 15:35:35 0011 QUAL/PED 56
2007.05.12 09:08:37 0025 QUAL/PED 62	2007.05.12 15:35:36 0005 QUAL/PED 17
2007.05.12 09:27:22 0021 QUAL/PED 42	2007.05.12 15:53:57 0025 QUAL/PED 46
2007.05.12 09:27:42 0025 QUAL/PED 63	2007.05.12 15:55:24 0001 QUAL/PED 26
2007.05.12 09:29:38 0025 QUAL/PED 00	2007.05.12 15:57:33 0025 QUAL/PED 47
2007.05.12 09:34:31 0025 QUAL/PED 01	2007.05.12 15:58:55 0025 QUAL/PED 48
2007.05.12 09:54:16 0025 QUAL/PED 02	2007.05.12 16:00:23 0025 QUAL/PED 49
2007.05.12 09:58:02 0013 QUAL/PED 54	2007.05.12 16:13:58 0025 QUAL/PED 50
2007.05.12 09:59:49 0025 QUAL/PED 03	2007.05.12 16:26:25 0025 QUAL/PED 51
2007.05.12 10:00:34 0023 SER FAULT 39 ?	2007.05.12 16:55:17 0001 QUAL/PED 27
2007.05.12 10:06:11 0025 QUAL/PED 04	2007.05.12 17:00:10 0025 QUAL/PED 52
2007.05.12 10:08:19 0025 QUAL/PED 05	2007.05.12 17:22:51 0025 QUAL/PED 53

2007.05.12 10:19:06 0025 QUAL/PED 06	2007.05.12 17:41:06 0025 QUAL/PED 54
2007.05.12 10:23:26 0025 QUAL/PED 07	2007.05.12 17:42:05 0011 QUAL/PED 57
2007.05.12 10:25:46 0025 QUAL/PED 08	2007.05.12 18:16:46 0011 QUAL/PED 58
2007.05.12 10:36:58 0025 QUAL/PED 09	2007.05.12 18:20:37 0025 QUAL/PED 55
2007.05.12 10:43:27 0001 QUAL/PED 25	2007.05.12 18:57:28 0025 QUAL/PED 56
2007.05.12 10:54:00 0025 QUAL/PED 10	2007.05.12 19:15:02 0025 QUAL/PED 57
2007.05.12 10:58:14 0025 QUAL/PED 11	2007.05.12 19:24:55 0025 QUAL/PED 58
2007.05.12 11:02:10 0025 QUAL/PED 12	2007.05.12 19:26:39 0025 QUAL/PED 59
2007.05.12 11:03:45 0025 QUAL/PED 13	2007.05.12 19:58:56 0025 QUAL/PED 60
2007.05.12 11:22:45 0025 QUAL/PED 14	2007.05.12 20:10:04 0025 QUAL/PED 61
2007.05.12 11:24:39 0013 QUAL/PED 55	2007.05.12 20:29:12 0025 QUAL/PED 62
2007.05.12 11:37:19 0025 QUAL/PED 15	2007.05.12 22:07:53 0025 QUAL/PED 63
2007.05.12 11:46:18 0025 QUAL/PED 16	2007.05.13 00:00:28 0001 QUAL/PED 28
2007.05.12 11:47:45 0025 QUAL/PED 17	2007.05.13 00:04:43 0025 QUAL/PED 00
2007.05.12 11:54:54 0025 QUAL/PED 18	2007.05.13 00:32:49 0025 QUAL/PED 01
2007.05.12 11:57:52 0027 QUAL/PED 40	2007.05.13 00:53:46 0025 QUAL/PED 02
2007.05.12 12:03:12 0026 QUAL/PED 36	2007.05.13 00:55:44 0028 QUAL/PED 26
2007.05.12 12:03:14 0013 QUAL/PED 56	2007.05.13 02:28:13 0025 QUAL/PED 03
2007.05.12 12:21:30 0025 QUAL/PED 19	2007.05.13 04:45:21 0021 QUAL/PED 00
2007.05.12 12:24:54 0025 QUAL/PED 20	2007.05.13 06:27:50 0025 QUAL/PED 04
2007.05.12 12:42:34 0011 QUAL/PED 54	2007.05.13 06:46:33 0025 QUAL/PED 05
2007.05.12 12:44:26 0025 QUAL/PED 21	2007.05.13 07:41:23 0025 QUAL/PED 06
2007.05.12 12:46:39 0025 QUAL/PED 22	2007.05.13 07:49:16 0027 QUAL/PED 41
2007.05.12 12:47:03 0025 QUAL/PED 23	2007.05.13 07:56:56 0027 QUAL/PED 42
2007.05.12 12:48:23 0018 QUAL/PED 11	2007.05.13 07:58:40 0025 QUAL/PED 07
2007.05.12 12:54:58 0025 QUAL/PED 24	2007.05.13 08:18:05 0025 QUAL/PED 08
2007.05.12 12:56:10 0025 QUAL/PED 25	2007.05.13 08:26:49 0019 QUAL 60
2007.05.12 13:03:42 0025 QUAL/PED 26	2007.05.13 08:26:50 0025 QUAL/PED 09
2007.05.12 13:09:54 0025 QUAL/PED 27	2007.05.13 08:26:51 0013 QUAL/PED 57
2007.05.12 13:13:35 0025 QUAL/PED 28	2007.05.13 08:38:34 0215 QUAL 55 ?

2007.05.12 13:13:41 0019 QUAL 59	2007.05.13 09:05:01 0025 QUAL/PED 10
2007.05.12 13:13:49 0025 QUAL/PED 29	2007.05.13 09:50:19 0025 QUAL/PED 11
2007.05.12 13:21:22 0025 QUAL/PED 30	2007.05.13 09:57:36 0025 QUAL/PED 12
2007.05.12 13:27:43 0025 QUAL/PED 31	2007.05.13 10:13:31 0025 QUAL/PED 13
2007.05.12 13:30:42 0025 QUAL/PED 32	2007.05.13 10:18:57 0025 QUAL/PED 14
2007.05.12 13:34:20 0025 QUAL/PED 33	2007.05.13 11:24:19 0025 QUAL/PED 15
2007.05.12 13:40:56 0025 QUAL/PED 34	2007.05.13 11:32:38 0025 QUAL/PED 16
2007.05.12 13:44:07 0025 QUAL/PED 35	2007.05.13 11:42:42 0025 QUAL/PED 17
2007.05.12 13:46:28 0021 QUAL/PED 43	2007.05.13 12:19:10 0001 QUAL/PED 29
2007.05.12 13:46:57 0021 QUAL/PED 44	2007.05.13 12:49:55 0025 QUAL/PED 18
2007.05.12 14:00:05 0025 QUAL/PED 36	2007.05.13 12:53:51 0025 QUAL/PED 19
2007.05.12 14:22:19 0025 QUAL/PED 37	2007.05.13 13:14:17 0025 QUAL/PED 20
2007.05.12 14:23:00 0025 QUAL/PED 38	2007.05.13 13:19:10 0001 QUAL/PED 30
2007.05.13 13:25:54 0025 QUAL/PED 21	2007.05.14 07:03:16 0025 QUAL/PED 14
2007.05.13 13:28:36 0025 QUAL/PED 22	2007.05.14 07:13:28 0025 QUAL/PED 15
2007.05.13 14:33:11 0025 QUAL/PED 23	2007.05.14 07:19:52 0025 QUAL/PED 16
2007.05.13 14:42:09 0025 QUAL/PED 24	2007.05.14 07:20:47 0025 QUAL/PED 17
2007.05.13 14:43:41 0025 QUAL/PED 25	2007.05.14 07:24:33 0025 QUAL/PED 18
2007.05.13 15:12:31 0025 QUAL/PED 26	2007.05.14 07:29:12 0025 QUAL/PED 19
2007.05.13 15:16:28 0025 QUAL/PED 27	2007.05.14 07:29:13 0001 QUAL/PED 32
2007.05.13 15:23:14 0025 QUAL/PED 28	2007.05.14 07:29:22 0025 QUAL/PED 20
2007.05.13 15:42:42 0025 QUAL/PED 29	2007.05.14 07:33:37 0011 QUAL/PED 60
2007.05.13 15:50:01 0025 QUAL/PED 30	2007.05.14 07:37:22 0025 QUAL/PED 21
2007.05.13 16:12:52 0025 QUAL/PED 31	2007.05.14 07:45:28 0025 QUAL/PED 22
2007.05.13 16:35:05 0025 QUAL/PED 32	2007.05.14 07:46:22 0025 QUAL/PED 23
2007.05.13 16:35:28 0025 QUAL/PED 33	2007.05.14 07:47:36 0025 QUAL/PED 24
2007.05.13 16:36:22 0025 QUAL/PED 34	2007.05.14 07:49:03 0025 QUAL/PED 25
2007.05.13 16:47:30 0025 QUAL/PED 35	2007.05.14 08:00:30 0027 QUAL/PED 43
2007.05.13 17:16:09 0025 QUAL/PED 36	2007.05.14 08:06:11 0025 QUAL/PED 26
2007.05.13 17:35:34 0025 QUAL/PED 37	2007.05.14 08:15:35 0025 QUAL/PED 27

