Cable Median Barrier Program in Washington State

WA-RD 812.1

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RESEARCH REPORT

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CABLE MEDIAN BARRIER PROGRAM IN WASHINGTON STATE

by

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The purpose of this report is to summarize the evolution and accomplishments of the Washington State Department of Transportation's (WSDOT's) cable median barrier program and to bring to conclusion the previous efforts published in the Cable Median Barrier Reassessment and Recommendations reports of 2007, 2008, and 2009. The objective of this program is to reduce fatal and serious injury collisions by targeting cross-median crashes on high-speed controlled access highways. This report outlines WSDOT's efforts to target those collisions. It compares crash rates before cable median barrier was installed with crash rates of the various barrier treatments that followed.</td></tr>
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SECTION 1: INTRODUCTION

The purpose of this report is to summarize the evolution and accomplishments of the Washington State Department of Transportation's (WSDOT's) cable median barrier program and to bring to conclusion the previous efforts published in the *Cable Median Barrier Reassessment and Recommendations* reports of 2007, 2008, and 2009. The objective of this program is to reduce fatal and serious injury collisions by targeting cross-median crashes on high-speed controlled-access highways. This report outlines WSDOT's efforts to target those collisions. It compares crash rates before cable median barrier was installed with crash rates of the various barrier treatments that followed.

The *Cable Median Barrier Reassessment and Recommendations* reports of 2007, 2008, and 2009 were produced largely in reaction to crash experience with some of WSDOT's first installations of cable median barrier. Those reports summarized the performance of all cable median barrier installations on Washington's highways. The 2009 report was the most recent and included crash history through the end of calendar year 2008. In this study, crash history for locations previously included in the 2007, 2008, and 2009 reports has been updated with the addition of crash performance history for calendar years 2009, 2010, and 2011.

Note: The focus of this report does not include all cable barrier installations throughout Washington State. Historically, WSDOT, along with county and local agencies, has used wire rope or cable-type barriers in a number of differing configurations and placements. They range from a single cable strung through concrete or wooden posts as curve delineation in the 1950s, to the current use of 3- or 4-strand high-tension cable barrier to shield errant vehicles from off-the-roadway hazards along either shoulder. Statewide, there are roughly 40 miles of these types of installations in runs of typically under 0.10 of a mile. These atypical installations are not examined for performance in this report.

SECTION 2: BACKGROUND

2.1 Origin/Intent of WSDOT Cable Median Barrier Program

The intent of WSDOT's cable median barrier program is to reduce fatal and serious injury collisions by targeting cross-median crashes. The speeds and energy associated with cross-median crashes increase the potential for severe or fatal injuries. A 1999 WSDOT study[1] evaluated cross-median crash experience in Washington State and concluded that median width was a significant factor in those collisions. The 1999 study recommended that median width and traffic volumes be re-evaluated as factors influencing median barrier placement decisions. In April 2001, WSDOT initiated a study[2] that evaluated Washington's cross-median crash experience on high-speed controlled-access highways. The 2001 study set out to evaluate median width and traffic volume, and ultimately focused on median width as the primary criteria for selection of median barrier. That study recommended barrier on controlled-access highways where median widths were 50' or narrower, and found that a cable barrier was the most cost-effective option. The recommendations from that study were the genesis for WSDOT's cable median barrier program.

WSDOT's first installation[3] of cable median barrier was approximately 2 miles long in the Marysville area in 1995. In 1999, that installation was expanded in length to nearly 10 miles. In 1999, cable median barrier was also placed in the Bellingham and Blaine areas on Interstate 5 (I-5). While the *Median Treatment Study on Washington State Highways* was progressing in 2001, cable median barrier was placed on I-5 in the Fife area and from Vancouver to Woodland. Progress toward implementing the cable median barrier program is detailed later in this report.

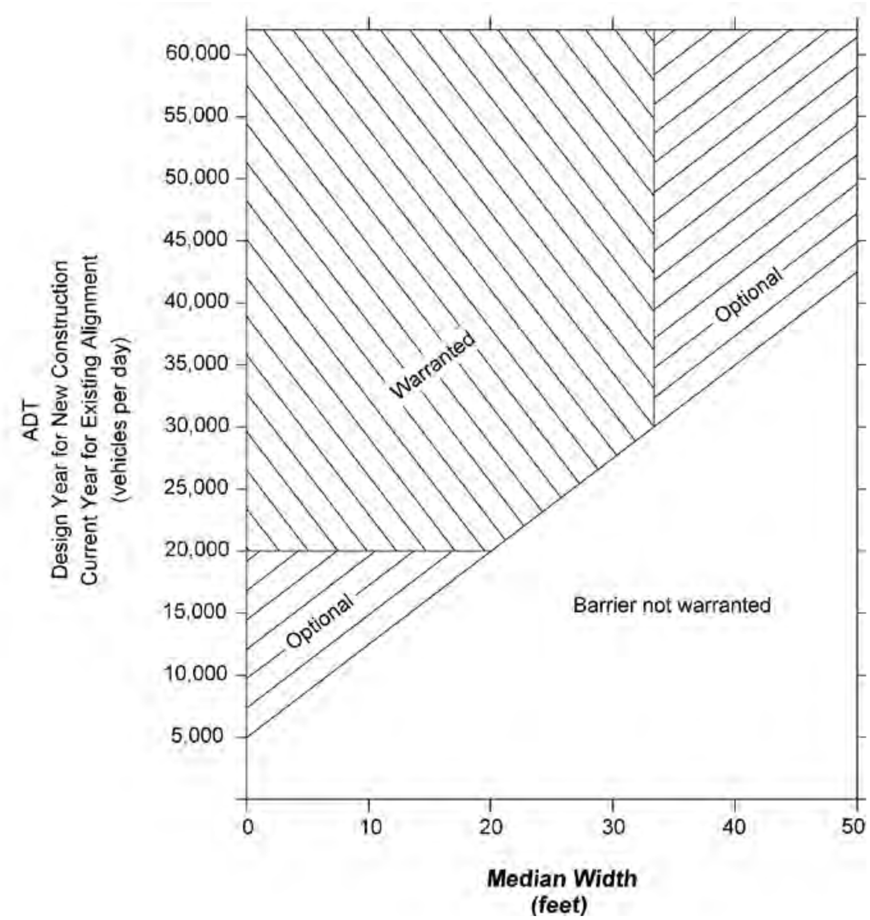
2.2 Design Policy Development and Evolution

WSDOT first presented guidance for the use of generic cable barriers in the median in the June 1995 revision of the WSDOT *Design Manual*. Previous *Design Manual* references to cable barrier were in regard to placement as a roadside barrier. Generic cable median barrier was first presented in the November 1997 revision to the WSDOT *Standard Plans*.

From June 1986 until August 2001, WSDOT's guidance for median barrier warrants was essentially unchanged. That guidance was based on a 1977 publication[4] from the American Association of State Highway and Transportation Officials (AASHTO). The AASHTO guidance used average daily traffic (ADT) and median width as variables in determining whether median barrier was appropriate. In May 2001, the WSDOT *Design Manual* presented this guidance in Chapter 700, Figure 700-7 (presented below in Figure 2.1). That figure indicated that median barrier was generally warranted when the ADT exceeded 20,000 and the median width was less than or equal to 32.8' (10 meters). It also provided guidance on when median barrier was optional, or not warranted.

[1] Shankar V., Albin R., Milton J., and Mannering F., *Evaluating Median Crossover Likelihoods with Clustered Accident Counts*, 1999, TRR 1635, Transportation Research Board, Washington D.C.
[2] Glad R.W., Albin R., McIntosh D., and Olson D., *Median Treatment Study on Washington State Highways*, WA-RD 516.1, March 2002, Washington State Department of Transportation
[3] Contract 4615, SR 5, SR 529 To Smokey Point I/C Vic. Paving Stage, Advertised for bids in Feb. 1995
[4] Ross, H.E., *Guide for Selecting, Locating, and Designing Traffic Barriers*, 1977, AASHTO

Figure 2.1 Warrants for median barrier (from 2001 *Design Manual* guidance)



In April 2001, WSDOT initiated the *Median Treatment Study on Washington State Highways*. That report outlined an analysis assessing whether WSDOT's guidance on the use of barriers should be expanded to wider medians. The study examined cross-median crash experience on selected Washington highways and predicted reduced frequencies and reduced injury severities for those events. A benefit/cost (B/C) ratio was generated for each location, allowing a comparison of investments in cable barrier, beam guardrail, and concrete barrier. The analysis found that cable barrier was the most cost-effective approach for most situations where the median width was in the range of 30' to 60'. The study report recommended that median barrier be installed in all medians on full access controlled multilane highways with posted speeds of 45 mph or higher, where the median width was 50' or less. Because the crash sample size and the B/C ratio were diminishing for medians 51–60' wide, the study recommended that wider medians be considered based on crash history.

An Instructional Letter was issued in August 2001 to revise the WSDOT *Design Manual* guidance for the use of median barriers. That letter implemented the recommendations of the *Median Treatment Study on Washington State Highways*. Soon after the issuance of the August 2001 Instructional Letter, WSDOT Project Development personnel began to raise questions about how to implement the new policy for those projects that were previously programmed with no money budgeted for median barrier. Consequently, a revised Instructional Letter was issued in November 2001, which provided clarity for dealing with previously programmed projects. *Design Manual* Figure 700-7 was deleted by guidance in the August 2001 and November 2001 *Design Manual* Supplements.

In April 2004, the Federal Highway Administration (FHWA) conducted full-scale crash testing of cable barrier placed in a depressed median with 6H:1V slopes. That testing was conducted to explore causation factors associated with cable median barrier penetrations in North Carolina. The testing revealed that placement in the proximity of the low point in the median was a factor in passenger-sized vehicles passing under the cables. When the barrier was placed at a 1' offset from the low point, the barrier contained and redirected the vehicle. When the barrier was placed at a 4' offset beyond the low point, the front suspension compressed and encountered the barrier before the suspension rebounded. This resulted in the vehicle passing below (under-riding) the lowest cable and penetrating the barrier system.

This placement concern was an issue for single runs of cable median barrier. When cable barrier was placed in parallel runs, with an installation on either side of the low point, the vehicle encountered the barrier before it reached the low point in the median and had a chance to compress the suspension. As a result of this testing, WSDOT issued interim guidance in May 2004 for placement of cable median barrier. WSDOT guidance was issued prior to any specific direction from FHWA. The guidance indicated that placement between 1' and 6' offset from the low point in the median was to be avoided.

In 2006, while assisting with a revision to Chapter 6 of the AASHTO *Roadside Design Guide,* WSDOT staff learned that FHWA would be recommending no placement in a zone offset between 1' and 8' from the low point. Consequently, WSDOT modified its placement guidance in November 2006 to avoid cable barrier from 1' to 8' offset from the low point in the median. The November 2006 *Design Manual* revision also stated that high-tension cable barrier systems were the first choice for new installations.

In 2007, WSDOT conducted an analysis of cable barrier performance in Washington, which is summarized in *Cable Median Barrier Reassessment and Recommendations*. That report included an independent analysis by Dr. Malcolm Ray, who reviewed the performance of cable median barrier systems and provided recommendations for improved performance. Dr. Ray's recommendations provided guidance on minimum offset to the cable barrier from adjacent lanes. As a result of Dr. Ray's recommendations, WSDOT modified cable median barrier placement policy in a January 2009 *Design Manual* revision.

In December 2009, *Design Manual* guidance was revised to specify the use of 4-strand cable barrier systems for future installations of cable barrier. Those newer designs offered a greater range of height coverage, and the *Design Manual* revision specified a minimum height of 35" for the top cable and a maximum height of 19" for the bottom cable. That revision was expected to further reduce the potential for vehicles to get under or over the barrier system.

Currently, the most common barrier systems considered for median applications are cable, beam guardrail, and concrete systems. The selection of median barrier type for any particular application is subject to WSDOT design policy at the time the project plan is developed. In general, the most flexible barrier appropriate to the conditions is the most desirable, with barrier placement as far from the traveled way as possible. The current policy also states that cable barrier is generally recommended in medians 30' wide or greater. Among the issues to be considered in selecting a barrier are constraints related to barrier placement, deflection characteristics, median slopes, and environmental issues (see WSDOT *Design Manual,* section 1610.05(6)).

2.3 Program Size and Implementation Approach

The *Median Treatment Study on Washington State Highways* identified high-speed controlled-access highway segments where there was no median barrier installed. Controlled-access highways were targeted because of the lack of left-turn movements across the median. Interrupting the barrier runs to provide for left-turning vehicles necessitates a more frequent need to terminate the median barriers and to provide adequate sight distance for turning vehicles. The study efforts produced a list of locations where median barrier would be considered to comply with the revised *Design Manual* guidance. The original list of locations targeted approximately 169 miles of highway for cable barrier installation. Those locations are provided in Appendix A. The locations on that list were identified as wide enough to accommodate the deflection distance of a cable barrier system.

The crash history was tabulated for each location identified on the list of targeted installations. Crash frequency and severity were used to estimate a benefit/cost (B/C) ratio, balancing injury reductions with installation and maintenance costs. The B/Cs calculated in the study became the starting point for prioritizing barrier installations. Higher B/C ratios were placed at the top of the list, as they were projected to provide a better return on the investment. Project funding opportunities and the ability to bundle locations in reasonably close proximity were additional factors in determining the order in which barrier installations progressed.

There was no dedicated funding source for implementing the cable median barrier program when it was initiated in 2001. Initially, locations that aligned with other preservation or improvement projects were addressed first, provided that the original project scope and budget could accommodate the barrier work. For developing projects, the barrier work was scoped as part of the project's budgeting process. Those efforts were implemented with Pre-Existing Funds. Median barrier installations initially competed with other safety work. For the 2003–2005 Biennium, safety improvement dollars were set aside to target median barrier installations.

The 5-cent gas tax increase in 2003 provided revenue that helped fund ten contracts that placed cable median barrier. Those ten contracts installed more than 28 miles of cable median barrier. The 9.5-cent gas tax increase enacted in 2005 (Transportation Partnership Account or "TPA" funds) enabled an accelerated delivery of WSDOT's cable median barrier program. The first project[5] WSDOT developed and advertised using TPA funding was an area-wide cable median barrier contract in a six-county area around Puget Sound that installed approximately 37 miles of cable median barrier. Additional TPA-funded projects installed another 48 miles. Dedicated funding for cable median barrier in the ensuing biennia allowed for the completion of WSDOT's cable median barrier program, with the last of the targeted installations[6] completed in 2011.

The American Recovery and Reinvestment Act of 2009 (ARRA) provided funds for saving and creating jobs in America. It has often been called the "economic stimulus" package. ARRA funds were matched with ready-to-deliver projects eligible for federal funding. WSDOT had identified several cable median barrier locations that were targeted for system upgrades. Those locations focused on WSDOT's earliest installations of cable median barrier, with plans to replace the generic cable barrier installations with 4-strand high-tension cable barriers. The ARRA dollars provided for replacement of nearly all the remaining installations of generic cable barrier. Only 1 mile of generic cable barrier was left in place, as that location was slated for realignment/reconstruction, with the addition of a concrete median barrier.

[5] Contract 7026, I-5 Et Al, Puget Sound Vic Cable Guardrail, Advertised for bids in Aug. 2005
[6] Contract 8005, Olympic Region Basic Safety Restoration, Advertised for bids in Aug. 2010

The 2001 *Median Treatment Study on Washington State Highways* targeted 169 miles for median barriers. The majority of those locations were addressed with cable barrier; however, concrete barrier or beam guardrail was selected for some of the locations. Another 77 miles of cable barrier was installed in wider medians on highways that did not have limited access control or on previously undivided highways that were rebuilt as divided facilities. Some of the cable median barrier was removed when highways were widened, adding lanes on the median side of the highway. In those instances, the median width was reduced to a dimension where a typical cable barrier system would likely deflect far enough to reach opposing traffic lanes. Consequently, concrete barrier replaced the cable barrier systems in those locations. At the end of 2012, the total mileage of cable median barrier in place on Washington's highways was 230 miles.

2.4 Cable Barrier Product Evolution

When WSDOT began installing cable median barrier, the only barrier option available was a generic low-tension cable barrier system with three cables (wire ropes). The first use of generic cable barrier in a median on a Washington State highway was in 1995 on approximately 2 miles in the vicinity of Marysville (Contract 4615). That barrier used three wire ropes with mounting heights of 30", 25.5", and 21". The cables were attached with J-bolts to steel posts driven into the ground. A subsurface soil plate on the side of the post provided additional resistance to rotation through the soil. Cable ends were secured to buried concrete anchors every 2,000'. The terminal was designed to release cable attachments when the terminal itself was struck, lessening the force of impact transferred to vehicle occupants. Each cable was attached to a spring compensating device that maintained sufficient tension to minimize sagging between the posts as temperature changes resulted in expansion or contraction. WSDOT installed approximately 42 miles of that barrier between 1995 and 2005.

New York had originally developed the generic cable barrier system as a roadside barrier. The 1995 publication, *A Guide to Standardized Highway Barrier Hardware,* referenced this system as the SGR01a-b weak-steel post cable guardrail system. When used as a roadside barrier, this cable guardrail system mounts all three cables on the traffic side of the post. It was modified for use in the median by placing the middle cable on the opposite side of the post. This median barrier configuration was crash tested in 1996 using a small car, in a National Cooperative Highway Research Program (NCHRP) 350-compliant crash test at test level 3. An NCHRP 350-compliant test level 3 crash test was conducted in 2000 using a pickup. These tests were conducted with the vehicles impacting from the direction where the middle cable was on the impact side of the posts. This application was referenced in the 1996 and 2002 AASHTO *Roadside Design Guide*, which indicated this barrier system "…remains effective when mounted on a moderate slope (up to 1V:6H)." Guidance on the appropriate slope appears to be based on a 1983 report[7] from Texas Transportation Institute, where various barrier systems were placed on side slopes and then impacted in full-scale crash tests. The last installation of generic cable median barrier was in 2005/2006 in Bellevue on Interstate 90 (Contract 6879).

In 2001, proprietary high-tension cable barrier systems appeared in the marketplace within the United States. That year, FHWA issued the first acceptance letter for a high-tension cable barrier system in the U.S. An FWHA acceptance letter indicates that the product is acceptable for use on the National Highway System. When product manufacturers have garnered FHWA acceptance, they typically contact state transportation agencies to make them aware of their products and to seek approval for use at the

[7] Ross H.E. and Sicking D., *Development of Guidelines for Placement of Longitudinal Barriers on Slopes*, 1983, Texas Transportation Institute, Report 3659-1

state level. At the request of the product manufacturers, high-tension cable barrier systems were evaluated and subsequently approved for use in Washington State.

In February of 2004, WSDOT approved (with limitations) products from Marion Steel Company and Trinity Highway Products, noting that their use was "experimental." The cable barrier system approved at that time used three wire ropes mounted on steel posts. The steel posts could be either direct driven or mounted in sockets that facilitated easy post removal by lifting damaged posts from the sockets and dropping in new ones. The wire rope mounting heights were 29.5", 25", and 20.4" or 20.8" (depending on the manufacturer), with ropes typically secured through a slot in the post. Each cable was attached to an individual anchor post that was designed to break free when struck by a vehicle. Following approval of the two high-tension cable barrier systems, WSDOT advertised Contract 6783, which specified a 3-strand high-tension cable median barrier system for installation on Interstate 90 in the area east of Spokane. The Spokane-area installation project concluded in October 2004.

Several contracts were advertised for either generic or high-tension cable barrier from 2004 through 2006. High-tension cable barrier systems were proposed by the successful low bidder in the majority of those contracts. Positive feedback from WSDOT maintenance staff, along with the recognition that high-tension cable barrier offered some operational benefits, led to a change in WSDOT *Design Manual* guidance in 2006. The most significant operational benefit identified was the recognition that, in the event a small number of posts were knocked down, the cable still remained at a functional height should another impact occur before the repairs could be made. With the generic cable barrier system, the cables tended to sag significantly when a few posts were knocked down. In November 2006, WSDOT's *Design Manual* stated that high-tension cable barrier was the first choice for new installations. There were no new installations of generic cable barrier after 2005.

In 2005, Gibraltar Cable Barrier Systems requested that WSDOT approve its proprietary high-tension cable barrier systems. Gibraltar had developed one system for test level 3 (TL3) and one for test level 4 (TL4). The TL3 system used three cables with mounting heights of 20", 25", and 30". The TL4 system also used three cables, but had mounting heights of 20", 30", and 39". The TL4 design was crash tested with a single unit box van truck. Those systems were approved for use on Washington's highways in December 2005.

In 2006, the limitations accompanying the approval of the Marion Steel Company and Trinity Highway Products cable barrier systems were dropped. This meant that they were approved for general use on Washington's highways and no longer relegated to experimental use.

In 2006, Brifen USA requested that WSDOT approve its proprietary high-tension cable barrier system. Those systems were approved for use on Washington's highways in late 2006. The Brifen cable barrier system used four cables with mounting heights of 28.4", 26", and 19.5". Two of the four cables were mounted at 26", with a rope on each side of the post. The 26" and 19.5" cables were mounted on alternating sides of the posts. The top cable at 28.4" was mounted on the post side nearest to the traffic.

These cable barrier manufacturers revised their systems over the ensuing years to: modify post spacing, add a fourth cable, adjust cable mounting heights, and test under test level 4 conditions. Today, WSDOT has a broad range of cable barrier designs to choose from. In 2009, WSDOT re-evaluated the variety of products available and established minimum top cable and maximum bottom cable height criteria based on market analysis. WSDOT also changed its policy to specify 4-strand cable systems for new installations. Those changes were made with the intent to minimize the potential for a vehicle to get over or under the barriers. The December 2009 *Design Manual* specified that the top cable not be less than 35" high and the bottom cable not be more than 19" high.

While products from several manufacturers have been approved for use in Washington, only two manufacturers have been successful in getting their products into installation contracts through the competitive bidding process. As of the end of calendar year 2012, proprietary cable barrier products from Trinity Highway Products and Gibraltar Cable Barrier Systems have been installed in the medians of Washington’s highways.

2.5 Progress/Completion of Cable Barrier Installations

As previously stated, the 2001 median treatment study initiated WSDOT’s cable median barrier program. There were approximately 26 miles of cable median barrier in place at the time WSDOT implemented the policy change to place barrier in medians up to 50’ wide on full access controlled highways. That policy change spawned the WSDOT cable median barrier program.

WSDOT’s funding programs and budget are developed on two-year cycles or “biennia.“ These cycles start on July 1 of odd-numbered years and extend through June 30, two years hence. Budgets and investment plans are determined prior to the start of a biennium based on investment priorities. Once a biennium plan is adopted, it is expected that work not included in that plan will rarely be done.

Because the new median barrier policy was developed mid-biennium, limited progress was made in implementing the program during the 2001–2003 Biennium (July 1, 2001, through June 30, 2003), as most of the construction projects had already been programmed without consideration of median barrier. Consequently, the budgets for those projects did not allow for adding cable barrier to the projects. By the end of the 2001–2003 Biennium, generic cable barrier was installed on just under 2 miles of highway, mostly in the Bellingham area (Contract 6473).

As the policy was under development, 18–19 miles of highway were programmed for cable median barrier in the 03–05 Biennium. Additional projects, identified after the policy change, were developed with scopes and budgets sufficient to address the median barrier. The 2003–2005 Biennium offered the first significant opportunity to address median barrier consistent with the 2001 policy change. Passage of 2003 and 2005 gas tax increases provided the funding needed to implement the cable median barrier program on a significant scale.

During the 2003–2005 Biennium, there were nine construction contracts advertised for bids that installed cable barrier. These contracts jointly installed about 52 miles of cable median barrier. The last of the generic cable barrier installations occurred during this time frame. Approximately 71% of the mileage installed under these nine contracts was 3-strand high-tension cable barrier systems.

In the 05–07 Biennium, 13 construction contracts were advertised for bids that ultimately installed 109 miles of cable median barrier. All of those miles were 3-strand high-tension cable barrier systems. Ten of the miles were an additional cable barrier system installed in the Marysville area. This resulted in a generic cable barrier system adjacent to the northbound lanes and a 3-strand high-tension cable barrier system adjacent to the southbound lanes.

In the 07–09 Biennium, there were ten construction contracts advertised that installed 42 miles of cable median barrier. During that biennium, WSDOT elected to use 4-strand high-tension cable barrier systems for new installations because they offered a greater range of height coverage, with a lower bottom cable and a higher top cable. Of the cable median barrier installed, 29 miles consisted of 4-strand high-tension cable. Those 29 miles were funded with economic stimulus (ARRA) funds and targeted the replacement of nearly all the generic cable barrier installed in Washington.

At the conclusion of those projects, the only remaining generic cable barrier installations were locations where programmed projects would later reconfigure or realign the roadway cross section with narrower medians and concrete barrier. Adding lanes in the median resulted in rebuilding approximately 7.5 miles of highway and removing 3-strand high-tension cable barrier, replacing it with concrete median barrier.

In the 09–11 Biennium, there were seven construction contracts advertised that installed nearly 59 miles of cable median barrier. Those installations were all 4-strand high-tension cable barrier systems. The last 1.5 mile of the targeted installations identified in the 2001/2002 *Median Treatment Study on Washington State Highways* was completed in this biennium. Of the total miles, 9.5 miles were associated with an upgrade to the 3-strand high-tension cable barrier on SR 512, which converted to a 4-strand high-tension cable barrier system. The majority of the 59 miles installed during this time period were in locations that were not identified in the original assessment of locations determined in 2001/2002. They included locations that were not on full access controlled highways and locations with wider medians. Adding lanes and reconstructing highways resulted in the replacement of nearly 6 miles of generic cable barrier and 2.5 miles of 3-strand high-tension cable barrier. Those locations were replaced with concrete median barrier. Another 10 miles of generic cable barrier was replaced with concrete median barrier in the Marysville area.

As of the end of calendar year 2012 in the 2011–2013 Biennium, there was one project initiated to install just over 3 miles of 4-strand high-tension cable barrier.

2.6 Cable Barrier Removed from Service

In the 07–09 Biennium, 7.5 miles of cable barrier was removed from I-5 in the Thurston/Lewis County area. That portion of the Interstate was widened by adding a lane in each travel direction in the median. The cable median barrier hardware removed was re-used in a cable median barrier installation in the Longview/Kelso area.

In the 09–11 Biennium, there was roughly 18 miles of cable median barrier removed from several locations across the state. On I-5 in the Marysville area, the installation consisted of 10 miles with a generic low-tension system in the northbound direction and a 3-strand high-tension system in the southbound direction. The low-tension cable median barrier system was replaced with a concrete barrier, and the high-tension system remained in place.

On I-5 in the Fife area, roughly 2 miles of cable median barrier was removed when a high-occupancy vehicle (HOV) lane was added in both directions in the former median. On I-90 in the Spokane area, the addition of travel lanes in each direction in the former median removed approximately 3.5 miles of cable median barrier. In both of those cases, the limited median width after the widening required the use of concrete barrier to separate the travel directions. The balance remaining of about 2 miles of cable median barrier was removed across the state in a number of projects, the longest of which was on I-5 at roughly 0.30 of a mile near the Blaine I-5 border crossing, where the roadway and interchange were widened and reconfigured to ease cross-border traffic. In all cases where the cable median barrier was removed, the major components of the barrier systems, such as the wire rope, were reclaimed to be used in later projects or maintenance of existing systems.

SECTION 3: NETWORK PERFORMANCE

3.1 Assessment Methodology

In this report, the research team compared median collision experience prior to barrier installation (the before period) with the collision experience after median barrier was placed (the after period). The researchers analyzed over 4,600 collisions along 238 miles of cable barrier, with installations starting in 1995 and continuing through December 2011. Collisions occurring during construction of the cable barrier were not normally included, since the traffic control used during construction presented unique traffic conditions that did not offer a fair comparison. Fatal and serious injury collisions were given additional consideration for inclusion.

Most of the miles analyzed had a before period duration of five years; however, limited data availability allowed for only two and a half years for the earliest installation (2.10 miles). Another 5.68 miles represented reconstructed highways, changing from undivided to divided highways. Consequently, the roadway geometry in the before period was radically different and did not provide a valid comparison with after-period collision experience. A before condition was not analyzed in this circumstance.

The after periods varied in duration and barrier type. Some locations had multiple after periods, with each period representing a different configuration of median barrier. As an example, an initial generic cable barrier installation that was later replaced by 4-strand high-tension cable barrier would have had two after periods. Study sites were limited to those with a minimum of six months of traffic exposure. There were no other limits on the after duration, and collision data was evaluated through 2011. There were, however, circumstances that prompted closure or reclassification of the after period. For sites that removed the cable barrier and replaced it with concrete barrier, the Work Started Date for the concrete barrier contract signaled the close of the after period for affected cable barrier installation.

Similarly, when a cable barrier installation was upgraded with another type of cable barrier, usually 3- or 4-strand high-tension from generic low-tension cable, the Work Started Date for the upgrade project marked the end of the after period for those initial installation miles. The Physical Completion Date of the upgrade project marked the beginning of an analysis period for the new barrier installation. This report covers 35.53 miles of those sequential installations of cable barrier systems, with the understanding that the intermediate period was already treated with a different type of cable barrier.

This report also presents 9.79 miles that feature multiple upgrades of median barrier systems. This is a special case where the researchers tracked the sequence from no median barrier before, to generic cable barrier, followed by an additional parallel installation of a 3-strand high-tension system, and then a final configuration with concrete barrier and a parallel 3-strand high-tension cable barrier system. This is detailed later in the report.

The research team determined that cross-median collisions in the before period likely occurred more frequently than reported in this study. It was not difficult to identify collisions where the vehicle's initial point of impact was within the median using electronic collision data; however, it only identified the initial point of impact. The sequences of events occurring after the initial impact were not available electronically. The electronic data did not allow the identification of cross-median events, such as a same-direction sideswipe where a vehicle was rebounded across the median, or any other secondary collision or incident.

For details on the sequence of events in a collision, it is necessary to physically review collision reports. Collision records are retained in a format that allows the complete record to be read, retrieved, and analyzed for a period of 6 years. Records older than 6 years are retained in an electronic coded format that retains only major data elements and not the officer's narrative or diagram. In an attempt to identify additional before-period cross-median events with the most severe injuries, the researchers reviewed troopers' reports for fatal and serious injury collisions since 2000 to collect additional cross-median events prior to any barrier being placed in the median. Based on this review of only the significant injury events and the records located, the researchers are confident that there remain many before-period events in the less severe injury categories that were not identified due to the data limitations and were not available for analysis.

3.2 Unreported Collisions

There are instances where drivers did not report a collision, and then drove away after striking the barrier. To gain some insight on the frequency of unreported collisions, the researchers reviewed cable barrier repair records from WSDOT maintenance offices. Initially, those records were rather difficult to find, but they became more readily available over time. In 2004, there were 117 more reported crashes than there were repair records. By 2006, that count had shrunk to only ten fewer cable repair records than cable collision reports. In 2007, there were 73 more repair records than crashes reported. This number remained steady with counts in the 90s until 2011, which had 70. With this trend in mind, the analysis of cable barrier repairs focused on the years 2007 to 2011, inclusive. During that period, there were 1,948 collisions involving cable barrier and 2,370 cable repairs, making a difference of 422 (18% more repairs).

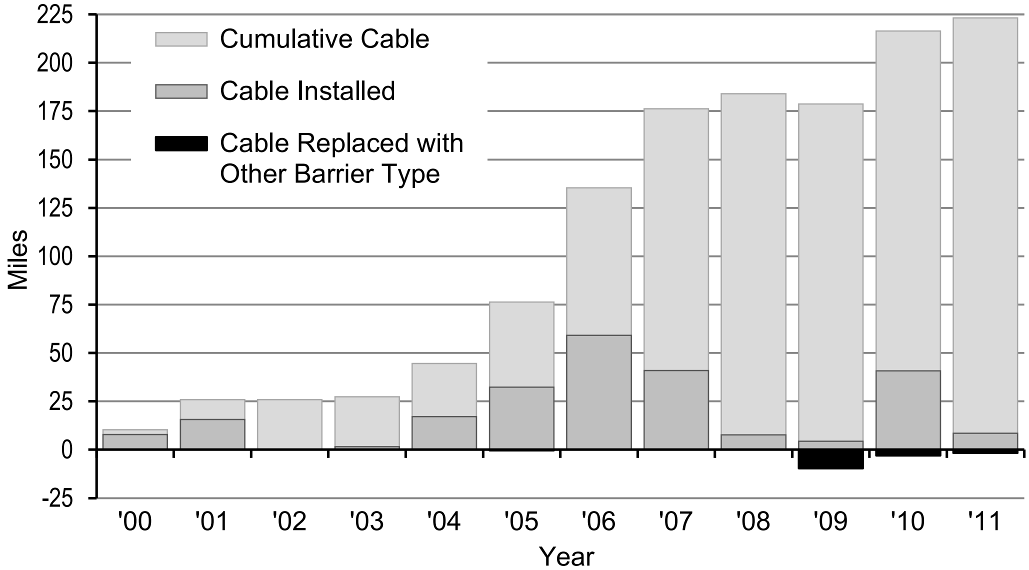
In further exploration, the research team attempted to match cable repairs with respective collisions over that same period. Relying heavily on the results of the department's cost recovery contingent, the team matched 1,345 repairs (approximately 70%) with specific collision reports. From this comparison, it is estimated that 15% to 40% of collisions with cable barrier are unreported. Because serious injury collisions are normally reported, the researchers assumed that none of the unreported collisions involved serious injury.

3.3 Cable Median Barrier Mileage

By the end of 2011, there were nearly 225 miles of cable median barrier still in place and another 3.34 miles were under contract for installation. The 224.92-mile total includes 1.63 miles that were installed too late in 2011 for inclusion in the performance analysis. Another 14.89 miles of cable barrier had been installed that, for various reasons, were replaced by other barrier systems over the years. This accounts for the cumulative dip in 2009. The most common situation was a condition where traffic lanes were added to the median side of the highway, which reduced the median width. Because narrow medians restrict the allowable deflection distance of barriers and complicate repairs, cable barriers were replaced with more rigid concrete barriers, which require less deflection and have less frequent need for repair. The cable barrier performance on these since-replaced miles is still included, thus making the total covered in this report 238.18 miles. This performance report total includes 35.53 miles where cable barrier systems were upgraded to another cable barrier system, usually from a low-tension to a high-tension system.

Figure 3.1 provides a year-by-year breakdown of the miles of cable barrier installed between 2000 and 2011. (It does not track subsequent cable barrier system upgrades).