2007.05.13 17:50:20 0025 QUAL/PED 38	2007.05.14 08:25:35 0025 QUAL/PED 28
2007.05.13 18:00:36 0025 QUAL/PED 39	2007.05.14 08:33:19 0025 QUAL/PED 29
2007.05.13 18:30:43 0001 QUAL/PED 31	2007.05.14 08:48:04 0025 QUAL/PED 30
2007.05.13 18:39:54 0025 QUAL/PED 40	2007.05.14 08:48:35 0025 QUAL/PED 31
2007.05.13 18:43:59 0025 QUAL/PED 41	2007.05.14 08:53:12 0025 QUAL/PED 32
2007.05.13 18:53:00 0013 QUAL/PED 58	2007.05.14 08:53:19 0011 QUAL/PED 61
2007.05.13 19:02:42 0025 QUAL/PED 42	2007.05.14 09:02:46 0025 QUAL/PED 33
2007.05.13 19:10:15 0025 QUAL/PED 43	2007.05.14 09:14:31 0025 QUAL/PED 34
2007.05.13 19:18:17 0011 QUAL/PED 59	2007.05.14 09:14:32 0013 QUAL/PED 60
2007.05.13 19:34:22 0025 QUAL/PED 44	2007.05.14 09:17:14 0025 QUAL/PED 35
2007.05.13 20:17:48 0025 QUAL/PED 45	2007.05.14 09:32:10 0025 QUAL/PED 36
2007.05.13 20:31:46 0025 QUAL/PED 46	2007.05.14 09:32:11 0013 QUAL/PED 61
2007.05.13 20:38:30 0025 QUAL/PED 47	2007.05.14 09:34:48 0025 QUAL/PED 37
2007.05.13 20:43:59 0025 QUAL/PED 48	2007.05.14 09:56:52 0025 QUAL/PED 38
2007.05.13 20:50:14 0025 QUAL/PED 49	2007.05.14 09:59:28 0025 QUAL/PED 39
2007.05.13 21:12:12 0025 QUAL/PED 50	2007.05.14 10:03:17 0025 QUAL/PED 40
2007.05.13 21:39:10 0025 QUAL/PED 51	2007.05.14 10:09:10 0025 QUAL/PED 41
2007.05.13 21:51:54 0025 QUAL/PED 52	2007.05.14 10:16:04 0013 QUAL/PED 62
2007.05.13 22:14:54 0025 QUAL/PED 53	2007.05.14 10:17:00 0019 QUAL 61
2007.05.13 22:52:32 0025 QUAL/PED 54	2007.05.14 10:22:15 0025 QUAL/PED 42
2007.05.13 23:18:53 0025 QUAL/PED 55	2007.05.14 10:26:30 0025 QUAL/PED 43
2007.05.13 23:25:43 0025 QUAL/PED 56	2007.05.14 10:34:16 0025 QUAL/PED 44
2007.05.13 23:41:43 0025 QUAL/PED 57	2007.05.14 10:43:04 0025 QUAL/PED 45
2007.05.14 01:40:31 0025 QUAL/PED 58	2007.05.14 10:46:09 0021 QUAL/PED 01
2007.05.14 02:09:03 0032 QUAL/PED 05	2007.05.14 10:46:44 0025 QUAL/PED 46
2007.05.14 02:09:58 0032 QUAL/PED 06	2007.05.14 10:50:41 0025 QUAL/PED 47
2007.05.14 02:24:22 0025 QUAL/PED 59	2007.05.14 10:51:10 0025 QUAL/PED 48
2007.05.14 03:52:09 0025 QUAL/PED 60	2007.05.14 10:56:38 0001 QUAL/PED 33
2007.05.14 05:07:07 0025 QUAL/PED 61	2007.05.14 11:00:47 0025 QUAL/PED 49
2007.05.14 05:09:08 0025 QUAL/PED 62	2007.05.14 11:02:06 0023 QUAL 02 ?

2007.05.14 05:20:28 0025 QUAL/PED 63	2007.05.14 11:10:01 0025 QUAL/PED 50
2007.05.14 05:25:37 0025 QUAL/PED 00	2007.05.14 11:12:22 0025 QUAL/PED 51
2007.05.14 05:29:43 0025 QUAL/PED 01	2007.05.14 11:27:42 0025 QUAL/PED 52
2007.05.14 05:34:28 0025 QUAL/PED 02	2007.05.14 11:32:29 0025 QUAL/PED 53
2007.05.14 05:41:29 0013 QUAL/PED 59	2007.05.14 11:36:37 0025 QUAL/PED 54
2007.05.14 05:45:19 0025 QUAL/PED 03	2007.05.14 11:41:53 0025 QUAL/PED 55
2007.05.14 05:49:16 0025 QUAL/PED 04	2007.05.14 11:42:16 0025 QUAL/PED 56
2007.05.14 05:51:26 0025 QUAL/PED 05	2007.05.14 11:42:58 0025 QUAL/PED 57
2007.05.14 05:56:33 0025 QUAL/PED 06	2007.05.14 11:51:09 0025 QUAL/PED 58
2007.05.14 06:01:52 0025 QUAL/PED 07	2007.05.14 12:02:29 0025 QUAL/PED 59
2007.05.14 06:15:20 0025 QUAL/PED 08	2007.05.14 12:05:43 0025 QUAL/PED 60
2007.05.14 06:23:28 0025 QUAL/PED 09	2007.05.14 12:13:52 0025 QUAL/PED 61
2007.05.14 06:27:11 0025 QUAL/PED 10	2007.05.14 12:19:36 0025 QUAL/PED 62
2007.05.14 06:49:17 0025 QUAL/PED 11	2007.05.14 12:19:55 0001 QUAL/PED 34
2007.05.14 06:55:29 0025 QUAL/PED 12	2007.05.14 12:27:29 0025 QUAL/PED 63
2007.05.14 07:01:51 0025 QUAL/PED 13	2007.05.14 12:46:56 0025 QUAL/PED 00
2007.05.14 12:52:11 0025 QUAL/PED 01	2007.05.14 19:46:07 0025 QUAL/PED 48
2007.05.14 12:55:42 0025 QUAL/PED 02	2007.05.14 19:54:22 0025 QUAL/PED 49
2007.05.14 13:08:19 0025 QUAL/PED 03	2007.05.14 20:11:10 0026 QUAL/PED 37
2007.05.14 13:15:58 0025 QUAL/PED 04	2007.05.14 20:11:17 0011 QUAL/PED 03
2007.05.14 13:21:53 0025 QUAL/PED 05	2007.05.14 20:15:03 0025 QUAL/PED 50
2007.05.14 13:35:23 0025 QUAL/PED 06	2007.05.14 20:29:53 0025 QUAL/PED 51
2007.05.14 13:37:51 0001 QUAL/PED 35	2007.05.14 20:37:02 0025 QUAL/PED 52
2007.05.14 13:38:26 0011 QUAL/PED 62	2007.05.14 20:40:43 0025 QUAL/PED 53
2007.05.14 13:40:32 0011 QUAL/PED 63	2007.05.14 20:43:06 0025 QUAL/PED 54
2007.05.14 13:56:24 0025 QUAL/PED 07	2007.05.14 20:55:28 0027 QUAL/PED 44
2007.05.14 13:56:58 0025 QUAL/PED 08	2007.05.14 20:57:54 0007 QUAL/PED 33
2007.05.14 13:57:56 0025 QUAL/PED 09	2007.05.14 21:21:50 0025 QUAL/PED 55
2007.05.14 14:07:28 0025 QUAL/PED 10	2007.05.14 21:24:58 0025 QUAL/PED 56
2007.05.14 14:07:37 0025 QUAL/PED 11	2007.05.14 21:51:27 0025 QUAL/PED 57

2007.05.14 14:09:59 0025 QUAL/PED 12
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2007.05.15 06:42:40 0025 QUAL/PED 17
2007.05.15 06:47:30 0025 QUAL/PED 18
2007.05.15 06:53:17 0011 QUAL/PED 04
2007.05.15 06:55:03 0025 QUAL/PED 19
2007.05.15 07:03:23 0025 QUAL/PED 20