Figure 3.1 Miles of cable median barrier installed

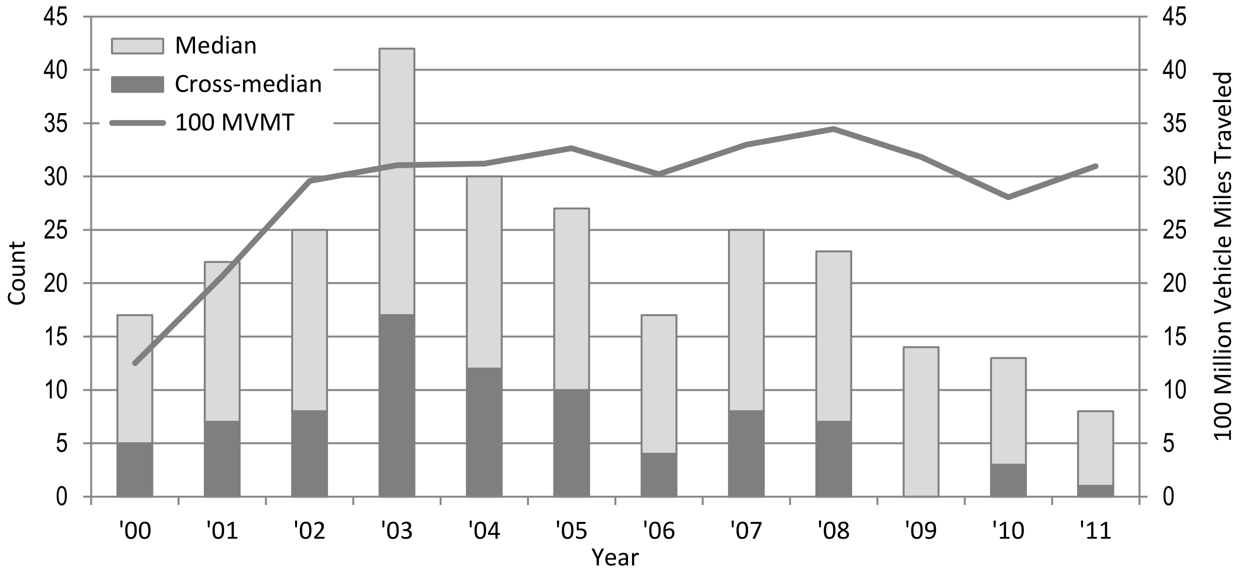


3.4 Decline in High-Severity Collisions

The full measure of effectiveness with median barriers is the overall impact on fatal and serious injury collisions. While cross-median collisions are an important component in median barrier performance, engineers must look at all collisions involving a barrier system to fully assess performance. Between 2000 and 2011, there was a dramatic decline in fatal and serious injury collisions within or across the median. Figure 3.2 illustrates the number of fatal and serious injury collisions occurring within or across the median where cable barrier had been installed, with a line indicating vehicle miles traveled (both omit the period during barrier installation). The decline in fatal and serious injury collisions corresponds to the increase in miles of barrier placed.

Figure 3.2 does not isolate collision experience before and after the cable barrier was placed; it simply presents the change in collision experience that WSDOT has realized with its median barrier program over time. A before/after comparison is presented later in this report. Figure 3.2's overall downward trend in fatal and serious injury median collisions is significant considering the relative stability in vehicle miles traveled from 2002 to 2011. As cable installations for limited access freeways with medians of 50'or narrower have been completed, the reduction in collision severity has been generally as expected.

Figure 3.2 **Median and cross-median fatal and serious injury collisions with vehicle miles traveled**



3.5 Increase in Reported Median Collisions

Once a barrier has been added to a median, errant vehicles no longer have the full width of the median to recover without striking the barrier. Consequently, reportable collisions in the median routinely increase after the installation of any barrier system. For this reason, WSDOT engineers consider the balance between the benefits of barriers and their associated risks. In the study sections, there were 277 median collisions reported annually prior to barrier placement and 776 after placing cable median barrier. That amounts to an increase of 180%. Figure 3.3 summarizes this data.

3.6 Collision Rates

Expressing collisions as a rate allowed the researchers to compare performance on segments with different lengths and traffic volumes. This report presents information on collision rates, expressing the number of collisions for each 100 million vehicle miles of travel (100 mvmt). Showing annual collisions is another means to present the data using a common reference point, although it does not account for traffic growth over time.

The overall collision rate jumped from 8.19 collisions per 100 mvmt to 15.61 per 100 mvmt after cable barrier was placed. Despite the overall increase in collisions, the fatal and serious injury rate dropped 58%. The rate of serious injury collisions was reduced by 61% and the rate of fatal collisions was reduced by 52%. If changes in traffic volume are not factored into the analysis, we still see a 46% reduction in annual fatal and serious injury collisions after cable median barrier was placed. There were 27.6 fatal and serious injury collisions per year prior to installation of barrier and 14.9 after (see Figure 3.3).

Figure 3.3 Collision rate data before and after cable barrier installation

	Before	After	Percent Change
Annual median collisions	277	776	+180%
Median collision rate*	8.19	15.61	+91%
Annual serious injury median collisions	18.6	8.4	-55%
Annual fatal median collisions	9.0	6.5	-28%
Serious injury median collision rate*	0.55	0.21	-61%
Fatal median collision rate*	0.26	0.13	-52%

*per 100 mvmt

3.7 Cross-Median Collisions

Prior to cable barrier installation, there were 61.8 cross-median incidents per year in the study segments. That number was reduced to 26.0 incidents per year after cable barrier was installed: a 58% decrease. The number of annual cross-median fatal and serious injury collisions was reduced 72%, dropping from 14.6 to 4.1. Cross-median fatality and serious injury rates when combined have dropped 76%. Figure 3.4 details the performance for cross median events with counts and rates of serious or fatal injury collisions.

Figure 3.4 Cross-median collisions

	Before	After	Percent Change
Annual cross-median collisions	61.8	26.0	-58%
Cross-median collision rate*	1.82	0.64	-65%
Annual serious injury cross-median collisions	9.4	1.9	-80%
Annual fatal cross-median collisions	5.2	2.2	-58%
Serious injury cross-median collision rate*	0.28	0.05	-81%
Fatal cross-median collision rate*	0.16	0.05	-66%

*per 100 mvmt

3.8 Rollover Collisions in the Median

In rollover collisions, vehicle occupants are subjected to a wider range of forces and more frequent impacts with vehicle components, resulting in more severe injuries, particularly at higher speeds and with unrestrained occupants. Figure 3.5 shows an overall reduction of 36% for all rollover collisions in the median. For serious injury collisions, the reduction is 65%, with a 31% reduction in fatal collisions.

Figure 3.5 Rollover collisions in the median

	Before	After	Percent Change
Annual median rollover collisions	115.0	74.1	-36%
Median rollover collision rate*	3.41	1.61	-53%
Annual serious injury median rollover collisions	9.2	3.2	-65%
Annual fatal median rollover collisions	3.4	2.3	-31%
Serious injury median rollover collision rate*	0.27	0.08	-69%
Fatal median rollover collision rate*	0.10	0.04	-55%

*per 100 mvmt

3.9 Comparing Cable Barrier Systems

As detailed in the Background section of this report, WSDOT’s initial cable barrier installation was a generic (low-tension) 3-strand cable barrier system. Over time, cable barrier systems have evolved and WSDOT has kept pace with these developments: first with 3-strand high-tension cable systems and more recently with 4-strand high-tension cable systems.

A direct comparison of sequential cable barrier system types in Washington State was complicated by concurrent policy development. About the same time that high-tension cable barriers began appearing in Washington, WSDOT also implemented changes in guidance on cable barrier placement. Although the research team attempted to separate the shift to high-tension systems from the policy change, the two were found to be too closely linked to isolate the effects. The researchers determined that changes in crash rates for the various barrier systems also reflected changes in placement policy, particularly as WSDOT shifted from generic cable barriers to 3-strand high-tension systems.

While considering the combined effects of barrier system changes and policy changes in the analysis, the researchers found that high-tension cable barrier systems resulted in a higher incidence of vehicles being redirected back into traffic lanes compared to low-tension systems (see Figure 3.6). They also found that the percentage of cross-median collisions was lower with high-tension cable barrier installations.

Figure 3.6 Comparing cable median barrier system performance

Barrier Type	Barrier Performance	Reported Collisions	Not Stated	No Injury	Possible Injury	Evident Injury	Serious Injury	Fatal
Low-tension	Contained in median[1]	815 (86.2%)	17 (1.8%)	660 (69.8%)	71 (7.5%)	55 (5.8%)	9 (1.0%)	3 (0.3%)
	Redirected[2]	75 (7.9%)	2 (0.2%)	64 (6.8%)	4 (0.4%)	4 (0.4%)	1 (0.1%)	0
	Cross-median[3]	55 (5.8%)	0	20 (2.1%)	10 (1.1%)	14 (1.5%)	6 (0.6%)	5 (0.5%)
3-strand high-tension*	Contained in median[1]	1,051 (65.9%)	11 (0.7%)	843 (52.8%)	109 (6.8%)	69 (4.3%)	13 (0.8%)	6 (0.4%)
	Redirected[2]	474 (29.6%)	7 (0.4%)	381 (23.9%)	54 (3.4%)	25 (1.6%)	5 (0.3%)	2 (0.1%)
	Cross-median[3]	72 (4.5%)	0	39 (2.4%)	8 (0.5%)	14 (0.9%)	5 (0.3%)	6 (0.4%)
4-strand high-tension	Contained in median[1]	100 (55.9%)	0	81 (45.3%)	13 (7.3%)	6 (3.4%)	0	0
	Redirected[2]	77 (43.0%)	0	62 (34.6%)	4 (2.2%)	11 (6.1%)	0	0
	Cross-median[3]	2 (1.1%)	0	2 (1.1%)	0	0	0	0

[1] **Contained in median:** The vehicle hit the barrier and did not re-enter any lanes of traffic.

[2] **Redirected:** The vehicle hit the barrier and re-entered the lanes of traffic.

[3] **Cross-median:** The vehicle hit the barrier, went across the median, and entered the opposing lanes. To be conservative, the researchers considered any incident as a cross-median incident, whether or not there was a collision with opposing traffic.

* The Marysville section had dual runs of barrier. Southbound collisions between February 2007 and June 2009 were attributed to 3-strand high-tension cable barrier. All others were low-tension. (See Appendix A for details.)

3.9.1 Comparison with other barrier types

WSDOT uses beam guardrail, concrete barrier, and cable barrier to reduce cross-median collisions and the number of fatal and serious injury collisions. Longer installations are typically concrete or cable barrier rather than beam guardrail.

In the 2009 analysis, the researchers compared the performance of cable barrier, beam guardrail, and concrete barrier used in the median by conducting a systemwide study and a more detailed segment analysis of 58 miles of concrete barrier installations. This report uses those findings for beam guardrail and concrete barrier, from 2002 to 2008, as a comparison to the cable barrier installation experience through 2011. The following analyses found performance comparison results similar to those in previous reports, while they reflect an increase in mileage of high-tension cable systems with a corresponding increase in collisions with that barrier type.

3.9.2 Comparison with other barrier types: Injury severity

Cable barrier systems are associated with a reduced incidence of fatal or injury collisions compared to other barrier systems commonly used in the medians of Washington's highways. In analyzing these data, the researchers found that 19% of collisions involving 4-strand high-tension cable barrier and 20% of collisions involving 3-strand high-tension and generic low-tension cable median barrier resulted in fatal or injury collisions. This compares favorably with collision results for beam guardrail barrier and concrete barrier systems, with the collisions associated with those systems involving injury or death 37% and 38% of the time, respectively (see Figure 3.7).

Figure 3.7 Comparison with other types of barriers: Injury severity

Barrier Type	Reported Collisions	Not Stated	No Injury	Possible Injury	Evident Injury	Serious Injury	Fatal
Low-tension cable	945	19 (2.0%)	744 (78.7%)	85 (9.0%)	73 (7.7%)	16 (1.7%)	8 (0.8%)
3-strand high-tension*	1,597	18 (1.1%)	1,263 (79.1%)	171 (10.7%)	108 (6.8%)	23 (1.4%)	14 (0.9%)
4-strand high-tension	179	0	145 (81.0%)	17 (9.5%)	17 (9.5%)	0	0
Beam guardrail (2002–2008)	2,979	59 (2.0%)	1,828 (61.4%)	654 (22.0%)	361 (12.1%)	56 (1.9%)	21 (0.7%)
Concrete barrier (2002–2008)	9,708	183 (1.9%)	5,788 (59.6%)	2,394 (24.7%)	1155 (11.9%)	148 (1.5%)	40 (0.4%)
Total	**15,408**	**279 (1.8%)**	**9,768 (63.4%)**	**3,321 (21.6%)**	**1,714 (11.1%)**	**243 (1.6%)**	**83 (0.5%)**

*The Marysville section had dual runs of barrier. Southbound collisions between February 2007 and June 2009 were attributed to 3-strand high-tension cable barrier. All others were low-tension. (See Appendix A for details.)

3.9.3 Comparison with other barrier types: Multi-vehicle collisions

The researchers found that cable barrier helped keep errant vehicles in the median, which resulted in fewer multi-vehicle collisions. Figure 3.8 illustrates that low-tension cable barrier collisions involved multiple vehicles 18% of the time, 16% with the high-tension systems, while that number increased to 32% with concrete barrier and 36% with beam guardrail.

Figure 3.8 Percentage of single- and multi-vehicle collisions with barrier types

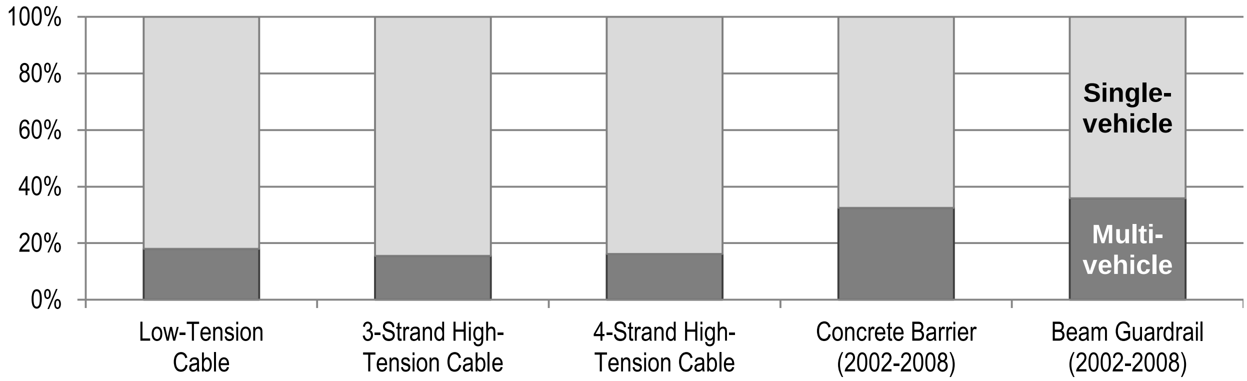


Figure 3.9 shows the number of injuries per single-vehicle and multi-vehicle collision event with the various barrier types. As shown, cable barrier collisions resulted in lower numbers of injuries per collision than other barrier types.

Figure 3.9 Number of injuries per collision

Collisions	Low-Tension Cable	3-Strand High-Tension Cable	4-Strand High-Tension Cable	Concrete Barrier*	Beam Guardrail*
Single-vehicle collisions	0.16	0.18	0.15	0.43	0.49
Multi-vehicle collisions	0.99	0.65	0.72	0.66	0.67
All collisions	0.31	0.25	0.25	0.51	0.56

*2002–2008

3.9.4 Comparison with concrete barrier

WSDOT engineers took a closer look at 58 miles of concrete barrier installations and compared them to 238 miles of cable barrier. The data for concrete barrier was taken from the 2009 analysis and covered years 2002 to 2008; data for cable barrier was through 2011. These concrete barrier segments were selected because their site characteristics were similar to highway locations where cable median barrier had been placed.

It is desirable to keep vehicles in the median once they have left the roadway. Vehicles that cross the median or are redirected back into traffic have a greater probability of involving additional vehicles, which likely results in higher numbers of injuries.

Depending on cable barrier type, the data show that between 8% and 43% of the vehicles striking cable barrier were redirected back into traffic lanes. This compares favorably to concrete barrier where nearly 64% of vehicles were redirected. The data also show that between 56% and 86% of the cable barrier collisions were contained in the median compared with 34% for concrete median barrier (see Figure 3.10). Note that, in addition to the rigidity of the barrier, the high percentage of vehicles redirected by concrete barrier was also influenced by the fact that concrete barriers were more frequently used in narrower medians, where the impacting vehicle did not have to travel as far to re-enter the lanes of travel.

Figure 3.10 Comparison of cable barrier and concrete barrier performance

Barrier Performance	**Low-Tension Cable** (42 miles) 1995–2011	**3-Strand High-Tension Cable** (170 miles)* 2004–2011	**4-Strand High-Tension Cable** (81 miles) 2009–2011	**Concrete Barrier** (58 miles) 2002–2008
Contained in median[1]	815 (86.2%)	1,051 (65.8%)	100 (55.9%)	441 (34.0%)
Redirected[2]	75 (7.9%)	474 (29.7%)	77 (43.0%)	828 (63.8%)
Cross-median[3]	55 (5.8%)	72 (4.5%)	2 (1.1%)	28 (2.2%)
Total	**945**	**1,597**	**179**	**1,297**

[1] **Contained in median:** The vehicle hit the barrier and did not re-enter any lanes of traffic.

[2] **Redirected:** The vehicle hit the barrier and re-entered the lanes of traffic.

[3] **Cross-median:** The vehicle hit the barrier, went across the median, and entered the opposing lanes. To be conservative, the researchers considered any incident as a cross-median incident, whether or not there was a collision with opposing traffic. In the analysis, there were 80 cross-median incidents involving cable barrier where there was not a collision with opposing traffic: 62% of the total.

* The Marysville section had dual runs of barrier. Southbound collisions between February 2007 and June 2009 were attributed to 3-strand high-tension cable barrier. All others were low-tension. (See Appendix A for details.)

An analysis of 58 miles of concrete median barrier revealed that 2.2% of the collisions with concrete barrier resulted in vehicles traveling over or through the barrier and reaching the opposing traffic lanes compared with 1.1% for 4-strand high-tension cable barrier, 4.5% for 3-strand high-tension cable barrier, and 5.8% for low-tension cable barrier. Concrete barrier showed a slightly lower percentage of cross-median collisions compared to 3-strand high-tension cable barrier. The 4-strand high-tension cable barrier appeared to balance the rigidity needed to resist cross-median events and with enough deflection of the barrier to reduce the number of redirected vehicles compared to concrete barrier.

Figure 3.11 shows barrier performance by collision severity. Again, 4-strand high-tension cable barrier outperformed the other types. The 3-strand high-tension cable barrier was comparable to concrete barrier in the serious injury category.

Figure 3.11 Injury severity where barrier was impacted

Most Severe Injury Type (where barrier was impacted)	**Low-Tension Cable** (42 miles) 1995–2011	**3-Strand High-Tension Cable** (170 miles)* 2004–2011	**4-Strand High-Tension Cable** (81 miles) 2009–2011	**Concrete Barrier** (58 miles) 2002–2008
Serious injury crash count	16 (1.7%)	23 (1.4%)	0	23 (1.8%)
Serious injury crash rate**	0.20	0.21	0	0.21
Fatal crash count	8 (0.8%)	14 (0.9%)	0	7 (0.5%)
Fatal crash rate**	0.10	0.13	0	0.06

* The Marysville section had dual runs of barrier. Southbound collisions between February 2007 and June 2009 were attributed to 3-strand high-tension cable barrier. All others were low-tension. (See Appendix A for details.)

**per 100 mvmt

3.10 Motorcycle Collisions

Injuries and fatalities involving motorcyclists have been increasing across the nation in recent years. This trend parallels an increase in motorcycle ridership. Motorcyclists are at greater risk of injury in crashes than occupants in passenger vehicles, who are protected by sheet metal, padded interiors, restraint systems, and air bags. Some motorcyclists have expressed concern that cable barrier systems present a high risk for severe lacerations or even dismemberment from contact with the cables. While motorcyclists are at greater risk of injury in a collision than occupants in most other vehicles, there is little evidence that these types of injuries are occurring. The researchers reviewed collisions involving motorcycles hitting median barrier and found no significant difference in injury severity regardless of what type of median barrier motorcyclists struck.

3.10.1 Motorcycle collisions involving medians with cable barrier

Through the end of 2011, there were ten collisions involving motorcycles and cable median barrier in Washington State. One of these events resulted in no injuries, one was coded as possible injury, three were classified as evident injury, one produced serious injury, and four resulted in fatalities. It is important to note that concern about severe lacerations or dismemberment resulting from contact with the cables has not been an issue in Washington. The researchers have monitored this issue in Washington and in other states and countries that have used cable barrier systems. They found that the concern about dismemberment resulting from motorcyclists colliding with cable barrier systems is not supported by data.

Following is a summary of the cable median barrier fatal injury motorcycle crashes in Washington State:

- **I-90, Milepost 184, Moses Lake – Oct. 26, 2008:** An inexperienced driver was entering I-90 westbound at MP 184 east of Moses Lake, when he left the paved on-ramp to the left, crossed through a gravel area between the ramp and the Interstate, crossed the Interstate traffic lanes, entered the median, and struck the cable barrier. The driver was upright on the motorcycle when it struck the barrier, was subsequently ejected, and struck the ground with his head. The driver was dead at the scene from a broken neck. Driver inattention was a factor in this collision.
- **SR 99, Milepost 25, Seattle – Aug. 24, 2008:** A northbound motorcycle on SR 99 between Tukwila and Seattle was traveling at high speed, lost control, and overturned in the lane. Witnesses reported the driver was doing wheelies prior to the crash. The driver separated from the motorcycle and struck a cable barrier post with his back. The driver was dead at the scene from spinal injuries. Speed was a factor in this collision.
- **SR 512, Milepost 10, Puyallup – June 27, 2008:** A westbound motorcycle on SR 512 was observed traveling at high speed, passing vehicles on both shoulders. The driver lost control, overturned in the lanes, and slid into the cable barrier. The driver suffered broken bones and a broken neck as a result of pavement contact and was pronounced dead at the scene. The investigating officer reported that the driver came to rest against a post of the barrier system. The driver was found to be under the influence of alcohol, which was a factor in this collision.
- **SR 512, Milepost 9, Puyallup – January 16, 2010:** An eastbound motorcycle made a lane change from lane one to lane two, lost control, entered the median, rolled, and came to a stop in the median. The driver was ejected from the motorcycle into lane two. A fatal injury resulted from being struck by other vehicles traveling in the same direction.

3.10.2 Motorcycle collisions involving medians without barrier

In locations without median barrier, motorcycles are as prone as any other vehicle type to be struck by an oncoming vehicle that crosses the median. Although the proportion of motorcycles to other vehicle types using the highways is low, the researchers identified five collisions of this kind:

- **SR-16, Milepost 12, Pioneer Way Interchange – November 5, 2003:** No Injury. Cable barrier was installed here in June 2007.
- **I-90, Milepost 103, west of Ellensburg – August 27, 2002:** Evident Injury. The median at this location is over 70' wide and does not meet the WSDOT criteria for median barrier.
- **I-90, Milepost 291, east of Spokane – June 13, 2002:** Evident Injury. Concrete median barrier was installed here in 2005.

Two of the five collisions resulted in fatal injuries:

- **I-90, Milepost 13, east of Bellevue – July 27, 2006:** The driver of a vehicle traveling on westbound I-90 apparently blacked out from a medical condition and crossed the median. The vehicle struck a motorcycle traveling in the eastbound direction. The driver of the motorcycle was killed. The median at this location is approximately 70' wide and does not meet the WSDOT criteria for median barrier.
- **SR 18, Milepost 19, Tiger Mountain – April 23, 2005:** The driver of a vehicle traveling on westbound SR 18 lost control and entered the median. The vehicle began to spin as it crossed the median and entered the eastbound lanes where it struck a motorcycle. The driver and passenger on the motorcycle were killed. This section of highway has since been reconstructed and a beam guardrail median barrier installed.

These collision events where motorcycles are struck by oncoming vehicles through medians without barrier are mentioned to illustrate that the benefit of cable barrier in the median extends to all highway users regardless of vehicle type.

3.10.3 Motorcycle collision research

As mentioned in previous cable barrier reports, a WSDOT-proposed research project titled, "Identification of Factors Related to Serious Injuries in Crashes of Motorcyclists into Traffic Barriers," was selected for funding as part of the National Cooperative Highway Research Program (NCHRP). This study began in 2009 and the results should be available in 2013.

The NCHRP study will identify characteristics involved in fatal and serious injury collisions involving motorcycles and traffic barriers. The research will investigate characteristics related to: the drivers involved; collision types; barrier types; roadway geometry and conditions; vehicle types; and environmental conditions. The study will also identify specific characteristics that could be studied further to develop potential ways to improve motorcycle safety. A WSDOT employee is on the project panel for this research.

SECTION 4: CABLE BARRIER REPAIRS: 2007 TO 2011

4.1 Cable Barrier Repair Records

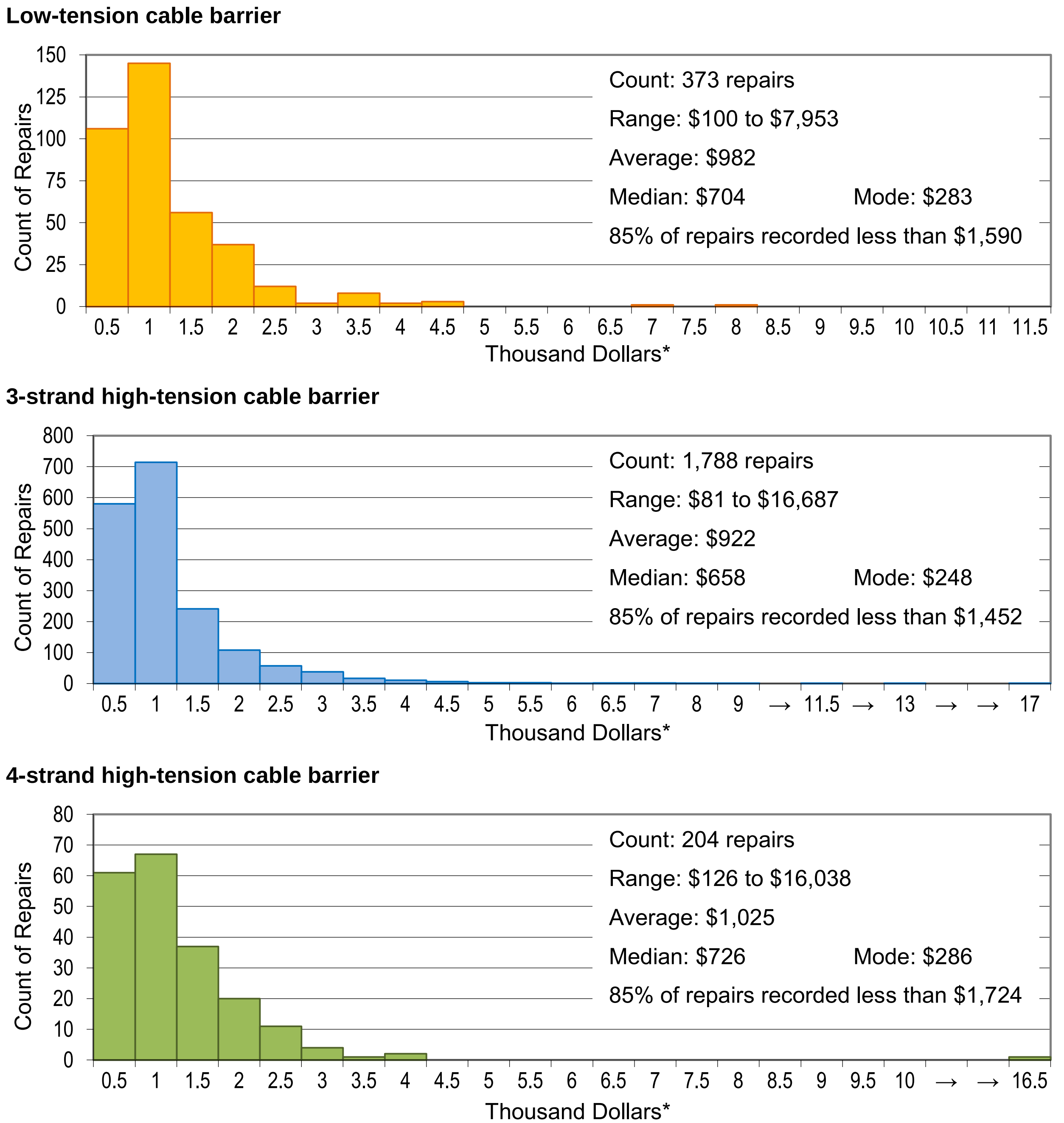
Every element that composes a roadway requires maintenance at some point; this includes traffic barriers, particularly if they are impacted. As mentioned previously in the narrative regarding unreported collisions, cable barrier repair records did not become widely available until 2007. For that reason, data used for the following summaries is from 2007 to 2011, inclusive.

This window of time naturally omits much of the earlier low-tension cable barrier duration. However, it retains almost 42 miles of composite segments, with an average duration of just under three years. It does capture most of the 3-strand high-tension cable barrier experience on 170 miles, with an average duration of 3.75 years. The first 4-strand high-tension run was not installed until late in 2009; consequently, 81 composite miles are represented, but with an average duration of just under 1.50 years.

4.1.1 Cost per repair

Cost here is defined as the sum of costs for all parts, labor, equipment, and administrative activity per repair, as recorded on the repair estimate. Figure 4.1 shows the distribution of cost per repair by cable barrier type.

Figure 4.1 Cost per repair by cable barrier type



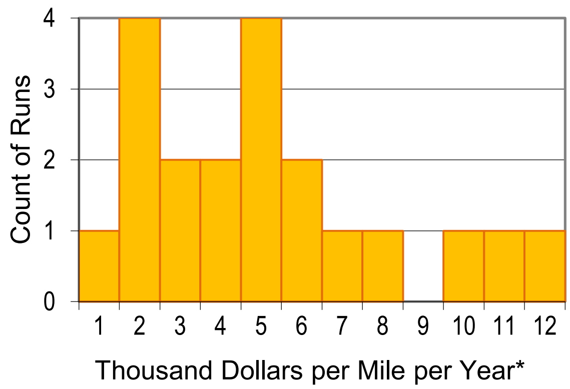
*Graph bin increments are the upper bounds; e.g., "1" shows the number of repairs that recorded $1,000 or less, but more than $500 to repair.

4.1.2 Repair cost per mile per year

This summary first totals the cost of all repairs on an individual treated segment, divides that total by the segment's length, and then divides that quotient by years in service, giving the cost per mile per year (pmy) of that segment (run). Figure 4.2 shows the repair cost pmy rate of runs by cable barrier type.

Figure 4.2 Repair cost per mile per year by cable barrier type

Low-tension cable barrier



Count: 20 segments (runs)

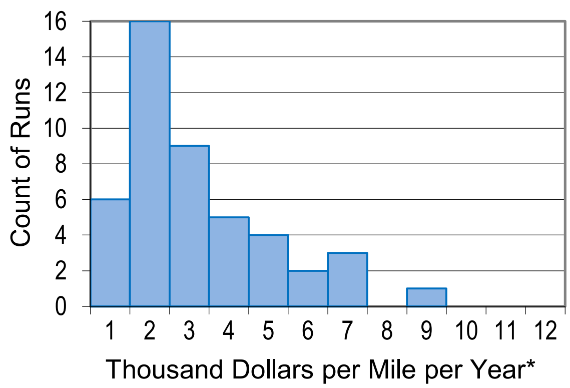
Range: $157 to $11,318 pmy

Average: $4,603 pmy

Median: $4,243 pmy

85% of runs had less than $7,743 pmy

3-strand high-tension cable barrier



Count: 46 segments (runs)

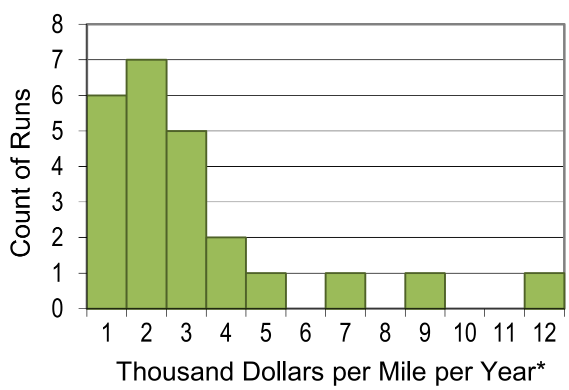
Range: $501 to $8,316 pmy

Average: $2,685 pmy

Median: $2,148 pmy

85% of runs had less than $4,458 pmy

4-strand high-tension cable barrier



Count: 24 segments (runs)

Range: $58 to $11,056 pmy

Average: $2,636 pmy

Median: $1,898 pmy

85% of runs had less than $4,209 pmy

*Graph bin increments are the upper bounds; e.g., "2" shows the number of runs rating $2,000 or less, but more than $1,000 repairs per mile per year.

4.1.3 Repair frequency per mile per year

This summary first totals the number of repairs on an individual treated segment, divides that total by the segment's length, and then divides that quotient by years in service, giving the repairs per mile per year (pmy) of that segment. Figure 4.3 shows the repair pmy frequency of runs by cable barrier type.

Figure 4.3 Repair frequency per mile per year by cable barrier type

Low-tension cable barrier

Count: 20 segments (runs)

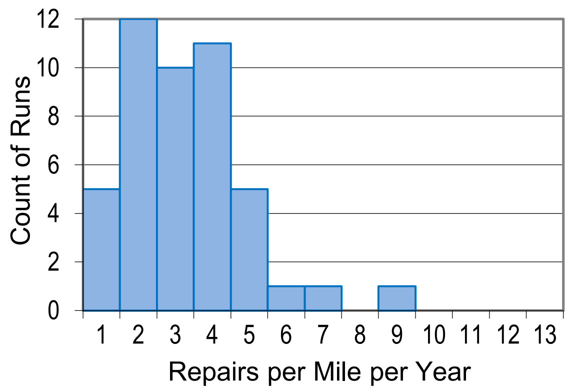
Range: 0.4 to 12.7 repairs pmy

Average: 4.6 repairs pmy

Median: 4.2 repairs pmy

85% of runs had less than 8.3 repairs pmy

3-strand high-tension cable barrier



Count: 46 segments (runs)

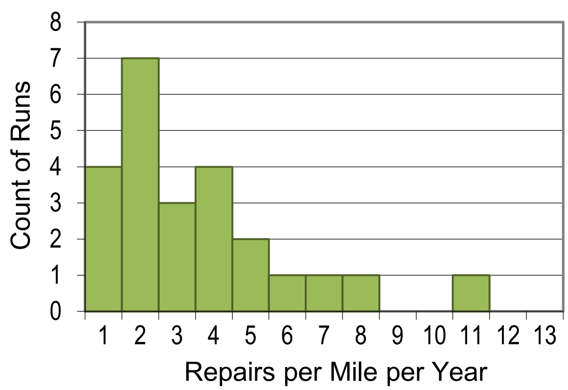
Range: 0.7 to 8.1 repairs pmy

Average: 2.8 repairs pmy

Median: 2.6 repairs pmy

85% of runs had less than 4.1 repairs pmy

4-strand high-tension cable barrier



Count: 24 segments (runs)

Range: 0.7 to 10.8 repairs pmy

Average: 3.0 repairs pmy

Median: 2.3 repairs pmy

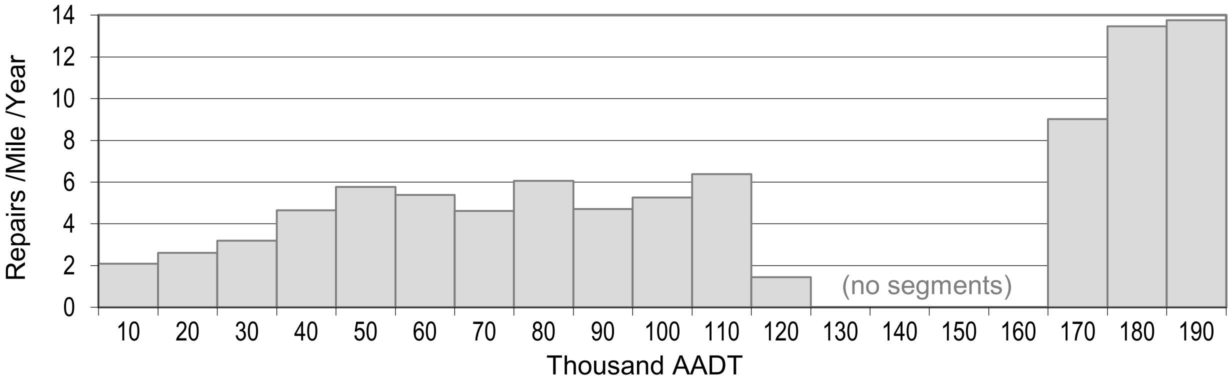
85% of runs had less than 5.3 repairs pmy

Note: Graph bin increments are the upper bounds; e.g., "2" shows the number of runs rating 2 or less, but more than 1 repair per mile per year.