2007.05.14 17:00:06 0001 QUAL/PED 54 ?	2007.05.15 07:07:53 0025 QUAL/PED 21
2007.05.14 17:23:35 0025 QUAL/PED 35	2007.05.15 07:09:45 0001 QUAL/PED 44
2007.05.14 17:25:20 0025 QUAL/PED 36	2007.05.15 07:19:02 0025 QUAL/PED 22
2007.05.14 17:28:26 0513 QUAL/PED 39 ?	2007.05.15 07:27:24 0025 QUAL/PED 23
2007.05.14 17:34:37 0025 QUAL/PED 37	2007.05.15 07:39:14 0025 QUAL/PED 24
2007.05.14 17:45:36 0011 QUAL/PED 01	2007.05.15 07:39:50 0025 QUAL/PED 25
2007.05.14 17:46:42 0001 QUAL/PED 40	2007.05.15 07:40:25 0013 QUAL/PED 63
2007.05.14 17:53:42 0025 QUAL/PED 38	2007.05.15 07:40:36 0025 QUAL/PED 26
2007.05.14 17:54:48 0025 QUAL/PED 39	2007.05.15 07:45:38 0025 QUAL/PED 27
2007.05.14 17:56:13 0025 QUAL/PED 40	2007.05.15 07:50:05 0025 QUAL/PED 28
2007.05.14 18:04:22 0025 QUAL/PED 41	2007.05.15 07:51:25 0025 QUAL/PED 29
2007.05.14 18:05:35 0025 QUAL/PED 42	2007.05.15 07:58:13 0001 QUAL/PED 46
2007.05.14 18:16:19 0025 QUAL/PED 43	2007.05.15 07:58:17 0025 QUAL/PED 30
2007.05.14 18:18:10 0025 QUAL/PED 44	2007.05.15 08:29:23 0025 QUAL/PED 31
2007.05.14 18:23:53 0025 QUAL/PED 45	2007.05.15 08:32:00 0013 QUAL/PED 00
2007.05.14 18:24:37 0001 QUAL/PED 41	2007.05.15 08:40:16 0025 QUAL/PED 32
2007.05.14 18:28:04 0025 QUAL/PED 46	2007.05.15 08:52:06 0001 QUAL/PED 47
2007.05.14 18:30:55 0025 QUAL/PED 47	2007.05.15 08:52:09 0025 QUAL/PED 33
2007.05.14 18:58:57 0011 QUAL/PED 02	2007.05.15 08:56:15 0025 QUAL/PED 34
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2007.05.15 09:15:26 0025 QUAL/PED 35	2007.05.15 14:24:04 0025 QUAL/PED 20
2007.05.15 09:23:44 0025 QUAL/PED 36	2007.05.15 14:29:39 0025 QUAL/PED 21
2007.05.15 09:25:53 0025 QUAL/PED 37	2007.05.15 14:30:44 0001 QUAL/PED 57
2007.05.15 09:29:12 0025 QUAL/PED 38	2007.05.15 14:33:16 0025 QUAL/PED 22
2007.05.15 09:29:44 0025 QUAL/PED 39	2007.05.15 14:42:27 0033 QUAL/PED 13
2007.05.15 09:31:20 0025 QUAL/PED 40	2007.05.15 14:50:20 0025 QUAL/PED 23
2007.05.15 09:35:32 0025 QUAL/PED 41	2007.05.15 14:52:00 0025 QUAL/PED 24
2007.05.15 09:39:41 0025 QUAL/PED 42	2007.05.15 14:52:57 0025 QUAL/PED 25
2007.05.15 09:40:09 0025 QUAL/PED 43	2007.05.15 14:54:04 0025 QUAL/PED 26
2007.05.15 09:54:25 0001 QUAL/PED 48	2007.05.15 14:58:39 0025 QUAL/PED 27

2007.05.15 09:58:58 0025 QUAL/PED 44	2007.05.15 15:06:50 0025 QUAL/PED 28
2007.05.15 10:01:46 0025 QUAL/PED 45	2007.05.15 15:35:05 0025 QUAL/PED 29
2007.05.15 10:06:08 0001 QUAL/PED 49	2007.05.15 15:45:32 0025 QUAL/PED 30
2007.05.15 10:16:09 0019 QUAL/PED 00	2007.05.15 15:49:35 0030 QUAL/PED 06
2007.05.15 10:16:42 0025 QUAL/PED 46	2007.05.15 15:50:31 0016 QUAL/PED 54
2007.05.15 10:16:50 0011 QUAL/PED 05	2007.05.15 15:58:43 0025 QUAL/PED 31
2007.05.15 10:19:29 0025 QUAL/PED 47	2007.05.15 16:04:27 0025 QUAL/PED 32
2007.05.15 10:24:13 0025 QUAL/PED 48	2007.05.15 16:08:11 0025 QUAL/PED 33
2007.05.15 10:27:41 0025 QUAL/PED 49	2007.05.15 16:21:29 0025 QUAL/PED 34
2007.05.15 10:34:55 0025 QUAL/PED 50	2007.05.15 16:30:23 0025 QUAL/PED 35
2007.05.15 10:44:09 0025 QUAL/PED 51	2007.05.15 16:47:14 0025 QUAL/PED 36
2007.05.15 10:50:46 0025 QUAL/PED 52	2007.05.15 16:47:58 0001 QUAL/PED 58
2007.05.15 10:58:52 0025 QUAL/PED 53	2007.05.15 16:48:04 0011 QUAL/PED 08
2007.05.15 11:03:05 4097 QUAL/PED 50 ?	2007.05.15 16:48:18 0025 QUAL/PED 37
2007.05.15 11:04:26 0025 QUAL/PED 54	2007.05.15 16:52:36 0025 QUAL/PED 38
2007.05.15 11:05:18 0025 QUAL/PED 55	2007.05.15 16:55:54 0025 QUAL/PED 39
2007.05.15 11:12:08 0025 QUAL/PED 56	2007.05.15 17:07:37 0025 QUAL/PED 40
2007.05.15 11:15:42 0025 QUAL/PED 57	2007.05.15 17:16:10 0025 QUAL/PED 41
2007.05.15 11:26:46 0025 QUAL/PED 58	2007.05.15 17:24:09 0011 QUAL/PED 09
2007.05.15 11:28:42 0025 QUAL/PED 59	2007.05.15 17:30:38 0025 QUAL/PED 42
2007.05.15 11:28:57 0025 QUAL/PED 60	2007.05.15 17:32:18 0025 QUAL/PED 43
2007.05.15 11:30:33 0033 QUAL/PED 12	2007.05.15 17:45:22 0025 QUAL/PED 44
2007.05.15 11:30:36 0019 QUAL/PED 01	2007.05.15 17:45:31 0001 QUAL/PED 59
2007.05.15 11:34:29 0025 QUAL/PED 61	2007.05.15 17:46:34 0001 QUAL/PED 60
2007.05.15 11:46:56 0025 QUAL/PED 62	2007.05.15 17:51:12 0025 QUAL/PED 45
2007.05.15 11:50:03 0025 QUAL/PED 63	2007.05.15 17:57:31 0025 QUAL/PED 46
2007.05.15 11:58:00 0001 QUAL/PED 51	2007.05.15 18:05:55 0025 QUAL/PED 47
2007.05.15 12:04:38 0025 QUAL/PED 00	2007.05.15 18:21:18 0011 QUAL/PED 10
2007.05.15 12:12:02 0025 QUAL/PED 01	2007.05.15 18:24:15 0025 QUAL/PED 48
2007.05.15 12:22:35 0025 QUAL/PED 02	2007.05.15 18:38:43 0025 QUAL/PED 49

2007.05.15 12:25:17 0025 QUAL/PED 03	2007.05.15 18:40:50 0011 QUAL/PED 11
2007.05.15 12:33:22 0025 QUAL/PED 04	2007.05.15 19:00:34 0025 QUAL/PED 50
2007.05.15 12:35:53 0011 QUAL/PED 06	2007.05.15 19:03:39 0028 QUAL/PED 27
2007.05.15 12:36:04 0025 QUAL/PED 05	2007.05.15 19:19:54 0025 QUAL/PED 51
2007.05.15 12:36:58 0025 QUAL/PED 06	2007.05.15 19:37:23 0025 QUAL/PED 52
2007.05.15 12:48:09 0025 QUAL/PED 07	2007.05.15 19:40:07 0025 QUAL/PED 53
2007.05.15 12:50:56 0001 QUAL/PED 53	2007.05.15 19:57:13 0025 QUAL/PED 54
2007.05.15 12:51:06 0025 QUAL/PED 08	2007.05.15 20:04:03 0025 QUAL/PED 55
2007.05.15 13:04:29 0025 QUAL/PED 09	2007.05.15 20:08:07 0025 QUAL/PED 56
2007.05.15 13:09:30 0025 QUAL/PED 10	2007.05.15 20:09:08 0025 QUAL/PED 57
2007.05.15 13:12:42 0025 QUAL/PED 11	2007.05.15 20:27:34 0025 QUAL/PED 58
2007.05.15 13:25:54 0025 QUAL/PED 12	2007.05.15 20:54:02 0025 QUAL/PED 59
2007.05.15 13:29:46 0025 QUAL/PED 13	2007.05.15 21:04:25 0011 QUAL/PED 12
2007.05.15 13:31:50 0001 QUAL/PED 54	2007.05.15 21:37:16 0025 QUAL/PED 60
2007.05.15 13:38:07 0025 QUAL/PED 14	2007.05.15 21:54:22 0025 QUAL/PED 61
2007.05.15 13:49:08 0001 QUAL/PED 55	2007.05.15 23:04:29 0025 QUAL/PED 62
2007.05.15 13:53:16 0025 QUAL/PED 15	2007.05.15 23:19:18 0025 QUAL/PED 63
2007.05.15 13:55:27 0025 QUAL/PED 16	2007.05.15 23:34:28 0025 QUAL/PED 00
2007.05.15 13:55:38 0025 QUAL/PED 17	2007.05.15 23:44:20 0025 QUAL/PED 01
2007.05.15 14:02:05 0025 QUAL/PED 18	2007.05.15 23:53:48 0025 QUAL/PED 02
2007.05.15 14:07:19 0011 QUAL/PED 07	2007.05.16 00:30:51 0025 QUAL/PED 03
2007.05.15 14:09:56 0001 QUAL/PED 56	2007.05.16 02:44:30 0025 QUAL/PED 04
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APPENDIX C

DETECTOR RECORDS

- **FROM 10/20/07 THROUGH 10/31/07**
- **FROM 04/21/08 THROUGH 04/23/08**
- **FROM 04/25/08 THROUGH 04/26/08**

2007.10.20 16:29:45 0009 QUAL/PED 22
2007.10.20 20:35:51 0016 QUAL/PED 03
2007.10.20 20:49:22 0018 QUAL/PED 04
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2007.10.24 08:06:46 0258 Event 24 46 ?
2007.10.24 08:06:49 0537 QUAL/PED 18 ?
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2008.04.26 06:02:01 0014 PED 54 51 04 ?
2008.04.26 06:05:37 0014 PED 55 37 03 ?
2008.04.26 06:05:39 0014 PED 55 37 ?AL/PED 04
2008.04.26 06:05:41 0014 PED 55 52/PED 05
2008.04.26 06:06:18 0014 PED 56 52 10
2008.04.26 06:06:20 0014 29 0
2008.04.26 06:06:23 0014 PED 56
2008.04.26 06:06:44 0014 PED 57 ?
2008.04.26 06:06:46 0014 PED 57 53
2008.04.26 06:06:49 0014 PED 57 53
2008.04.26 06:07:57 0014 PED 58 53 ?
2008.04.26 06:07:59 0014 PED 58 47 08 ?B
2008.04.26 06:08:01 0014 PED 58 47AL/PED 11
2008.04.26 06:08:16 0014 PED 59 54AL/PED 11
2008.04.26 06:08:18 0014 PED 59 47AL/PED 11
2008.04.26 06:08:20 0014 PED 59 54AL/PED 09
2008.04.26 06:08:32 0014 PED 60 54AL/PED 20
2008.04.26 06:08:35 0014 PED 60 55AL/PED 20
2008.04.26 06:08:37 0014 PED 60 55AL/PED 20
2008.04.26 06:08:53 0025 01
2008.04.26 06:08:55 0013 QUAL/PED 36
2008.04.26 06:08:57 0013 QUAL/PED 36 ?
2008.04.26 06:09:00 0013 QUAL/PED 36 12 ?
2008.04.26 06:09:24 0014 PED 61t 56 29 ?
2008.04.26 06:09:26 0014 PED 61QUAL/PED 08
2008.04.26 06:09:28 0014 PED 61QUAL/PED 08
2008.04.26 06:09:51 0014 PED 62QUAL/PED 08
2008.04.26 06:09:53 0014 PED 62QUAL/PED 13
2008.04.26 06:09:56 0014 PED 62QUAL/PED 13
2008.04.26 06:10:04 0014 PED 63 ?AL/PED 13
2008.04.26 06:10:06 0014 PED 63 40t 56 15 ?
2008.04.26 06:10:08 0014 PED 63 56QUAL/PED 18
2008.04.26 06:10:58 0014 PED 00 56QUAL/PED 50 ?
2008.04.26 06:11:00 0014 01
2008.04.26 06:11:02 0014 PED 00
2008.04.26 06:13:13 0020 QUAL/PED 16
2008.04.26 06:13:16 0020 QUAL/PED 16
2008.04.26 06:13:18 0020 QUAL/PED 16
2008.04.26 06:13:24 0019 QUAL/PED 23 ?
2008.04.26 06:13:26 0020 QUAL/PED 17 12
2008.04.26 06:13:28 0020 QUAL/PED 17 12

```
2008.04.26 06:13:31 0020 QUAL/PED  17  12
2008.04.26 06:13:39 0019 QUAL/PED  24  04
2008.04.26 06:13:42 0019 QUAL/PED  24  07
2008.04.26 06:13:44 0020 QUAL/PED  18  07
2008.04.26 06:13:46 0020 QUAL/PED  18  07
2008.04.26 06:13:48 0020 QUAL/PED  18  05
2008.04.26 06:13:54 0019 00
2008.04.26 06:13:56 0019 QUAL/PED  257
2008.04.26 06:13:59 0019 QUAL/PED  257
2008.04.26 06:14:46 0014 PED       017
2008.04.26 06:14:48 0014 PED       018
2008.04.26 06:14:50 0014 PED       018
2008.04.26 06:15:00 0014 PED       028
2008.04.26 06:15:02 0014 PED       020
2008.04.26 06:15:05 0014 PED       026
2008.04.26 06:16:35 0014 PED       037
2008.04.26 06:16:38 0014 PED       033
2008.04.26 06:16:40 0014 PED       030
2008.04.26 06:29:46 0014 PED       040
2008.04.26 06:29:48 0014 PED       040
2008.04.26 06:29:51 0014
2008.04.26 06:30:01 0014 PED       05
2008.04.26 06:30:04 0014 PED       05
2008.04.26 06:30:06 0014 PED       05
2008.04.26 06:33:41 0014 PED       06
2008.04.26 06:33:44 0014 PED       06
2008.04.26 06:33:46 0014 PED       06
2008.04.26 06:33:56 0014 PED       07
2008.04.26 06:33:59 0014 PED       07
2008.04.26 06:34:01 0014 PED       07
2008.04.26 06:34:26 0014 PED       08
2008.04.26 06:34:27 0010 QUAL/PED  35
2008.04.26 06:34:28 0014 PED       08
2008.04.26 06:34:29 0010 QUAL/PED  35
2008.04.26 06:34:30 0014
2008.04.26 06:34:32 0010 QUAL/PED  35
2008.04.26 06:34:42 0014 PED       09
2008.04.26 06:34:44 0014 PED       09
2008.04.26 06:34:47 0014 PED       09
2008.04.26 06:37:39 0014 PED       10
2008.04.26 06:37:41 0014 PED       10
2008.04.26 06:37:44 0014 PED       10
2008.04.26 06:38:04 0014 PED       11
2008.04.26 06:38:06 0014 PED       11
2008.04.26 06:38:09 0014 PED       11
2008.04.26 06:39:06 0014 LEFT      12
2008.04.26 06:39:09 0014 LEFT      12
2008.04.26 06:39:11 0014 LEFT      12
2008.04.26 06:39:58 0016
2008.04.26 06:40:01 0016 QUAL/PED  20
2008.04.26 06:40:03 0016 QUAL/PED  20 ?
2008.04.26 06:40:28 0014 PED       13 ?02
2008.04.26 06:40:30 0014 PED       13  04
2008.04.26 06:40:33 0014 PED       13  04
```