4.1.4 Repair frequency per mile per year by AADT

This summary determines the number of repairs per mile per year, without regard to cable barrier type, at estimated annual average daily traffic (AADT) increments, as shown in Figure 4.4.

Figure 4.4 Repair frequency per mile per year by AADT



Note: Graph bin increments are the upper bounds; e.g., "20" shows the repairs per mile per year at 20,000 AADT or less, but more than 10,000.

As expected, the frequency of repairs generally increases with traffic. Anyone using Figure 4.4 to estimate the repair cost per year given a length of highway, its AADT, and a derived cost per repair of a cable barrier type is cautioned that it is composed of an aggregate of sites that vary in median width, number of lanes, posted speed, barrier offset, presence of rumble strips, horizontal alignment, etc. Besides AADT, specific site conditions could affect the frequency of repair.

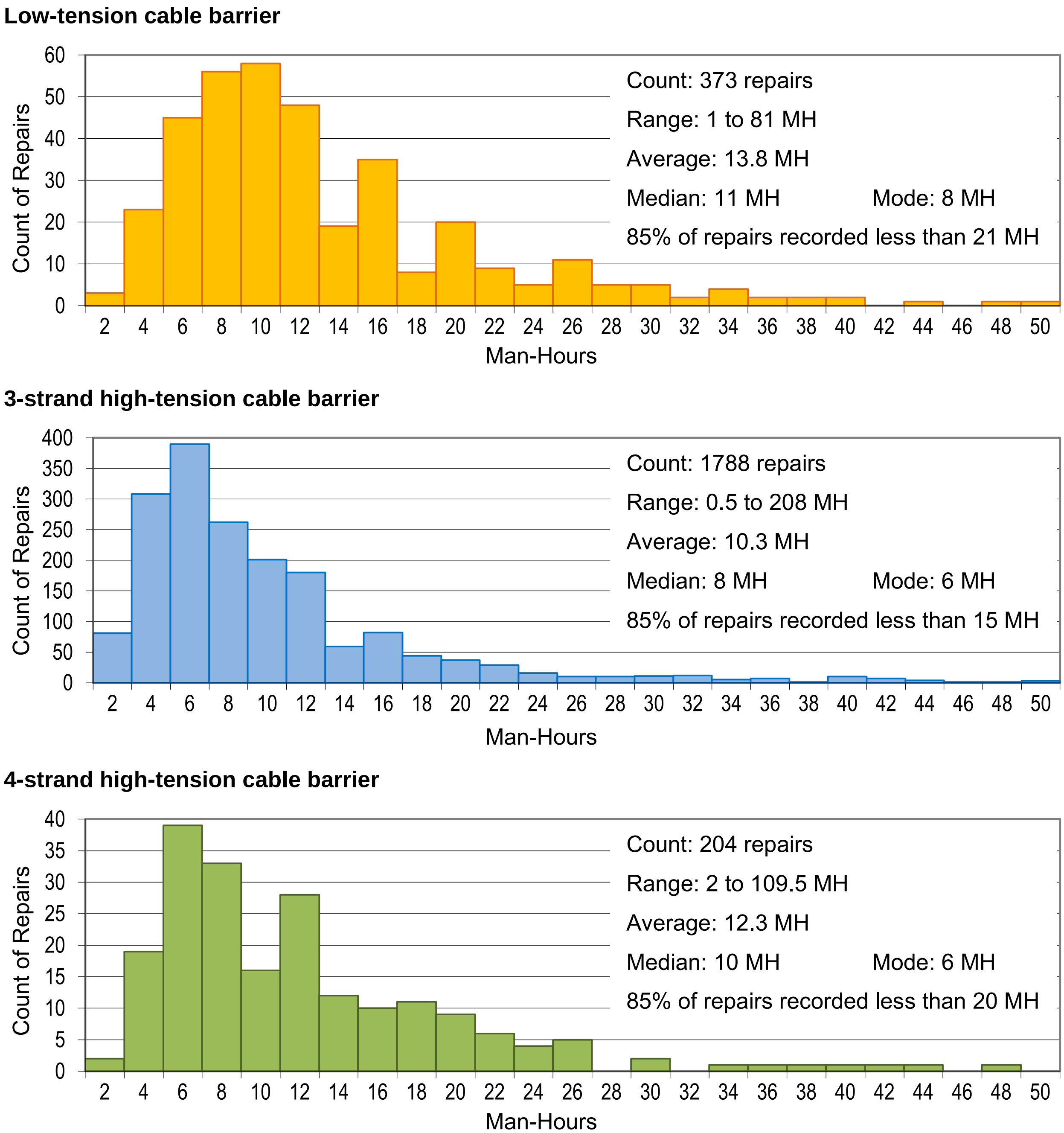
It should be noted that not all of the barrier repair costs are necessarily borne by the agency responsible for maintenance. WSDOT makes cost recovery efforts when the person responsible for the damage of any agency-owned property can be clearly identified. This includes cable median barrier, guardrail, and similar roadway safety hardware. This cost recovery is not tracked by the type of property damaged; as a result, the percentage of the damage costs recovered for the cable median barrier is not available. Statewide, the WSDOT Risk Management Office stated in 2012 that, on average, the state highways and other facilities suffer $9.3 million in damages each year. In 2011, WSDOT recovered 3,600 payments totaling almost $7 million.

4.1.5 Man-hours per repair

Maintenance activities conducted under traffic expose personnel to hazards. Obviously, less time required to perform an activity in a traffic environment is preferable. To get a relative indication of cable barrier repair exposure time, the researchers used the total man-hours (person-hours) quantity recorded for repair. This measure could mean five man-hours are equivalent to one person working for five hours or five people working for one hour.

A repair usually includes essential activities that do not directly involve barrier components, while still under traffic exposure such as traffic control. Terminal repairs are also represented in these sets. Though less common than a repair somewhere within a run, repairs to cable barrier anchors or tie-ins to other barriers are inevitable and usually require more time. Not all of the hours entail exposure to traffic; they may include the time needed to prepare, travel to the site, file paperwork, etc. The analysis includes all of the time reported by the maintenance reports, including travel, paperwork, etc. Figure 4.5 shows the distribution of man-hours per repair by cable barrier type.

Figure 4.5 Man-hours (MH) per repair by cable barrier type



Note: Graph bin increments are the upper bounds; e.g., "8" shows the number of repairs that recorded 8 or less, but more than 6 man-hours,

Figure 4.5 shows that the high-tension systems are recording fewer man-hours to repair. The 3-strand high-tension system appears to require the fewest average man-hours. The 3-strand high-tension repair numbers are nine times that of the 4-strand system, which is a result of being in place over a longer period of time. There is an expectation that, as they spend more time and gain familiarity with the 4-strand system, maintenance crews will reduce the average time required to repair these systems.

4.2 Planned versus Installed and the Future

In 2001, the cable median barrier program began as an effort to reduce cross-median collision events and the significant risk of injuries these types of collisions presented on our controlled-access highways with medians 50’ or less. The original benefit/cost (B/C) analysis identified 169 miles of roadway suitable for cable median barrier installations. Of this original 169 miles, less than 1 mile remains without cable median barrier. This portion of a mile is made up of numerous very short lengths where other barrier types have typically been used.

The cable median barrier program grew beyond the 169 miles identified in the B/C analysis of the 2001 *Median Treatment Study on Washington State Highways* to include limited access high-speed routes and some locations where medians were greater than the 50’ width guidance. This broader use of the cable median barrier increased the total mileage to just over 233 miles on state highways.

Over the last dozen years that this program has been in place, there have been a number of locations where cable median barrier was installed, only to be removed later. In most instances, this has been on routes where a project to increase the number of travel lanes reduced the median width for a paved travel lane. In almost all cases, these reduced-width medians had the cable barrier removed and reused in another location, and concrete barrier was installed in its place. In total, roughly 67 miles of cable median barrier has been removed and replaced or upgraded.

Without a significant change to the cable median barrier policy or major construction projects, the number of locations that these products may be installed as median barrier is at an end. The cable barrier is being used as a barrier on both sides of the roadway to shield drivers from hazards where the cable barrier’s deflection is not an issue. Uses similar to this and others may be found for the product in the future; however, the number of miles of median cable barrier is not expected to increase.

4.2.1 Cost effectiveness comparison

Cable median barrier can be more economical to install than other median barriers for several reasons. One significant cost difference is the site preparation. Concrete and guardrail median barrier require at least minor grading to have slopes that fit at least 10H:1V. Cable barrier can be installed on slopes of 6H:1V and flatter by current design guidance.

Guardrail is not often used as a median barrier. Concrete barrier is usually a better option than guardrail if cable barrier is not feasible due to deflection concerns. Guardrail in single or double-faced runs for bi-directional traffic requires a greater footprint for installation, deflection, and anchorage over concrete barrier. The maintenance cost of guardrail usually exceeds that of concrete barrier. The site preparation and construction of guardrail and concrete are similar in that they require the same slopes and grading for installation in a median. Concrete barrier systems usually require catch basin drainage and water retention systems for roadway runoff that results from the paving required. These hydraulic features are not required for most cable median barrier systems. Guardrail median barrier systems often require similar water drainage features. When comparing installation costs between systems, there are some difficulties in the comparisons. Site preparation is a major factor in installing differing median barrier systems. Grading work can be a significant issue. Materials used may be similar, but quantities can be significantly different.

In comparing the costs of these systems, the following assumptions will be made to compare systems as directly as possible. Two values will be calculated: an average cost with minor grading and an average cost with major grading.

1. Project length is 4 miles.
2. Median is 50’ wide.
3. Existing median is depressed with 4H:1V slopes.
4. Barrier is placed in center of median in each option.
5. Existing median shoulders are 10’ for minor grading and 4’ for other scenarios.
6. Major grading work assumed for 1 mile of a 4-mile segment with existing 4’ shoulder.
7. Minor grading work for guardrail and concrete barrier installation assumes 10H:1V slopes, with soils sufficient for infiltration.
8. Assume four separate retention ponds at an estimated cost of $150,000; estimate is low on other hydraulic features for concrete barriers due to complexity of systems.
9. These estimates preclude miscellaneous costs that can vary from each barrier system.
10. Construction engineering estimates are based on the project being a collision-reduction improvement project.

In evaluating the cost differences between median barrier systems, the dollar values are based on the 2009–2011 Biennium statewide average low bid amount from the contracts funding these specific types of barrier projects.

The methodology of this cost comparison is to identify those essential features and construction techniques and/or methods of each barrier type and using the awarded contract bid amounts to establish a comparable cost basis.

The three barrier types to be examined—cable, guardrail, and concrete—share some similar work items: volumes of the material or number of hours required for a task with each barrier type can vary significantly. Site preparation is required for all types, as is erosion control and planting; these costs remain roughly equal between barrier types.

Traffic control is another work item that all barrier types require; however, the length of work in the contract will vary with the type of barrier being installed. Some of the specific costs associated with traffic control would be the staffing of flaggers and spotters, portable message signage, and temporary and truck-mounted impact attenuators. These costs are based on an hourly or daily rate.

The assumptions used in these scenarios are a 40- or 60-day (dependent on minor or major grading) contract for cable median barrier, a 60- or 90-day period for guardrail, and an 85- or 120-day period for concrete barrier. The traffic control costs associated with cable barrier may be one-third that of the same location where concrete is installed due to the period involved in installing each.

All barrier types share the same expenses involved in design, right of way acquisition, administration, mobilization, and engineering. This analysis includes an estimate of the engineering and design costs based on a percentage, which varies based on the total value of the construction costs: the higher the total cost, the less the percentage added on for engineering and design. Preliminary design engineering and construction engineering costs are calculated on the total of the construction contract. For projects that costs less than $1 million, the total design and engineering costs are calculated at a total of 35% of the construction cost. This percentage will decrease as the contract construction estimate increases. Also included is the cost of mobilization, which is based on a percentage of the construction costs; currently, this percentage is set at 10%. The cost of Washington State sales tax is also included in the cost estimate at a base percentage of 8.5% on the construction cost estimate; the engineering costs are not calculated into the sales tax amount.

These work items or associated costs are those that are common between each barrier type. The expenses may vary due to the period the work requires, the total cost of the construction contract, or other considerations, but these are the common elements.

4.2.2 Installation and costs

Following is a brief overview of the unique aspects of each barrier type, including installation and associated costs.

Cable median barrier

- Cable median barrier installation requires little heavy equipment or paving for installation. The barrier is supported by metal posts inserted in concrete sockets that have been placed in the median. The cable barrier systems require anchorages at each termination end, some of which may tie into another median barrier system. These anchorages are the most equipment-intense portion of the installation where some excavation or concrete work may be required. Once the cable posts are set and the anchorages secured, the cables are unspooled from trucks and the cable is mounted to the posts and then tensioned.

Beam guardrail

- The guardrail in this comparison is the WSDOT standard item type 4 double-faced W-beam rail mounted at 31”. Guardrail requires slopes equal to those of concrete barrier, which results in higher grading expenses over cable barrier. In those situations where major grading is required, drainage installations for roadway runoff are also required. This would include catch basins for both directions of travel on the roadway installed at roughly nine catch basins per mile (503’ center to center with soils assumed sufficient for infiltration).
- The basic materials of posts and rails compare closely to those of the cable barrier components; in this comparison, about 10–12% higher for guardrail over cable components. The terminals are less expensive than those for cable barrier. However, there are costs associated with the drainage issues created with the installation of guardrail, and even greater expense when connecting to existing barrier systems and structures. The rest of the construction of guardrail is similar to that of cable barrier. The guardrail posts are mechanically set in the ground and the panels are bolted to the posts, completing the installation.

Concrete barrier

- Concrete barrier in this comparison is the WSDOT standard item precast single-slope barrier 42” in height. Concrete barrier requires a stable and smooth base for installation. This means paving must meet the conditions required for the installation. Paving the center median area also requires handling the roadway runoff from rain and weather events. This increases the number of catch basins and grates in the entire segment as a basic requirement. Additional expenses are added when connecting to the additional drainage facilities, retention ponds, and structures to support the barrier.
- Concrete barrier requires the use of beam guardrail for termination and tying into other structures such as bridges, over/under crossings, or similar features. This concrete barrier installation includes 4,000’ of WSDOT standard item type 31 beam guardrail for use as described above.

In each of these barrier scenarios there are work items or materials that have not been included. One of the more complex issues is the highway drainage and hydraulic structures required for concrete barrier or in some cases guardrail. These costs are most likely under-reported in these analyses. The dollar values of each of the barrier systems were rounded to the nearest thousand at the conclusion of each work item or task that had been calculated by barrier type.

This installation cost comparison stated in the assumptions that there would be two values calculated: a minor grading cost and a major grading cost over a portion of the segment. The average of the values of these two costs will be used as the single point of comparison between barrier types.

This discussion is not a life cycle cost analysis. Maintenance costs, expected longevity, and the costs associated with the life of the feature are not analyzed. The point of this analysis is to identify, for a specific median barrier type, the average cost of a sample segment of roadway 4 miles in length.

- The estimated installation costs for a 4-strand high-tension cable median barrier system with minor grading were $46.00 per linear foot and $71.00 per linear foot with major grading, which averaged $58.40 per linear foot.
- The estimated installation costs for guardrail median barrier with minor grading were $53.00 per linear foot and $127.00 per linear foot with major grading, which averaged $89.94 per linear foot.
- The estimated installation costs for concrete median barrier with minor grading were $187.00 per linear foot and $521.00 per linear foot with major grading, which averaged $351.11 per linear foot.

It is clear that cable median barrier is considerably less expensive to install. Guardrail installation cost is roughly one-third greater than cable median barrier, and concrete barrier is almost six times the cost per linear foot of cable median barrier. The greater length of coverage offered by cable median barrier brings a reduction in cross-median events by offering more protection along the highway.