2008.04.26 06:40:57 0022 QUAL/PED 01 04
2008.04.26 06:40:59 0022 QUAL/PED 01 48 ?B
2008.04.26 06:41:02 0022 QUAL/PED 01   0509
2008.04.26 06:45:30 0014 PED   14   0511
2008.04.26 06:45:32 0014 PED   14   0512
2008.04.26 06:45:35 0014 PED   14   0614 ?
2008.04.26 06:47:15 0018 QUAL/PED 63   06ED 63 ?
2008.04.26 06:47:17 0018 QUAL/PED 63   06AL/PED 00
2008.04.26 06:47:19 0018 11 0
2008.04.26 06:47:20 0014 PED   15
2008.04.26 06:47:22 0014 PED   15
2008.04.26 06:47:24 0014 PED   15
2008.04.26 06:47:42 0014 PED   16
2008.04.26 06:47:45 0014 PED   16
2008.04.26 06:47:47 0014 PED   16
2008.04.26 06:48:30 0014 PED   17
2008.04.26 06:48:32 0014 PED   17
2008.04.26 06:48:34 0014 PED   17
2008.04.26 06:48:51 0014 PED   18
2008.04.26 06:48:54 0014 PED   18
2008.04.26 06:48:56 0014 PED   18 ?
2008.04.26 06:50:12 0014 PED   19 09
2008.04.26 06:50:14 0014 01
2008.04.26 06:50:17 0014 PED   19
2008.04.26 06:52:05 0013 QUAL/PED 37
2008.04.26 06:52:07 0013 QUAL/PED 37
2008.04.26 06:52:08 0014 PED   20
2008.04.26 06:52:09 0013 QUAL/PED 37
2008.04.26 06:52:11 0014 PED   20
2008.04.26 06:52:13 0014 PED   20
2008.04.26 06:53:12 0014 PED   21
2008.04.26 06:53:14 0014 PED   21 ?
2008.04.26 06:53:16 0014 PED   21 19 ?
2008.04.26 06:53:46 0014 PED   22/PED 20 ?
2008.04.26 06:53:49 0014 PED   22QUAL/PED 00
2008.04.26 06:53:51 0014 PED   22QUAL/PED 00 ?
2008.04.26 06:55:56 0014
2008.04.26 06:55:58 0014 PED   23
2008.04.26 06:56:01 0014 PED   23
2008.04.26 06:56:41 0014 PED   24 ?B
2008.04.26 06:56:44 0014 PED   24ED 52 ?
2008.04.26 06:56:46 0014 PED   24AL/PED 05
2008.04.26 06:57:22 0024 QUAL/PED 10AL/PED 13
2008.04.26 06:57:24 0024 QUAL/PED 10AL/PED 13
2008.04.26 06:58:37 0014 PED   25AL/PED 13
2008.04.26 06:58:39 0014 PED   25AL/PED 14
2008.04.26 06:58:41 0014 PED   25AL/PED 14
2008.04.26 06:59:47 0014 PED   26AL/PED 14
2008.04.26 06:59:50 0014 PED   26AL/PED 03
2008.04.26 06:59:52 0014 PED   26AL/PED 03
2008.04.26 07:00:26 0014 4:48
2008.04.26 07:00:29 0014 PED   27
2008.04.26 07:00:31 0014 PED   27
2008.04.26 07:00:51 0014 PED   28

```
2008.04.26 07:00:54 0014 PED       28
2008.04.26 07:00:56 0014 PED       28
2008.04.26 07:05:30 0014 PED       29 ?
2008.04.26 07:05:33 0014 PED       29  01
2008.04.26 07:05:35 0014 PED       29  04
2008.04.26 07:09:06 0014 PED       30  04
2008.04.26 07:09:08 0014 PED       30  04
2008.04.26 07:09:11 0014 PED       30  01
2008.04.26 07:10:19 0014 PED       31  01
2008.04.26 07:10:22 0014 PED       31  01
2008.04.26 07:10:24 0014 02
2008.04.26 07:12:13 0014 PED       32
2008.04.26 07:12:15 0014 PED       32
2008.04.26 07:12:18 0014 PED       32
2008.04.26 07:12:34 0014 PED       33
2008.04.26 07:12:37 0014 PED       33 ?
2008.04.26 07:12:39 0014 PED       33  45
2008.04.26 07:13:35 0014 PED       34  45
2008.04.26 07:13:38 0014 PED       34  23
2008.04.26 07:13:40 0014 PED       34  23 ?
2008.04.26 07:16:01 0014 PED       35  23  02
2008.04.26 07:16:03 0014 PED       35  46  02
2008.04.26 07:16:06 0014 PED       35  46  02
2008.04.26 07:17:17 0014 PED       36  46  03
2008.04.26 07:17:19 0014 01 0
2008.04.26 07:17:22 0014 PED       36
2008.04.26 07:18:25 0014 PED       37
2008.04.26 07:18:28 0014 PED       37
2008.04.26 07:18:30 0014 PED       37
2008.04.26 07:23:43 0014 PED       38
2008.04.26 07:23:46 0014 PED       38
2008.04.26 07:23:48 0014 PED       38
2008.04.26 07:23:57 0014 PED       39
2008.04.26 07:23:59 0014 PED       39
2008.04.26 07:24:02 0014 PED       39
2008.04.26 07:24:21 0014 PED       40
2008.04.26 07:24:23 0014 PED       40
2008.04.26 07:24:26 0014 PED       40
2008.04.26 07:24:51 0014
2008.04.26 07:24:53 0014 PED       41
2008.04.26 07:24:56 0014 PED       41
2008.04.26 07:27:25 0014 PED       42
2008.04.26 07:27:28 0014 PED       42 ?
2008.04.26 07:27:30 0014 PED       42  31
2008.04.26 07:27:54 0014 PED       43  31
2008.04.26 07:27:56 0014 PED       43  32
2008.04.26 07:27:59 0014 PED       43  32
2008.04.26 07:36:54 0014 PED       447 32 ?
2008.04.26 07:36:57 0014 PED       44      33 ?
2008.04.26 07:36:59 0014 PED       44QUAL/PED  33
2008.04.26 07:37:22 0014 PED       45QUAL/PED  00
2008.04.26 07:37:24 0014 PED       45QUAL/PED  00
2008.04.26 07:37:27 0014
2008.04.26 07:37:42 0014 PED       46
```

2008.04.26 07:37:44 0014 PED 46 ?
2008.04.26 07:37:47 0014 PED 46 15
2008.04.26 07:38:06 0014 PED 47 15
2008.04.26 07:38:08 0014 PED 47 15
2008.04.26 07:38:10 0014 PED 47 ?B5
2008.04.26 07:39:35 0014 PED 48ED 15
2008.04.26 07:39:37 0014 PED 48ED 15
2008.04.26 07:39:40 0014 PED 48ED 15
2008.04.26 07:41:35 0014 PED 49ED 04
2008.04.26 07:41:38 0014 PED 49ED 05
2008.04.26 07:41:40 0014 PED 49ED 58
2008.04.26 07:42:45 0014 PED 50 40 05 ?
2008.04.26 07:42:48 0014 6:10
2008.04.26 07:42:50 0014 PED 50
2008.04.26 07:43:59 0014 PED 51
2008.04.26 07:44:01 0014 PED 51
2008.04.26 07:44:04 0014 PED 51
2008.04.26 07:45:17 0014 PED 52
2008.04.26 07:45:20 0014 PED 52
2008.04.26 07:45:22 0014 PED 52
2008.04.26 07:48:59 0014 PED 53
2008.04.26 07:49:01 0014 PED 53
2008.04.26 07:49:04 0014 PED 53
2008.04.26 07:53:22 0014 PED 54
2008.04.26 07:53:24 0014 PED 54 ?
2008.04.26 07:53:26 0014 PED 54 03
2008.04.26 07:55:03 0019 00
2008.04.26 07:55:05 0019 QUAL/PED 26
2008.04.26 07:55:08 0019 QUAL/PED 26
2008.04.26 07:56:08 0013 QUAL/PED 38
2008.04.26 07:56:11 0013 QUAL/PED 38
2008.04.26 07:56:13 0013 QUAL/PED 38
2008.04.26 07:58:31 0014 PED 55
2008.04.26 07:58:34 0014 PED 55
2008.04.26 07:58:36 0014 PED 55
2008.04.26 07:58:53 0014 PED 56
2008.04.26 07:58:55 0014 PED 56
2008.04.26 07:58:57 0014 PED 56
2008.04.26 07:59:05 0014 RIGHT 57
2008.04.26 07:59:07 0014 RIGHT 57
2008.04.26 07:59:10 0014
2008.04.26 08:00:11 0014 PED 58
2008.04.26 08:00:13 0014 PED 58
2008.04.26 08:00:15 0014 PED 58
2008.04.26 08:00:52 0014 PED 59
2008.04.26 08:00:55 0014 PED 59
2008.04.26 08:00:57 0014 PED 59
2008.04.26 08:03:08 0014 PED 60
2008.04.26 08:03:11 0014 PED 60
2008.04.26 08:03:13 0014 PED 60
2008.04.26 08:04:30 0014 PED 61
2008.04.26 08:04:32 0014 PED 61
2008.04.26 08:04:34 0014 PED 61
2008.04.26 08:05:40 0014 PED 62

2008.04.26 08:05:42 0014
2008.04.26 08:05:45 0014 PED 62
2008.04.26 08:09:55 0014 PED 63
2008.04.26 08:09:58 0014 PED 63 ?
2008.04.26 08:10:00 0014 PED 63 21
2008.04.26 08:11:03 0014 PED 00 44
2008.04.26 08:11:05 0014 PED 00 44
2008.04.26 08:11:08 0014 PED 00 44
2008.04.26 08:13:08 0014 PED 01 45
2008.04.26 08:13:10 0014 PED 01 45
2008.04.26 08:13:13 0014 PED 01 45
2008.04.26 08:17:05 0014 PED 02 46
2008.04.26 08:17:07 0014 PED 02 46
2008.04.26 08:17:10 0014 PED 02 46
2008.04.26 08:19:55 0014 01
2008.04.26 08:19:58 0014 PED 03
2008.04.26 08:20:00 0014 PED 03
2008.04.26 08:20:37 0019 QUAL/PED 27 ?
2008.04.26 08:20:40 0019 QUAL/PED 27 23
2008.04.26 08:20:42 0019 QUAL/PED 27 23
2008.04.26 08:21:14 0014 PED 04
2008.04.26 08:21:16 0014 PED 04
2008.04.26 08:21:19 0014 PED 04
2008.04.26 08:22:32 0014 PED 05
2008.04.26 08:22:34 0014 PED 05
2008.04.26 08:22:36 0014 PED 05
2008.04.26 08:26:11 0014 PED 06
2008.04.26 08:26:14 0014 PED 06
2008.04.26 08:26:16 0014 PED 06
2008.04.26 08:35:38 0014 PED 07
2008.04.26 08:35:40 0014 PED 07
2008.04.26 08:35:42 0014 PED 07
2008.04.26 08:39:36 0014 PED 08
2008.04.26 08:39:38 0014 PED 08
2008.04.26 08:39:41 0014 PED 08
2008.04.26 08:42:09 0014 PED 09
2008.04.26 08:42:11 0014 PED 09
2008.04.26 08:42:14 0014 PED 09
2008.04.26 08:44:18 0014 PED 10
2008.04.26 08:44:21 0014 PED 10
2008.04.26 08:44:23 0014 PED 10
2008.04.26 08:49:48 0014 PED 11
2008.04.26 08:49:50 0014 PED 11
2008.04.26 08:49:53 0014 PED 11

APPENDIX D

STATISTICAL ANALYSES SAS PROGRAM INPUT

```
data eighth;
      input HITS TOD VOLUME HEAVY AVGSPEED_M AVGSPEED_S;
      cards;
4     1     41    4     70.24390244 67.06818182
4     1     28    2     70.64285714 64.44827586
0     1     33    2     71.27272727 63.54285714
1     1     30    2     70.53333333 64.57142857
2     1     25    4     69    64.96153846
1     1     24    0     71.54166667 62.5
0     1     17    0     71.17647059 64.15789474
2     1     26    4     67.34615385 61.92
1     1     26    4     66.19230769 63.25925926
1     0     16    0     55.375      59.35294118
1     0     17    0     66.11764706 58.47058824
0     0     13    0     70.07692308 61.57142857
1     0     17    0     68.41176471 59.1875
0     0     10    0     76.6  68.18181818
0     0     3     0     76.66666667 66
0     0     4     0     68.25 56.5
0     0     4     0     64.75 57.5
0     0     4     2     70.5  59
0     0     3     0     71    62.33333333
0     0     1     0     71    59
0     0     2     0     66    52
3     0     1     0     69    67
0     0     1     0     51    62
0     0     2     0     60    57.5
1     0     3     0     74    70
5     0     3     0     64.66666667 58.66666667
3     0     10    0     68    62.3
4     0     16    2     66.5625     60.125
1     1     17    0     64.64705882 57.5625
9     1     35    0     67.11428571 58.08571429
10    1     62    6     65.79032258 60.61904762
15    1     88    6     68.29545455 62.85227273
7     1     53    2     67.98113208 63.94545455
4     1     34    6     69.11764706 63.2
3     1     43    6     67.18604651 63.71428571
0     1     45    4     69.97777778 65.77083333
0     1     44    4     68.70454545 62.51111111
0     1     43    0     68.93023256 62.54761905
0     1     45    4     68.31111111 64.6
0     1     49    4     69.95918367 64.60784314
3     1     29    4     69.93103448 65
1     1     49    4     68.83673469 64.32653061
3     1     34    2     70.67647059 65.71428571
10    1     46    0     69    67.85106383
6     1     30    6     68.83333333 65
0     1     58    2     72.05172414 65.45762712
4     1     42    2     70.30952381 64.97727273
2     1     39    4     70.79487179 65.47619048
3     1     41    4     70.12195122 66.88636364
0     1     56    4     71.14285714 66.26415094
3     1     45    0     67.62222222 63.8125
4     1     46    4     71.58695652 65.61538462
```

```
2       1       34      0       72.11764706 65.02777778
0       1       20      8       69.8    64.71428571
0       1       20      0       68.7    62
1       1       29      2       67.68965517 65.86666667
0       1       23      2       67.69565217 61.6
0       0       16      0       69.125      62
0       0       11      0       65.90909091 58.16666667
0       0       11      4       68      60.53846154
4       0       11      0       67.18181818 61.66666667
1       0       8       0       67.75 61.125
0       0       4       0       68      60.75
1       0       5       0       67.4    65.4
1       0       3       0       64      61.8
0       0       1       0       62      54
0       0       1       0       74      60
0       0       2       0       70.5    55
0       0       1       0       67      64
0       0       1       0       67      58
0       0       2       0       76.5    66
2       0       6       2       66.16666667 63.2
1       0       11      0       69      65.09090909
2       0       15      2       67.33333333 58.86666667
4       1       23      0       65.30434783 62.65217391
5       1       42      0       69.0952381  62.46341463
16      1       55      6       66.12727273 61.40384615
8       1       96      0       65.94791667 62.01010101
7       1       49      4       68.30612245 63.83673469
6       1       44      4       68.68181818 65.44680851
4       1       30      4       67.8    64.1
        ;
data eleventh;
        input HITS TOD VOLUME HEAVY AVGSPEED_M AVGSPEED_S;
        cards;
        7       1       42      6       70.02380952 63.42857143
        3       1       43      4       70.65116279 63.5
        2       1       38      2       69.28947368 63.94594595
        1       1       35      4       68.88571429 64.73684211
        0       1       32      4       66.5    61.84375
        2       1       45      2       68.66666667 65.1875
        2       1       40      4       68.925      63.52380952
        2       1       47      2       69.61702128 63.97727273
        1       1       33      2       69      62.08333333
        1       1       29      4       70.20689655 66.74193548
        2       1       36      6       70.11111111 65.97222222
        4       1       37      2       70.27027027 65.8
        1       1       36      2       69.27777778 64.09090909
        2       1       36      4       67.02777778 63.72222222
        1       1       37      4       69      65.02631579
        0       1       40      6       67.825      66.7
        0       1       44      0       69.5    64.60416667
        1       1       40      4       68.925      65.20454545
        0       1       41      0       70.19512195 64.05
        5       1       27      0       69.96296296 66.20689655
        1       1       39      4       68.69230769 64.45
        2       1       23      0       68.65217391 63.83333333
```

```
	7	1	21	2	68.61904762 62.77272727
	0	1	24	0	68.33333333 66.20833333
	1	1	16	2	65.5	58.42857143
	1	1	15	0	64.66666667 61.27777778
	9	0	7	0	66	60.28571429
	2	0	8	0	60.125	55.625
	1	0	9	2	70	61.5
	6	0	3	0	69.66666667 60.33333333
	11	0	5	0	65.6	51.6
	8	0	3	0	61.66666667 53
	6	0	5	0	66.4	53
	;

proc reg data=eighth;
model AVGSPEED_S = VOLUME TOD;
run;

proc reg data=eighth;
model AVGSPEED_M = VOLUME TOD;
run;

proc reg data=eighth;
model AVGSPEED_S = HITS TOD;
run;

proc reg data=eighth;
model AVGSPEED_M = HITS TOD;
run;

proc reg data=eleventh;
model AVGSPEED_S = VOLUME TOD;
run;

proc reg data=eleventh;
model AVGSPEED_M = VOLUME TOD;
run;

proc reg data=eleventh;
model AVGSPEED_S = HITS TOD;
run;

proc reg data=eleventh;
model AVGSPEED_M = HITS TOD;
run;

proc reg data=eleventh;
model AVGSPEED_S = TOD;
run;

quit;
```

```
data signB0421;
      input HITS TOD Sign_B_Speed;
      cards;
2       1      70.53
0       1      71.75
1       1      68.91
1       1      69.87
0       1      69.05
0       1      68.32
1       1      70.86
1       1      69.60
0       0      64.00
0       0      62.10
4       0      57.35
0       0      62.50
1       0      63.43
0       0      66.67
1       0      66.86
1       0      61.00
4       0      54.00
0       0      54.00
3       0      59.67
1       0      57.00
0       0      57.00
1       0      48.00
1       0      40.00
1       0      62.80
1       0      65.50
2       0      62.86
10      0      66.50
8       0      67.86
3       1      67.37
5       1      66.89
2       1      66.39
2       1      67.28
2       1      66.70
0       1      66.98
2       1      68.91
1       1      69.44
1       1      67.23
5       1      68.32
1       1      66.63
4       1      67.70
0       1      70.71
1       1      69.13
4       1      71.22
2       1      69.90
0       1      66.19
1       1      68.40
0       1      68.63
0       1      69.47
0       1      72.38
16      1      68.29
0       1      66.66
0       1      67.76
```

```
0      1      70.11
0      1      65.25
0      1      63.86
0      0      66.85
0      0      54.93
0      0      64.64
0      0      56.50
0      0      51.00
0      0      67.33
0      0      57.33
0      0      58.00
       ;
       proc reg data=signB0421;
model Sign_B_Speed = HITS TOD;
run;
```