With these estimated costs per linear foot, a comparison can be made of the number of miles that could be installed for each barrier type. Using the total current miles of median cable barrier (232.50 miles) and the average cost per linear foot of $58.40 for cable median barrier, the number of miles that could be installed can be calculated by using a ratio between the cable barrier average cost and the concrete or guardrail average cost, and applying that ratio to the total length of the mileage. The reader is advised that these cost values are averages of minimum and maximum values based on the previously described assumptions and not on the program costs associated with the specific cable median barrier sites examined. The average costs calculated for the other barrier types are as follows:

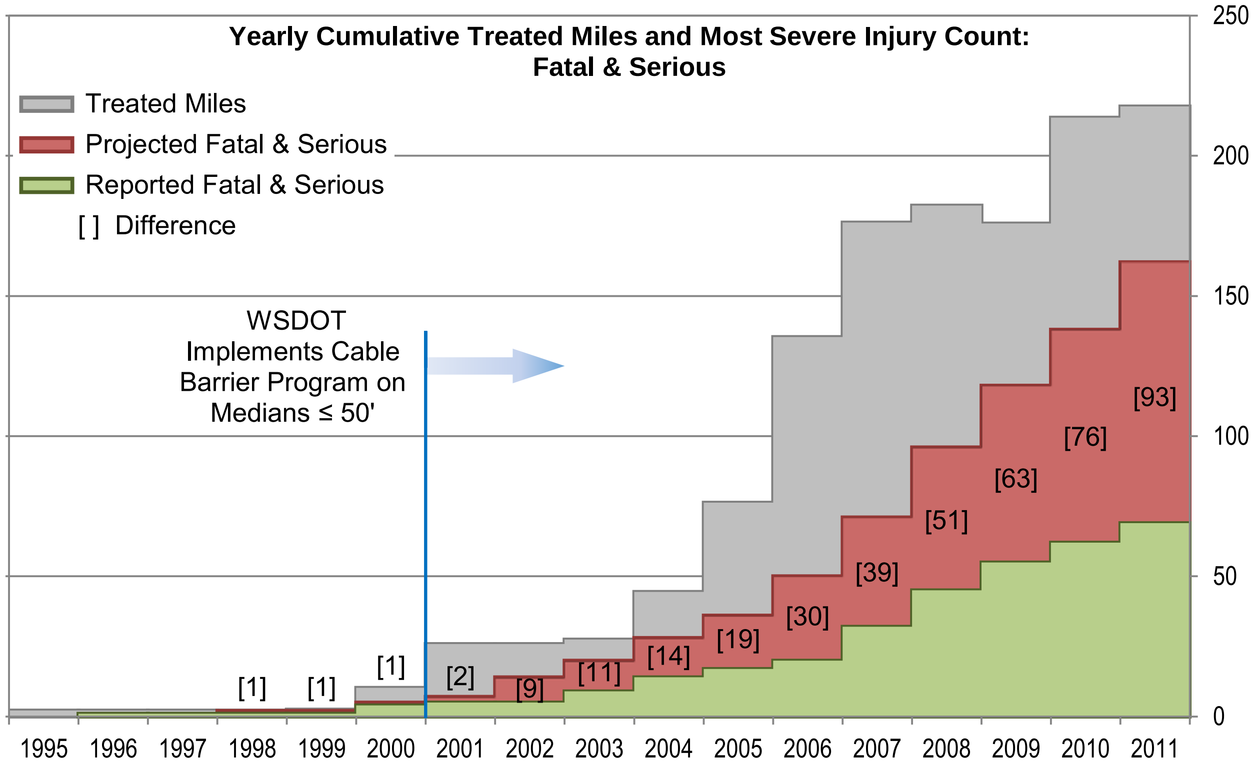
- Beam guardrail average installation cost of $89.94 per linear foot funded at the same level as the cable median barrier system ($58.40) would result in the installation of 173.51 miles, which would leave 58.99 miles of the current 232.50 miles with no median protection.
- Concrete median barrier average installation cost of S351.11 per linear foot funded at the level of the cable median barrier system would result in the installation of 44.45 miles, leaving 188.05 miles of unprotected median.

From calculating the lengths of each barrier type that could have been installed under the dollars spent on the cable median barrier program, it is also possible to project the number of fatal events that might have occurred under each barrier type as well as the no-median-barrier condition.

4.2.3 No barrier versus cable barrier

Another way to express the effectiveness of the WSDOT cable median barrier program is to compare the actual performance with that of a projected non-barrier condition (see Figure 4.6).

Figure 4.6 Actual performance versus a projected nonbarrier condition



In this comparison, the count of fatal and serious injury collisions in a cable median barrier segment's "before" (installation) period is divided by the duration (usually five years) of that period. This gives a collisions-per-year (CPY) value to the number of collisions that would have occurred in each following year had cable median barrier not been installed on those miles (i.e., projected fatal and serious injury collisions).

Figure 4.6 shows the per year projected fatal and serious injury collision count (red) on a backdrop of cumulative cable median barrier miles installed (gray). As the years progress, more segments (miles) are installed and their respective CPY values are calculated and added to those already established, cumulatively at each year. In contrast (green) are the actual reported fatal and serious injury collision cumulative counts. The difference is given in [brackets]. This suggests that the WSDOT cable median barrier network, in its history, has deterred over ninety-three fatal and serious injury collisions.

Using collision rates is another way to view the effectiveness of cable median barrier in comparison to other barriers as well as the no-barrier condition. In this and in previous cable median barrier reports, WSDOT has reported on fatal collision rates by barrier type. In the case of the no-barrier condition, the fatal rate observed in the before period (0.26 per 100 mvmt) is projected across the after period, to arrive at the projected number of fatalities if nothing had been done for cross-median protection.

Similarly for guardrail and concrete barrier, the fatal rates of each (as previously reported) are used to calculate the projected number of fatalities for those areas that are covered by the length of the barrier and the unprotected length in the before period fatal rate. For guardrail, the rate of fatal collisions is 0.16 per 100 mvmt; for concrete barrier, the fatal collision rate is 0.06 per 100 mvmt; and for cable median barrier, the fatal collision rate is 0.13 per 100 mvmt.

Figure 4.7 displays the data of the projected fatalities across the barrier types and miles each is estimated to have installed. The values in blue indicate those fatal collisions that are projected not to have occurred. Under this view, the untreated median indicates that a projected 53 fatal events would have occurred. This value is indicated by the red arrow in the figure, which acts as the baseline number of events that the median barrier types would be expected to reduce.

The projection indicates that for:

- Concrete barrier, fatal collision events would be reduced to 45: a reduction of 8 projected fatalities.
- Beam guardrail, fatal collision events would be reduced to 37: a reduction of 16 projected fatalities.
- Cable median barrier, fatal collision events would be reduced to 26: a reduction of 27 projected fatalities.

Figure 4.7 Projected fatalities across barrier types and miles

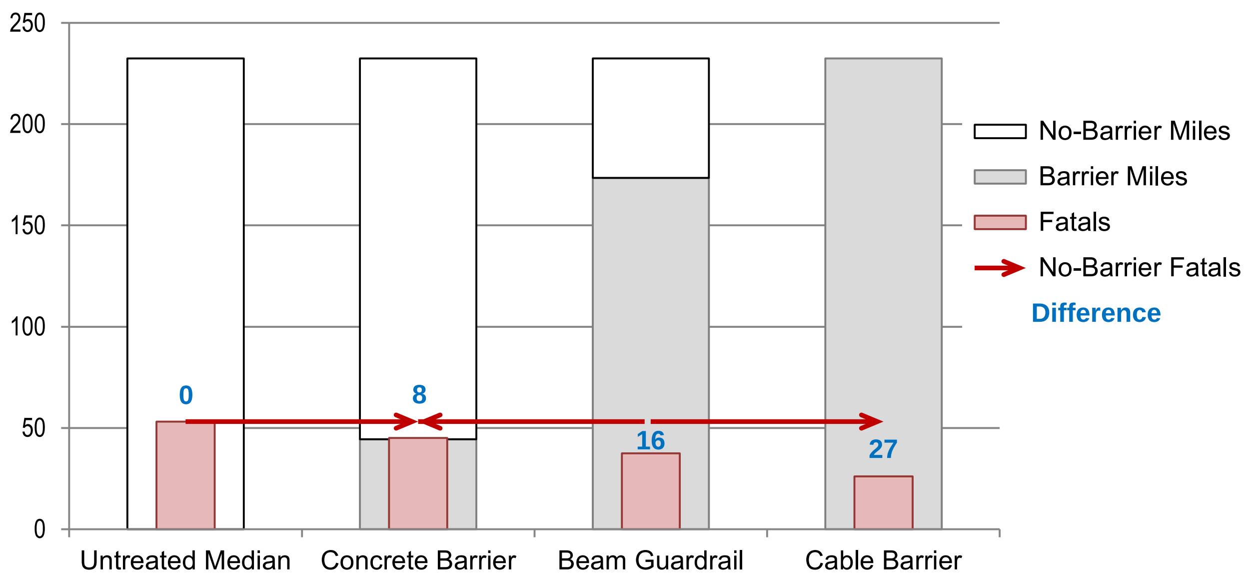


Figure 4.7 indicates that cable median barrier performance and low-cost per linear foot allowed a greater impact in reducing fatal collisions that may have occurred. In comparison to concrete median barrier, WSDOT was able to install over four times the miles and positively affect over three times the number of drivers who may have perished in a cross-median collision had concrete barrier been installed instead of cable barrier.

SECTION 5: SUMMARY OF EXPERIENCE

The cable median barrier program's initial objective was to reduce the frequency and severity of cross-median collisions on high-speed controlled-access roadways. This was successful. The fatal collision rate of 0.26 per 100 mvmt in the before period has been reduced by one-half: to 0.13 per 100 mvmt.

The data demonstrates that the 4-strand cable median barrier experience has one-half the frequency of cross-median 4 Strand concrete barrier: 1.1% for cable median barrier compared to 2.2% for concrete barrier (see Figure 3.10). The inherent low cost of cable median barrier installations allowed WSDOT to extend coverage over a greater length of roadway than if another barrier system had been installed. The increased length combined with the effectiveness of the cable median barrier systems described in this report have offered a greater level of safety for more of the state's citizens, compared to what might have been expected with another type of barrier system.

If no barrier had been installed, the researchers calculated that 53 fatal collisions would have occurred over the roadways where cable median barrier was actually installed. As a result of the cable median barrier program, an estimated 27 families did not suffer the loss of a loved one in a cross-median collision. This result is significantly greater than another barrier system could realize with a similar investment (see Figure 4.7).

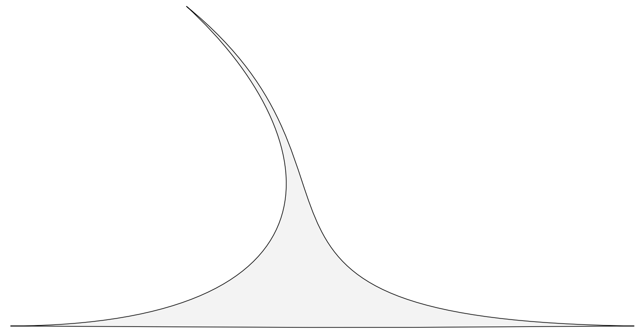
The researchers believe the cable median barrier program and its evolution in Washington State has met and exceeded the intent of the initial program for a low-cost, safe, and effective median barrier system.

APPENDIX A: CABLE MEDIAN BARRIER LOCATIONS IN WASHINGTON STATE

Map of Report Sites

SR 3 Silverdale

Milepost: 38.53 to 53.18



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2007	38.53	45.12	6.59	55
	Jun 2007	46.38	53.18	6.80	55
	Dec 2008	45.51	45.98	0.47	37

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	52	24	8	0
	Rate*	0.048	0.022	0.738	0.000
3-Strand High-Tension	Count	125	103	2	0
	Rate*	0.130	0.107	0.208	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	11	5	4	0
	Rate*	0.010	0.005	0.369	0.000
3-Strand High-Tension	Count	4	3	0	0
	Rate*	0.004	0.003	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

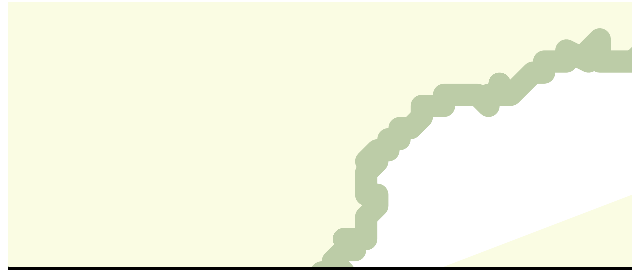
Notes:

Four cross-median events have occurred since this cable me
collisions that occurred in 2011 and the fourth was a 2009 c

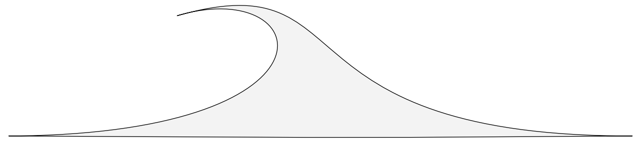
- One 2011 cross-median collision event involved a semi-
barrier prevented the truck and trailers from entering t
the trailer's restraints and entered opposing traffic.
- Another cross-median incident in 2011 that occurred in
that struck the cable barrier anchor and broke away as
point of a cable median barrier system is not expected

I-5 Vancouver

Milepost: 7.80 to 22.56



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Nov 2001	7.80	11.10	3.30	99
	Nov 2001	12.28	22.56	10.28	99
4-Strand High-Tension	Mar 2010	7.80	11.10	3.30	21
	Mar 2010	12.28	22.49	10.21	21



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	122	64	7	6
	Rate*	0.086	0.045	0.496	0.425
Generic Cable	Count	362	287	7	0
	Rate*	0.130	0.103	0.251	0.000
4-Strand High-Tension	Count	52	39	1	1
	Rate*	0.084	0.063	0.161	0.161

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	17	4	2	4
	Rate*	0.012	0.003	0.142	0.283
Generic Cable	Count	9	5	2	0
	Rate*	0.003	0.002	0.072	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

Nine cross-median incidents occurred while the generic cabl

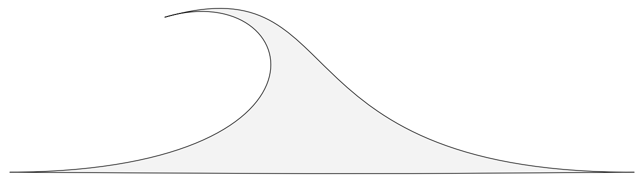
- Six of the nine cross-median events were southbound v
- No cross-median incidents have occurred since the 4-st
- The 4-strand high-tension system has two separate mec injury and a fatal event, respectively. Neither of those c events occurred in the northbound lanes of the Lewis R

I-5 Longview

Milepost: 37.42 to 40.69

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Oct 2009	37.42	40.69	3.34	26

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	44	26	3	1
	Rate*	0.153	0.091	1.046	0.349
3-Strand High-Tension	Count	22	18	0	0
	Rate*	0.181	0.148	0.000	0.000



Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	3	0	1
	Rate*	0.021	0.010	0.000	0.349
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

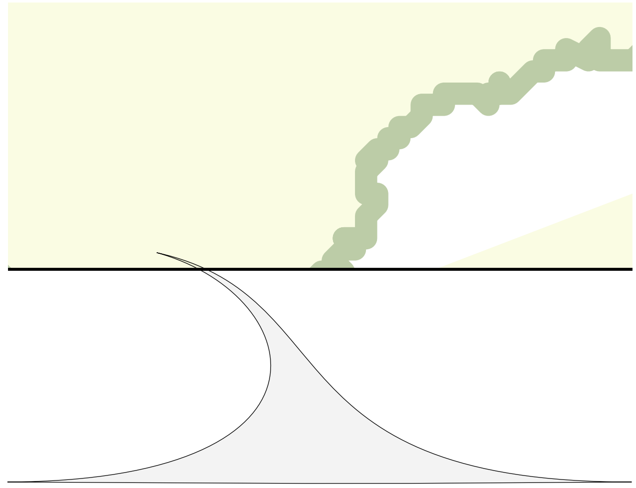
Notes:

Prior to the installation of the 3-strand high-tension cable m
one of which was fatal.

- After the barrier installation, there have been no cross-
- After the barrier installation, 14 of the 22 crashes occur

I-5 Lewis County Line to Maytown

Milepost: 85.28 to 95.70



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Jul 2004	85.28	88.33	3.05	71
3-Strand High-Tension	Mar 2006	88.33	95.70	7.37	38

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	33	15	2	1
	Rate*	0.105	0.048	0.636	0.318
Generic Cable	Count	58	42	1	0
	Rate*	0.150	0.109	0.258	0.000
No Barrier (60 months)	Count	53	30	2	3
	Rate*	0.071	0.040	0.269	0.403
3-Strand High-Tension	Count	68	54	0	1
	Rate*	0.144	0.114	0.000	0.212

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	2	0	1
	Rate*	0.019	0.006	0.000	0.318
Generic Cable	Count	1	0	1	0
	Rate*	0.003	0.000	0.258	0.000
No Barrier (60 months)	Count	22	9	2	3
	Rate*	0.030	0.012	0.269	0.403
3-Strand High-Tension	Count	3	2	0	1
	Rate*	0.006	0.004	0.000	0.212

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

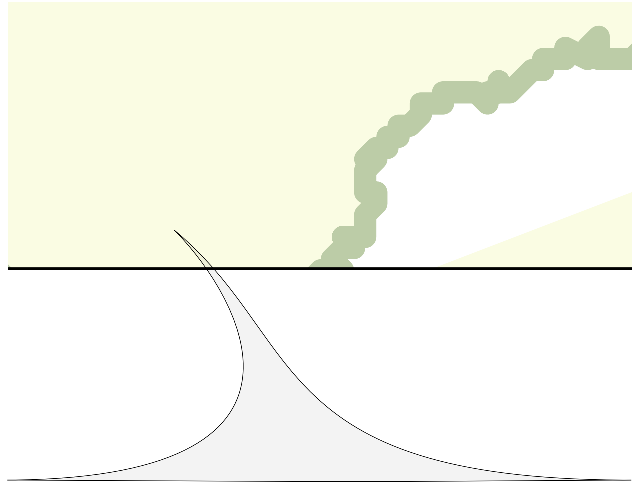
Notes:

Four cross-median collisions have occurred since this cable n
resulted in a fatal event.