APPENDIX E

SAS OUTPUT TO TEST THE EFFECTIVENESS

OF THE DRIVER WARNING SYSTEM

Model: MODEL1
Dependent Variable: AVGSPEED_S

Number of Observations Read	81
Number of Observations Used	81

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	176.86300	88.43150	9.54	0.0002
Error	78	723.16438	9.27134		
Corrected Total	80	900.02739			

Root MSE	3.04489	R-Square	0.1965
Dependent Mean	62.54621	Adj R-Sq	0.1759
Coeff Var	4.86822		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	60.85036	0.53845	113.01	<.0001
VOLUME	1	0.00703	0.02711	0.26	0.7960
TOD	1	2.73578	1.12622	2.43	0.0174

Model: MODEL1

Dependent Variable: AVGSPEED_M

Number of Observations Read	81
Number of Observations Used	81

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	37.25753	18.62876	1.34	0.2675
Error	78	1083.43805	13.89023		
Corrected Total	80	1120.69557			

Root MSE	3.72696	R-Square	0.0332
Dependent Mean	68.35779	Adj R-Sq	0.0085
Coeff Var	5.45214		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	67.74288	0.65906	102.79	<.0001
VOLUME	1	-0.01632	0.03318	-0.49	0.6242
TOD	1	1.84198	1.37850	1.34	0.1854

Model: MODEL1

Dependent Variable: AVGSPEED_S

Number of Observations Read	81
Number of Observations Used	81

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	178.80849	89.40424	9.67	0.0002
Error	78	721.21890	9.24640		
Corrected Total	80	900.02739			

Root MSE	3.04079	R-Square	0.1987
Dependent Mean	62.54621	Adj R-Sq	0.1781
Coeff Var	4.86167		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	60.94836	0.51606	118.10	<.0001
HITS	1	-0.05959	0.11305	-0.53	0.5996
TOD	1	3.12376	0.74100	4.22	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_M

Number of Observations Read	81
Number of Observations Used	81

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	65.50705	32.75352	2.42	0.0955
Error	78	1055.18853	13.52806		
Corrected Total	80	1120.69557			

Root MSE	3.67805	R-Square	0.0585
Dependent Mean	68.35779	Adj R-Sq	0.0343
Coeff Var	5.38059		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	67.81452	0.62421	108.64	<.0001
HITS	1	-0.20902	0.13674	-1.53	0.1304
TOD	1	1.84648	0.89629	2.06	0.0427

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_S

Number of Observations Read	33
Number of Observations Used	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	341.91476	170.95738	30.24	<.0001
Error	30	169.62135	5.65405		
Corrected Total	32	511.53612			

Root MSE	2.37782	R-Square	0.6684
Dependent Mean	62.50488	Adj R-Sq	0.6463
Coeff Var	3.80422		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	55.91060	0.95005	58.85	<.0001
VOLUME	1	0.09925	0.05390	1.84	0.0755
TOD	1	4.79681	1.85106	2.59	0.0146

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_M

Number of Observations Read	33
Number of Observations Used	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	73.51123	36.75561	9.45	0.0007
Error	30	116.64357	3.88812		
Corrected Total	32	190.15480			

Root MSE	1.97183	R-Square	0.3866
Dependent Mean	68.11463	Adj R-Sq	0.3457
Coeff Var	2.89487		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	65.07273	0.78784	82.60	<.0001
VOLUME	1	0.09873	0.04470	2.21	0.0350
TOD	1	0.30659	1.53501	0.20	0.8430

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_S

Number of Observations Read	33
Number of Observations Used	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	333.71187	166.85593	28.15	<.0001
Error	30	177.82425	5.92747		
Corrected Total	32	511.53612			

Root MSE	2.43464	R-Square	0.6524
Dependent Mean	62.50488	Adj R-Sq	0.6292
Coeff Var	3.89512		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	58.03083	1.46660	39.57	<.0001
HITS	1	-0.25283	0.18590	-1.36	0.1840
TOD	1	6.57324	1.30439	5.04	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_M

Number of Observations Read	33
Number of Observations Used	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	55.85105	27.92553	6.24	0.0054
Error	30	134.30375	4.47679		
Corrected Total	32	190.15480			

Root MSE	2.11584	R-Square	0.2937
Dependent Mean	68.11463	Adj R-Sq	0.2466
Coeff Var	3.10630		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	65.10055	1.27456	51.08	<.0001
HITS	1	0.08731	0.16156	0.54	0.5929
TOD	1	3.51660	1.13359	3.10	0.0042

The REG Procedure
Model: MODEL1
Dependent Variable: AVGSPEED_S

Number of Observations Read	33
Number of Observations Used	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	322.74823	322.74823	53.00	<.0001
Error	31	188.78789	6.08993		
Corrected Total	32	511.53612			

Root MSE	2.46778	R-Square	0.6309
Dependent Mean	62.50488	Adj R-Sq	0.6190
Coeff Var	3.94814		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	56.47772	0.93273	60.55	<.0001
TOD	1	7.64986	1.05082	7.28	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: HITS

Number of Observations Read	48
Number of Observations Used	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	17627	17627	78.00	<.0001
Error	46	10395	225.98029		
Corrected Total	47	28022			

Root MSE	15.03264	R-Square	0.6290
Dependent Mean	37.56250	Adj R-Sq	0.6210
Coeff Var	40.02034		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	12.23518	3.59608	3.40	0.0014
VOLUME	1	0.92450	0.10468	8.83	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: Sign_A_Speed

Number of Observations Read	49
Number of Observations Used	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	39.60459	19.80229	7.68	0.0013
Error	46	118.59950	2.57825		
Corrected Total	48	158.20408			

Root MSE	1.60569	R-Square	0.2503
Dependent Mean	67.46939	Adj R-Sq	0.2177
Coeff Var	2.37988		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	68.54227	0.37470	182.93	<.0001
HITS	1	-0.06655	0.11556	-0.58	0.5675
TOD	1	-1.58476	0.58059	-2.73	0.0090

The REG Procedure

Model: MODEL1

Dependent Variable: Sign_B_Speed

Number of Observations Read	49
Number of Observations Used	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	270.62334	135.31167	1.34	0.2715
Error	46	4639.49911	100.85868		
Corrected Total	48	4910.12245			

Root MSE	10.04284	R-Square	0.0551
Dependent Mean	65.55102	Adj R-Sq	0.0140
Coeff Var	15.32065		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	62.58016	2.34355	26.70	<.0001
HITS	1	0.38747	0.72277	0.54	0.5945
TOD	1	3.28202	3.63133	0.90	0.3708

The REG Procedure

Model: MODEL1
Dependent Variable: Sign_D_Speed

Number of Observations Read	49
Number of Observations Used	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	4.52915	2.26457	0.51	0.6066
Error	46	206.16473	4.48184		
Corrected Total	48	210.69388			

Root MSE	2.11704	R-Square	0.0215
Dependent Mean	65.16327	Adj R-Sq	-0.0210
Coeff Var	3.24882		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	65.49583	0.49402	132.58	<.0001
HITS	1	0.00317	0.15236	0.02	0.9835
TOD	1	-0.62077	0.76549	-0.81	0.4216

The REG Procedure

Model: MODEL1
Dependent Variable: Sign_B_Speed

Number of Observations Read	63
Number of Observations Used	63

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1174.23687	587.11843	27.54	<.0001
Error	60	1279.27899	21.32132		
Corrected Total	62	2453.51586			

Root MSE	4.61750	R-Square	0.4786
Dependent Mean	64.64079	Adj R-Sq	0.4612
Coeff Var	7.14332		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	59.58705	0.92418	64.48	<.0001
HITS	1	0.18571	0.21851	0.85	0.3988
TOD	1	8.58206	1.17217	7.32	<.0001

APPENDIX F

DVR MONITORING SHEET

Date:	
Begin Time:	**End Time:**
Prevailing Weather: Clear Partly Cloudy Mostly Cloudy Snowing	

Event	**Time** (HH:MM:SS)	**Side of Road** (L or R)	**Did the sign turn on?** (Y or N)

Date:	
Begin Time:	**End Time:**
Prevailing Weather: Clear Partly Cloudy Mostly Cloudy Snowing	

Event	**Time** (HH:MM:SS)	**Side of Road** (L or R)	**Did the sign turn on?** (Y or N)

Date:

Begin Time:	**End Time:**
Prevailing Weather: Clear Partly Cloudy Mostly Cloudy Snowing	

Event	**Time** (HH:MM:SS)	**Side of Road** (L or R)	**Did the sign turn on?** (Y or N)