This cable median barrier was removed under a constructior
in each direction by narrowing the median. The cable barrier
The major cable components were re-used in a Longview cak

I-5 Nisqually

Milepost: 112.66 to 114.28



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Oct 2004	112.66	114.07	1.41	61
	######	114.14	114.28	0.14	55
4-Strand High-Tension	Apr 2010	112.66	114.28	1.62	20

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	11	6	2	1
	Rate*	0.042	0.023	0.760	0.380
Generic Cable	Count	45	34	1	0
	Rate*	0.160	0.121	0.355	0.000
4-Strand High-Tension	Count	13	10	0	0
	Rate*	0.131	0.101	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	3	0	0	1
	Rate*	0.011	0.000	0.000	0.380
Generic Cable	Count	3	1	0	0
	Rate*	0.011	0.004	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

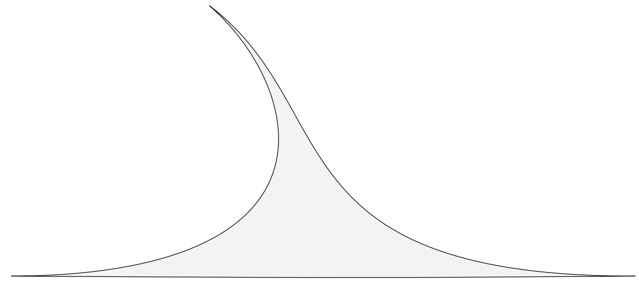
Three cross-median incidents have occurred since this cable

- 27 of the 45 generic cable median barrier collisions occu
- Nine of the 13 collisions with the 4-strand high-tension
- Prior to either cable barrier-type installation, seven of 1 direction.

I-5 Puyallup River and Fife

Milepost: 135.62 to 139.49

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Jun 2001	137.49	139.02	1.53	98
	Jun 2001	139.02	139.49	0.47	45
	Feb 2004	135.62	136.60	0.98	96
	Feb 2004	136.62	137.41	0.79	66



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	57	22	3	6
	Rate*	0.051	0.020	0.270	0.540
Generic Cable	Count	173	138	3	1
	Rate*	0.105	0.084	0.182	0.061

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	10	3	0	3
	Rate*	0.009	0.003	0.000	0.270
Generic Cable	Count	14	5	1	1
	Rate*	0.008	0.003	0.061	0.061

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

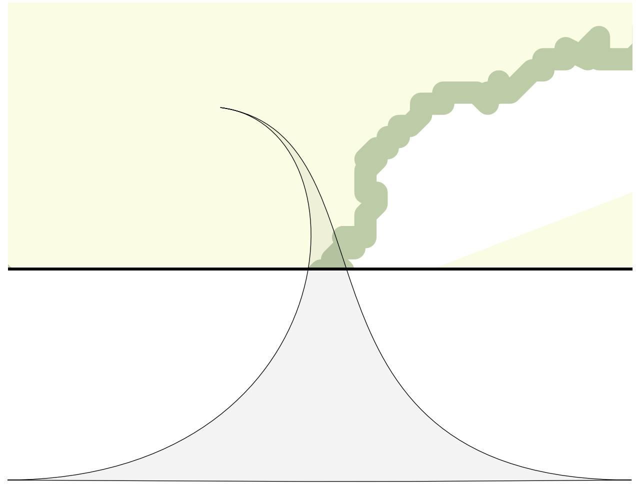
Notes:

Fourteen cross-median events have occurred since this cable
direction and eight in the southbound direction.

- In July 2007, one fatal cross-median collision occurred v
curve. The vehicle traveled under the cable barrier and
- Of the 173 total median collisions, 113 have occurred ir
northbound direction.

I-5 Marysville

Milepost: 199.34 to 209.31



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Nov 1995	201.58	203.69	2.10	130
	Jan 2000	199.34	201.37	2.03	80
	Jan 2000	203.77	209.28	5.51	80
Add 3-Strand High-Tension (Southbound side)					
Generic Cable remains (Northbound side)					
	Feb 2007	199.34	209.31	9.79	29
Add Concrete Barrier (Northbound side)					
3-Strand High-Tension remains (Southbound side)					
	Oct 2010	199.34	209.31	9.79	14

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	77	32	6	3
	Rate*	0.070	0.029	0.547	0.273
Generic Cable	Count	301	217	5	8
	Rate*	0.131	0.094	0.217	0.347
Generic Cable +	Count	87	72	1	0
3-Strand High-Tension	Rate*	0.108	0.090	0.124	0.000
3-Strand High-Tension ·	Count	35	25	0	1
Concrete Barrier	Rate*	0.083	0.059	0.000	0.236

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	26	7	4	1
	Rate*	0.024	0.006	0.364	0.091
Generic Cable	Count	22	6	2	5
	Rate*	0.010	0.003	0.087	0.217
Generic Cable +	Count	0	0	0	0
3-Strand High-Tension	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension ·	Count	0	0	0	0
Concrete Barrier	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

The Marysville segment of cable median barrier is one of the
Washington State, dating back to late 1995. Since the initial installation of generic cable median barrier, there have been two significant modifications to the installation.

A contract to install a second 3-strand high-tension cable median barrier adjacent to the southbound lanes was completed in late February 2007. In early February, prior to this contract's completion, though both the generic and high-tension cable barriers were in place, a southbound vehicle passed through both barriers and struck a tour bus in the northbound lanes, which resulted in a fatal injury.

It was this collision that led to a decision to replace the generic cable barrier with a concrete median barrier. This was the only penetration of these barrier systems; in all other collisions over the life of this dual-barrier system, the vehicles either remained in the median or were redirected.

The current configuration of the Marysville segment is that of a single-slope concrete barrier on the northbound side and a 3-strand high-tension cable barrier on the southbound side. There were 26 median collisions reported in the southbound direction; 23 struck 3-strand high-tension barrier. One of these events was a fatal collision, where a Honda Accord was struck in the rear by a semi-truck and trailer combination. The Honda was pushed across three lanes and into the median, where it came to rest against the cable median barrier.

In the northbound direction, there have been nine collisions with the concrete median barrier. There have been no serious or fatal injuries recorded from any of these collisions.

I-5 SR 532 vicinity

Milepost: 212.18 to 212.90

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	Aug 2010	212.18	212.90	0.72	17

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	14	7	0	0
	Rate*	0.178	0.089	0.000	0.000
4-Strand High-Tension	Count	11	8	0	0
	Rate*	0.510	0.371	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	3	1	0	0
	Rate*	0.038	0.013	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

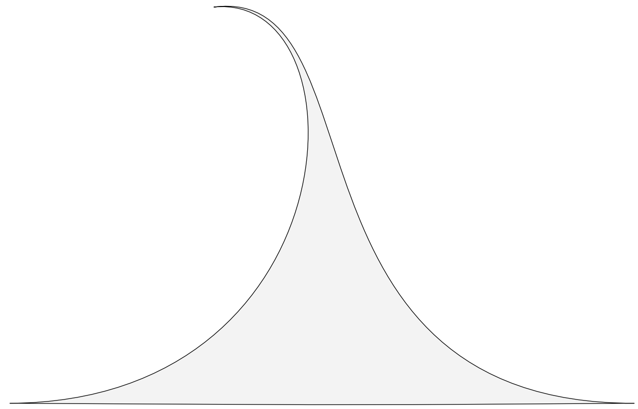
Notes:

Prior to the installation of this cable median barrier, there w segment.

- After the installation of the 4-strand high-tension barrie collisions.
- Of the 11 cable barrier impacts, five occurred in the sou direction.

I-5 Mount Vernon

Milepost: 215.12 to 225.48



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	215.12	225.48	10.36	67

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	44	25	6	5
	Rate*	0.041	0.023	0.558	0.465
3-Strand High-Tension	Count	160	134	1	0
	Rate*	0.132	0.111	0.083	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	9	1	3	3
	Rate*	0.008	0.001	0.279	0.279
3-Strand High-Tension	Count	3	3	0	0
	Rate*	0.002	0.002	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

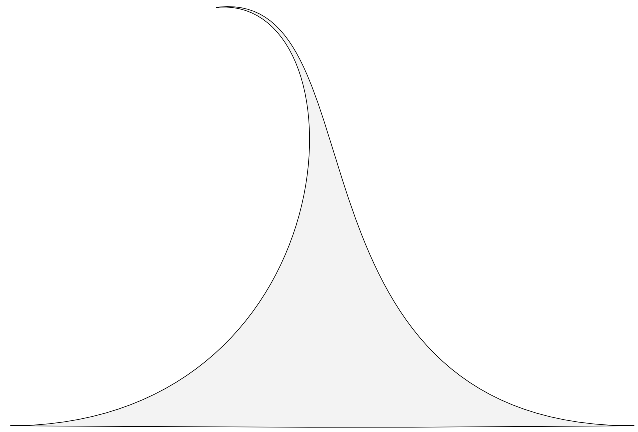
Notes:

Three cross-median events have occurred since this cable m
injury crashes.

- Prior to installing the cable median barrier, this segmen
collisions out of a total of nine cross-median crashes.

I-5 North of Burlington

Milepost: 230.90 to 234.61



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	######	230.90	234.61	3.71	68

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	39	18	4	3
	Rate*	0.126	0.058	1.293	0.970
3-Strand High-Tension	Count	66	52	1	0
	Rate*	0.193	0.152	0.293	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	12	4	4	2
	Rate*	0.039	0.013	1.293	0.647
3-Strand High-Tension	Count	4	2	1	0
	Rate*	0.012	0.006	0.293	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

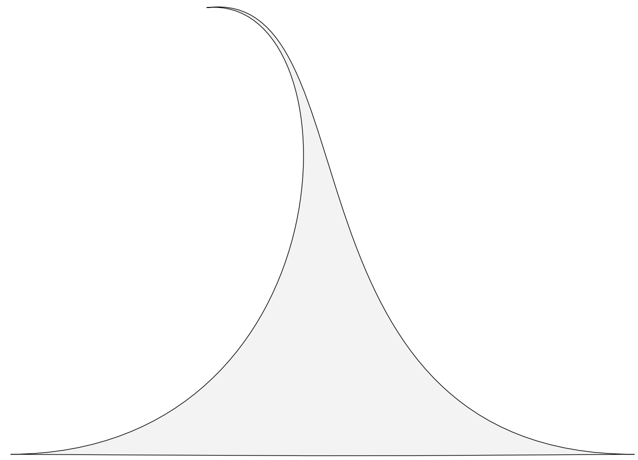
Notes:

There have been four cross-median collisions since this cable
occurred at an official median crossing; cable median barrier
occurred in the northbound direction.

- Prior to the installation of the cable median barrier, the
two fatal and four serious injury collisions.
- Since the cable median barrier installation, there has be

I-5 South Bellingham to Bakerview Road

Milepost: 250.96 to 258.27



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Jul 1999	250.96	251.33	0.37	125
	Nov 2003	252.16	253.51	1.35	73
	Nov 2003	255.08	255.35	0.27	73
3-Strand High-Tension	Jun 2006	251.34	252.15	0.81	67
	Jun 2006	255.45	258.27	2.82	67
4-Strand High-Tension	Apr 2010	250.96	251.33	0.37	20
	Apr 2010	252.16	253.51	1.35	20
	Apr 2010	255.08	255.35	0.27	20

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	14	8	1	0
	Rate*	0.078	0.044	0.554	0.000
Generic Cable	Count	94	77	0	0
	Rate*	0.324	0.265	0.000	0.000
4-Strand High-Tension	Count	21	17	0	0
	Rate*	0.302	0.244	0.000	0.000
No Barrier (60 months)	Count	37	23	0	1
	Rate*	0.102	0.064	0.000	0.276
3-Strand High-Tension	Count	90	74	1	0
	Rate*	0.212	0.175	0.236	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	4	1	0
	Rate*	0.033	0.022	0.554	0.000
Generic Cable	Count	3	1	0	0
	Rate*	0.010	0.003	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	6	1	0	1
	Rate*	0.017	0.003	0.000	0.276
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

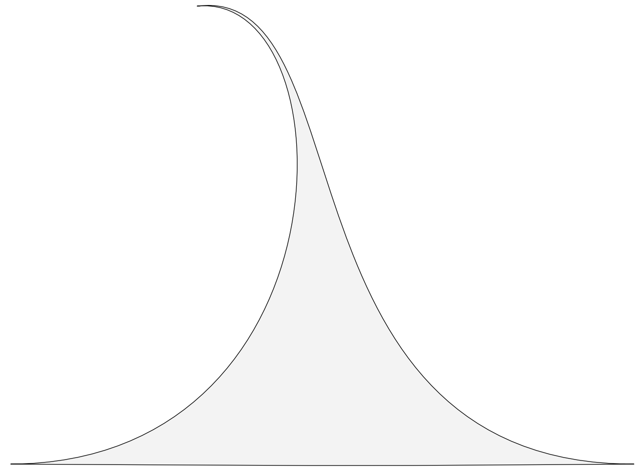
Notes:

There have been three cross-median incidents since this cab
2008.

- All three incidents involved northbound vehicles.
- None of the incidents resulted in a fatal or serious injury collision.

I-5 Ferndale

Milepost: 262.41 to 266.00



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	262.41	266.00	3.59	67

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	37	24	1	0
	Rate*	0.154	0.100	0.416	0.000
3-Strand High-Tension	Count	49	35	1	0
	Rate*	0.182	0.130	0.372	0.000

Cross Median Collision:		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	8	5	1	0
	Rate*	0.033	0.021	0.416	0.000
3-Strand High-Tension	Count	2	2	0	0
	Rate*	0.007	0.007	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

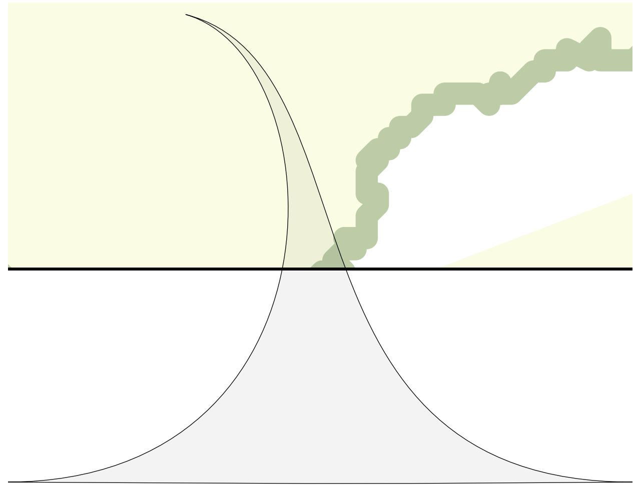
Notes:

Two cross-median incidents have occurred since this cable m
and neither event resulted in an injury.

- One incident involved a southbound vehicle that entere
came to rest in the northbound lanes without striking a
- The other incident involved a northbound vehicle that c
right shoulder of the southbound lanes. No other vehicl

I-5 Blaine

Milepost: 273.93 to 276.14



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Aug 2000	275.87	276.14	0.27	105
3-Strand High-Tension	Jun 2006	273.93	275.87	1.94	67
	Mar 2011	275.87	276.14	0.27	9

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
MP 275.87 — 276.14	Rate*	0.000	0.000	0.000	0.000
Generic Cable	Count	2	2	0	0
	Rate*	0.493	0.493	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	8	2	0	0
MP 273.93 — 275.87	Rate*	0.198	0.049	0.000	0.000
3-Strand High-Tension	Count	12	11	0	0
	Rate*	0.240	0.220	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
MP 275.87 — 276.14	Rate*	0.000	0.000	0.000	0.000
Generic Cable	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	1	1	0	0
MP 273.93 — 275.87	Rate*	0.025	0.025	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

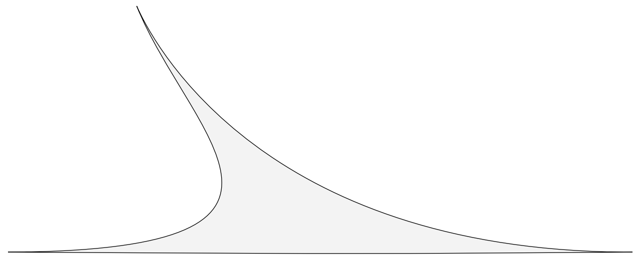
Note:

No cross-median incidents have occurred since this cable me

SR 8 Elma to US 101

Milepost: 0.00 to 20.60

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	Jun 2010	0.00	9.60	9.60	19
	Jun 2010	10.58	10.95	0.37	19
	Jun 2010	13.83	17.72	3.89	19
	Jun 2010	19.20	20.60	1.40	19



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	35	24	3	1
	Rate*	0.078	0.053	0.666	0.222
4-Strand High-Tension	Count	38	32	0	0
	Rate*	0.276	0.232	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	2	2	0
	Rate*	0.013	0.004	0.444	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

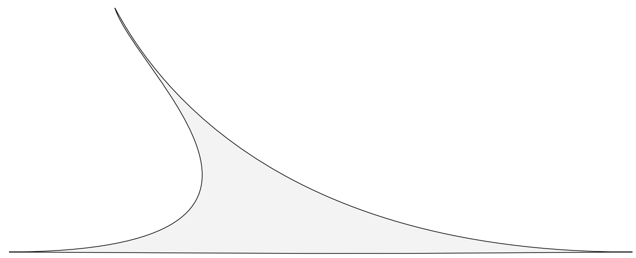
No cross-median incidents have occurred since this cable me

- Prior to the cable median barrier, there were six cross-r injuries.