APPENDIX G

WILDLIFE POPULATION DATA

PRONGHORN			Population	
Year	Herd Code	Pronghorn Herd Unit	Pop. Est.	Pop. Obj.
2006	401	Sublette	60,100	48,000
2005	401	Sublette	47,900	48,000
2004	401	Sublette	42,500	48,000
2003	401	Sublette	44,200	48,000
2002	401	Sublette	44,700	48,000
2001	401	Sublette	47,700	48,000
2000	401	Sublette	47,100	48,000
1999	401	Sublette	49,500	48,000
1998	401	Sublette	45,500	48,000
1997	401	Sublette - combined with West Green River	42,300	48,000
1996	401	Sublette	35,000	40,000
1995	401	Sublette	31,300	40,000
1994	401	Sublette	31,740	40,000
1993	401	Sublette	27,672	40,000
1992	401	Sublette	32,811	30,000
1991	401	Sublette	33,250	30,000
1996	417	West Green River - combined with Sublette	8,900	8,000
1995	417	West Green River	8,146	8,000
1994	417	West Green River	7,810	8,000
1993	417	West Green River	6,400	8,000
1992	417	West Green River	10,731	3,000
1991	417	West Green River	11,700	3,000

		MULE DEER	Population	
Year	Herd Code	Mule Deer Herd Unit	Pop. Est.	Pop. Obj.
2006	104	Sublette	26,474	32,000
2005	104	Sublette	28,044	32,000
2004	104	Sublette	26,633	32,000
2003	104	Sublette	34,022	32,000
2002	104	Sublette	32,924	32,000
2001	104	Sublette	34,700	32,000
2000	104	Sublette	36,000	32,000
1999	104	Sublette	31,000	32,000
1998	104	Sublette	26,100	32,000
1997	104	Sublette	24,700	32,000
1996	104	Sublette	27,900	32,000
1995	104	Sublette	28,400	32,000
1994	104	Sublette	25,302	32,000
1993	104	Sublette	22,060	32,000
1992	104	Sublette	32,618	32,000
1991	104	Sublette	32,000	32,000

		MOOSE	Population	
Year	Herd Code	Moose Herd Unit	Pop. Est.	Pop. Obj.
2006	105	Sublette	4,066	5,500
2005	105	Sublette	3,926	5,500
2004	105	Sublette	4,107	5,500
2003	105	Sublette	4,028	5,500
2002	105	Sublette	3,726	5,500
2001	105	Sublette	5,665	5,500
2000	105	Sublette	6,000	5,500
1999	105	Sublette	5,800	5,500
1998	105	Sublette	5,700	5,500
1997	105	Sublette	5,500	5,500
1996	105	Sublette	5,840	5,500
1995	105	Sublette	6,000	5,500
1994	105	Sublette	5,700	5,500
1993	105	Sublette	5,112	5,500
1992	105	Sublette	5,704	5,500
1991	105	Sublette	5,650	5,500

ELK			Population		
Year	Herd Code	Elk Herd Unit	Pop. Est.	Pop. Obj.	
2006	106	Piney	3,227	2,400	5,794
2005	106	Piney	3,429	2,424	5,935
2004	106	Piney	2,796	2,424	5,054
2003	106	Piney	2,836	2,424	4,988
2002	106	Piney	2,581	2,424	5,231
2001	106	Piney	2,535	2,424	5,185
2000	106	Piney	3,409	2,424	6,109
1999	106	Piney	3,832	2,424	6,732
1998	106	Piney	3,664	2,424	6,464
1997	106	Piney	3,267	2,424	6,067
1996	106	Piney	3,900	2,424	6,650
1995	106	Piney	3,740	2,424	6,440
1994	106	Piney	3,530	2,424	6,180
1993	106	Piney	3,357	2,424	5,957
1992	106	Piney	3,250	2,424	5,950
1991	106	Piney	2,594	2,424	5,194
2006	107	Green River	2,567	2,500	
2005	107	Green River	2,506	2,500	
2004	107	Green River	2,258	2,500	
2003	107	Green River	2,152	2,500	
2002	107	Green River	2,650	2,500	
2001	107	Green River	2,650	2,500	
2000	107	Green River	2,700	2,500	
1999	107	Green River	2,900	2,500	
1998	107	Green River	2,800	2,500	
1997	107	Green River	2,800	2,500	
1996	107	Green River	2,750	2,500	
1995	107	Green River	2,700	2,500	
1994	107	Green River	2,650	2,500	
1993	107	Green River	2,600	2,500	
1992	107	Green River	2,700	2,500	
1991	107	Green River	2,600	2,500	

APPENDIX H

CRASH RECORDS

Base Key	Year	Report #	Milepost	Date	Time of Day	Lighting	Road Conditions	Weather	1st Harmful Event
9518001	95	18001	10600	112995	18:00	DARK UNLIGHTED	DRY	CLEAR	DEER
9516698	95	16698	10650	110595	X :	DAYLIGHT	SNOWY	SNOWING	DEER
9619983	96	19983	10554	120496	08:40	DAYLIGHT	SNOWY	CLEAR	MV-MV
9604462	96	04462	10595	30196	10:14	DAYLIGHT	ICY	CLEAR	GUARDRAIL BY STRUCTURE
9617429	96	17429	10600	102896	18:00	DAWN OR DUSK	DRY	CLEAR	MV-MV
9607219	96	07219	10640	50696	11:15	DAYLIGHT	DRY	CLEAR	DEER
9606665	96	06665	10654	41696	06:30	DAYLIGHT	DRY	CLEAR	DEER
9819098	98	19098	10645	120198	22:30	DARK UNLIGHTED	DRY	CLEAR	DEER
9801016	98	01016	10670	11198	04:00	DARK UNLIGHTED	ICY	CLEAR	DEER
9901332	99	01332	10589	11899	19:40	DARK UNLIGHTED	ICY	CLEAR	GUARDRAIL BY STRUCTURE
9900117	99	00117	10600	10199	05:12	DARK UNLIGHTED	DRY	CLEAR	DEER
9916145	99	16145	10600	92799	07:20	DAYLIGHT	DRY	CLEAR	OVERTURN
9900118	99	00118	10620	10299	17:55	DARK UNLIGHTED	DRY	CLEAR	DEER
0000311	00	00311	10595	10600	17:40	DARK UNLIGHTED	DRY	CLEAR	DEER
0016146	00	16146	10595	102800	21:00	DARK UNLIGHTED	DRY	CLEAR	DEER
0017807	00	17807	10650	111500	18:48	DARK UNLIGHTED	DRY	CLEAR	DEER
0102183	01	02183	10554	13101	11:39	DAYLIGHT	DRY	STRONG WIND	MV-MV
0115450	01	15450	10554	101301	09:35	DAYLIGHT	WET	CLEAR	MV-MV
0106236	01	06236	10590	42701	07:00	DAYLIGHT	DRY	CLEAR	DEER
0105690	01	05690	10650	41701	07:50	DAYLIGHT	DRY	CLEAR	DEER
0217675	02	17675	10600	110502	13:05	DAYLIGHT	DRY	CLEAR	DEER
0218402	02	18402	10600	111502	18:15	DARK UNLIGHTED	DRY	CLEAR	DEER
0220771	02	20771	10600	121802	23:10	DARK UNLIGHTED	ICY	CLEAR	DEER
0205433	02	05433	10623	40302	09:10	DAYLIGHT	DRY	CLEAR	DEER

Base Key	Year	Report #	Milepost	Date	Time of Day	Lighting	Road Conditions	Weather	1st Harmful Event
0313679	03	13679	10573	91003	06:56	DAWN OR DUSK	WET	CLEAR	ANTELOPE
0319042	03	19042	10600	113003	16:49	DAWN OR DUSK	DRY	CLEAR	DEER
0415211	04	15211	10566	100504	01:15	DARK UNLIGHTED	DRY	CLEAR	COW
0409665	04	09665	10654	42604	07:15	DAYLIGHT	DRY	CLEAR	DEER
0417063	04	17063	10663	103004	17:00	DAYLIGHT	DRY	CLEAR	MV-MV
0420018	04	20018	10683	121404	17:15	DARK UNLIGHTED	DRY	CLEAR	DEER
0521253	05	21253	10627	121905	16:55	DAWN OR DUSK	DRY	CLEAR	MV-MV
0521479	05	21479	10602	121505	14:30	DAYLIGHT	DRY	CLEAR	DEER
0619878	06	19878	10640	111906	13:50	DAYLIGHT	DRY	CLEAR	DEER
0607127	06	07127	10650	041206	06:30	DAWN OR DUSK	DRY	CLEAR	DEER
0619742	06	19742	10600	103106	19:00	DAYLIGHT	DRY	CLEAR	DEER
0619764	06	19764	10600	111206	17:35	DARK UNLIGHTED	DRY	CLEAR	DEER
0709143	07	09143	10570	052407	07:30	DAYLIGHT	DRY	CLEAR	ANTELOPE
0719747	07	19747	10600	110807	19:30	DARK UNLIGHTED	DRY	CLEAR	DEER
0716723	07	16723	10680	091107	16:30	DAYLIGHT	DRY	CLEAR	OVERTURN