US 12 Montesano

Milepost: 9.11 to 20.95

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Sep 2006	9.11	20.95	11.84	64



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	30	21	3	0
	Rate*	0.066	0.046	0.659	0.000
3-Strand High-Tension	Count	116	101	3	0
	Rate*	0.264	0.230	0.684	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	9	3	2	0
	Rate*	0.020	0.007	0.439	0.000
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.002	0.002	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

One cross-median incident has occurred since this cable barı

- An eastbound vehicle made an evasive move to avoid a over the cable barrier, and came to rest in the westbou incident.

US 12 Yakima

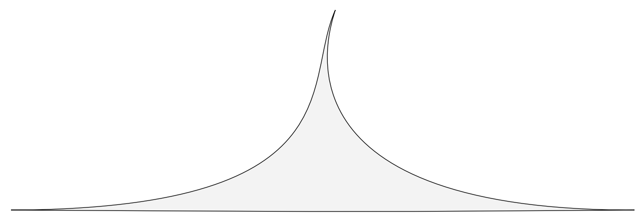
Milepost: 193.67 to 202.50

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Nov 2007	201.90	202.50	0.60	50
4-Strand High-Tension	Aug 2010	193.67	198.61	4.97	17

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	7	4	0	0
	Rate*	0.233	0.133	0.000	0.000
3-Strand High-Tension	Count	12	8	0	0
	Rate*	0.455	0.303	0.000	0.000
No Barrier (60 months)	Count	12	6	0	0
	Rate*	0.115	0.058	0.000	0.000
4-Strand High-Tension	Count	4	3	0	0
	Rate*	0.144	0.108	0.000	0.000

Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.038	0.038	0.000	0.000
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

One cross-median incident has occurred since this cable mec

- In December 2008, an eastbound vehicle struck the enc in the westbound lanes. No other vehicles were involve
- Since the cable median barrier was installed, there have which were in the eastbound direction. 10 of the 16 col to 202.23 (0.27 of a mile).

SR 16 Olympic Drive to SE Burley-Olalla Road

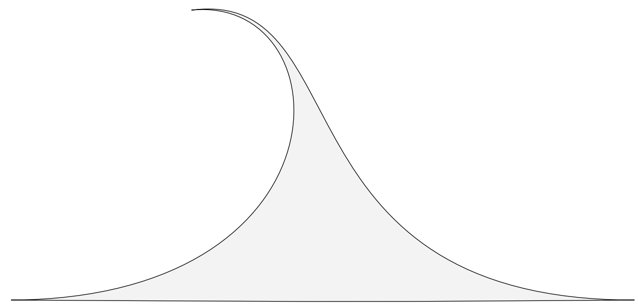
Milepost: 10.83 to 20.52

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	16.03	19.00	2.97	67
	Jun 2007	10.83	15.12	4.29	55
	Feb 2011	19.70	20.52	0.82	10

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	49	24	2	1
	Rate*	0.065	0.032	0.265	0.133
3-Strand High-Tension	Count	87	69	1	1
	Rate*	0.125	0.099	0.143	0.143

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	5	2	2	0
	Rate*	0.007	0.003	0.265	0.000
3-Strand High-Tension	Count	2	0	0	1
	Rate*	0.003	0.000	0.000	0.143

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



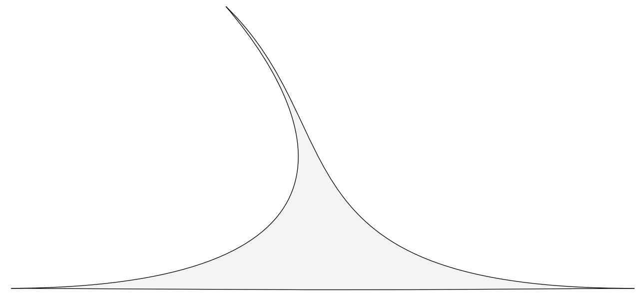
Notes:

Two cross-median incidents have occurred since this cable m

- In 2008, a westbound vehicle entered the median, rolle the eastbound lanes; no other vehicles were involved. T
- In 2009, a westbound vehicle entered the median, over across the eastbound lanes, where the vehicle came to this incident.

SR 18 Covington

Milepost: 7.80 to 11.38



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Nov 2004	7.80	7.89	0.09	61
3-Strand High-Tension	Jun 2006	9.00	11.38	2.38	67
4-Strand High-Tension	Apr 2010	7.80	7.96	0.16	20

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
Generic Cable	Count	8	7	0	0
	Rate*	1.159	1.014	0.000	0.000
4-Strand High-Tension	Count	2	2	0	0
	Rate*	0.454	0.454	0.000	0.000
No Barrier (60 months)	Count	10	7	0	0
	Rate*	0.068	0.048	0.000	0.000
3-Strand High-Tension	Count	35	29	0	0
	Rate*	0.175	0.145	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
Generic Cable	Count	1	1	0	0
	Rate*	0.145	0.145	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	4	3	0	0
	Rate*	0.027	0.020	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

There has been one cross-median incident since this cable m

- In 2006, a westbound vehicle lost control and entered t W-beam guardrail in the median, continued across the without striking any other vehicles.
- 25 of the 37 cable median barrier impacts occurred in the westbound travel direction.

SR 18 Issaquah / Hobart

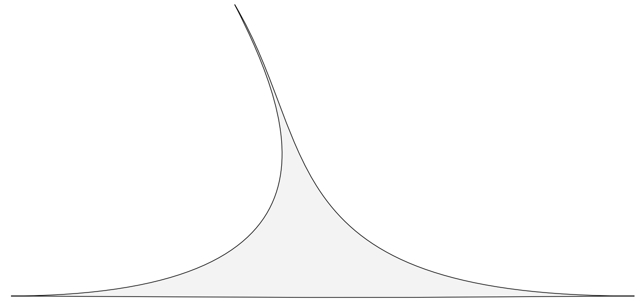
Milepost: 19.65 to 20.22

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Mar 2008	19.65	20.22	0.57	45

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	5	2	1	0
	Rate*	0.264	0.106	5.279	0.000
3-Strand High-Tension	Count	7	6	0	0
	Rate*	0.417	0.358	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

No cross-median incidents have occurred since this cable me

- There were seven reported cable median barrier collisic direction.

SR 20 Fredonia

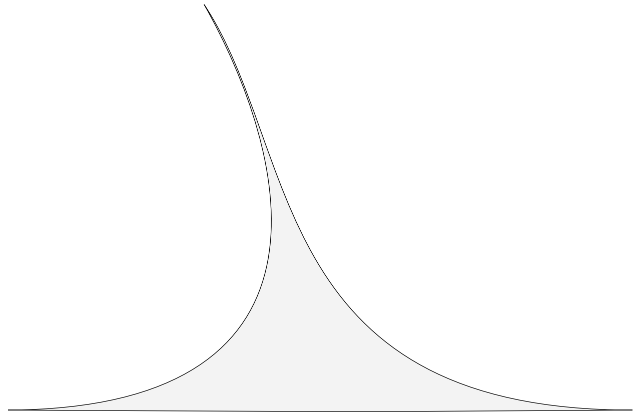
Milepost: 54.72 to 58.35

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jul 2008	54.72	56.50	1.78	42
	Oct 2009	56.50	57.29	0.79	26
	Oct 2009	58.05	58.35	0.30	26

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (0 months)	Count	Roadway configuration not comparable			
	Rate*				
3-Strand High-Tension	Count	12	11	1	0
	Rate*	0.180	0.165	1.501	0.000

Cross Median Collision:		All	Non Injury	Serious Injury	Fatal
No Barrier (0 months)	Count	Roadway configuration not comparable			
	Rate*				
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.015	0.015	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

Prior to the construction project that installed the cable mec
lane undivided facility. The project increased the number of
median.

- There has been one cross-median incident since this cal
  injuries in this incident.

I-82 Yakima

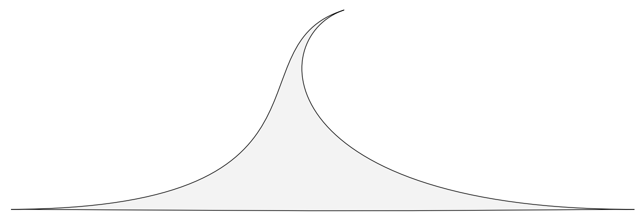
Milepost: 29.38 to 39.14

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Nov 2007	31.39	39.14	7.75	50
	Sep 2008	29.38	29.99	0.61	40

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	45	25	3	1
	Rate*	0.088	0.049	0.589	0.196
3-Strand High-Tension	Count	94	72	0	0
	Rate*	0.230	0.176	0.000	0.000

Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	12	5	3	1
	Rate*	0.024	0.010	0.589	0.196
3-Strand High-Tension	Count	7	4	0	0
	Rate*	0.017	0.010	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

There have been seven cross-median incidents since this cab

- Five of the seven cross-median incidents occurred in th
- Six of the seven incidents occurred during daylight hour
- All seven incidents occurred while the roadway was dry
- Two incidents occurred in 2009 and the other five happ

I-82 Prosser

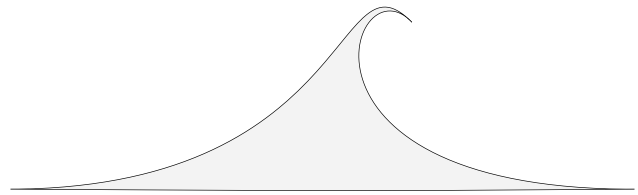
Milepost: 88.51 to 92.14

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Oct 2008	88.51	92.14	3.63	38

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	8	6	0	0
	Rate*	0.081	0.061	0.000	0.000
3-Strand High-Tension	Count	9	7	1	0
	Rate*	0.129	0.101	1.437	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	2	1	0	0
	Rate*	0.020	0.010	0.000	0.000
3-Strand High-Tension	Count	2	1	1	0
	Rate*	0.029	0.014	1.437	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

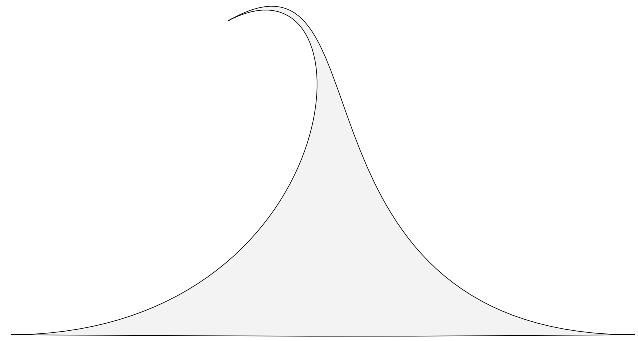
Prior to the installation of this cable median barrier, there w
occurred in the westbound travel direction.

There have been two cross-median incidents since the cable

- In 2010, a westbound vehicle lost control, entered the
continued to overturn into the eastbound lanes, where
collision.
- In 2011, an eastbound vehicle overcorrected, entered
median barrier, and came to rest in the westbound lanes. No other vehicles were struck nor were any injuries reported.

I-90 Bellevue to Issaquah

Milepost: 11.75 to 17.12



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Feb 2005	15.99	17.12	1.13	58
	Dec 2006	11.75	12.05	0.30	35
4-Strand High-Tension	Apr 2010	11.75	12.05	0.30	20
		15.99	17.12	1.13	20
	Aug 2010	13.73	14.41	0.69	17

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	11	6	0	0
	Rate*	0.068	0.037	0.000	0.000
Generic Cable	Count	20	16	0	0
	Rate*	0.113	0.090	0.000	0.000
4-Strand High-Tension	Count	5	4	0	0
	Rate*	0.070	0.056	0.000	0.000
No Barrier (60 months)	Count	3	2	1	0
MP 13.73 — 14.41	Rate*	0.022	0.015	0.727	0.000
4-Strand High-Tension	Count	3	1	0	0
	Rate*	0.076	0.025	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	2	1	0	0
	Rate*	0.012	0.006	0.000	0.000
Generic Cable	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	1	0	1	0
MP 13.73 — 14.41	Rate*	0.007	0.000	0.727	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

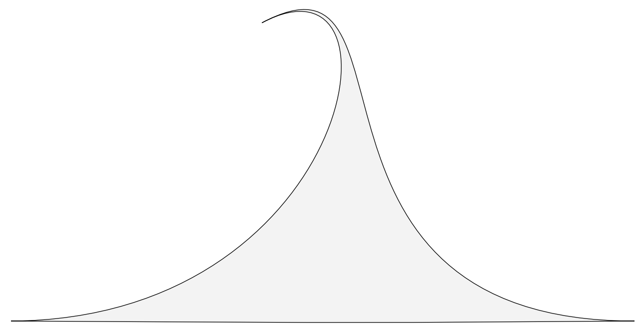
Note:

No cross-median incidents have occurred since this cable me

I-90 Homestead Road to Tinkam Road vicinity

Milepost: 37.29 to 43.61

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	Aug 2010	37.29	43.61	6.32	17



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	59	31	1	0
	Rate*	0.171	0.090	0.290	0.000
4-Strand High-Tension	Count	13	11	0	0
	Rate*	0.133	0.113	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	0	0	0
	Rate*	0.017	0.000	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

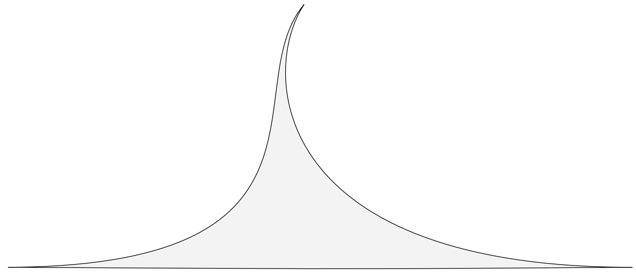
Note:

No cross-median incidents have occurred since this cable me

I-90 Cle Elum

Milepost: 82.88 to 84.28

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Oct 2008	83.60	84.28	0.68	38
4-Strand High-Tension	Aug 2010	82.88	83.52	0.64	17



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	9	6	0	0
	Rate*	0.323	0.215	0.000	0.000
3-Strand High-Tension	Count	8	5	0	0
	Rate*	0.435	0.272	0.000	0.000
No Barrier (60 months)	Count	25	13	0	1
	Rate*	0.951	0.495	0.000	3.806
4-Strand High-Tension	Count	7	6	0	1
	Rate*	0.902	0.773	0.000	12.882

Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	2	1	0	0
	Rate*	0.076	0.038	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

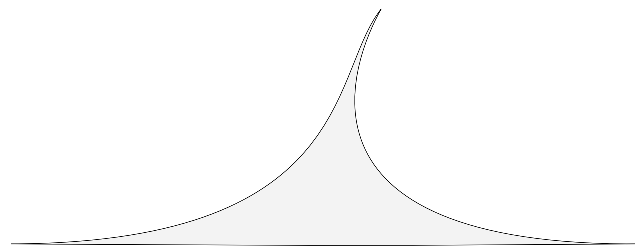
Note:

No cross-median incidents have occurred since this cable me

I-90 Vantage

Milepost: 136.61 to 136.71

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Nov 2007	136.61	136.71	0.10	50



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

Cross Median Collision:		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

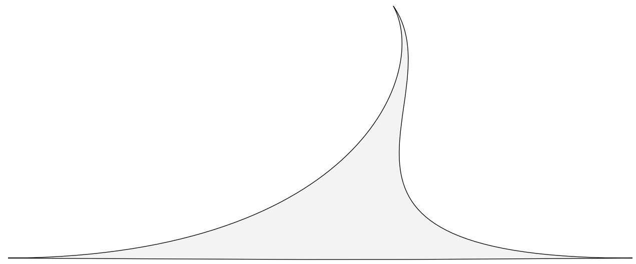
Note:

No cross-median incidents have occurred since this cable me

I-90 George

Milepost: 144.30 to 156.32

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Nov 2005	144.30	156.32	12.02	74



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	38	18	6	0
	Rate*	0.147	0.070	2.325	0.000
3-Strand High-Tension	Count	51	45	1	0
	Rate*	0.154	0.136	0.302	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	9	7	0	0
	Rate*	0.035	0.027	0.000	0.000
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.003	0.003	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

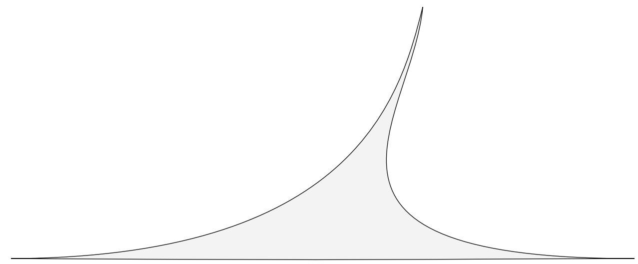
There has been one cross-median incident since this cable m

- A westbound passenger car struck the left side of a sem went under the cable barrier, and entered the eastbour vehicles were involved.

I-90 east of George to Moses Lake

Milepost: 160.70 to 174.52

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
Generic Cable	Oct 2004	164.16	170.39	6.23	60
	Oct 2004	173.70	174.52	0.82	60
3-Strand High-Tension	Nov 2005	160.70	164.15	3.45	74
4-Strand High-Tension	Nov 2009	164.16	170.39	6.23	26
	Nov 2009	173.70	174.52	0.82	26



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	16	6	0	0
	Rate*	0.093	0.035	0.000	0.000
Generic Cable	Count	55	41	2	1
	Rate*	0.329	0.245	1.195	0.597
4-Strand High-Tension	Count	18	11	0	0
	Rate*	0.239	0.146	0.000	0.000
No Barrier (60 months)	Count	8	2	0	1
	Rate*	0.119	0.030	0.000	1.489
3-Strand High-Tension	Count	16	13	1	0
	Rate*	0.167	0.136	1.045	0.000

Cross Median Collision:		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	8	2	0	0
	Rate*	0.046	0.012	0.000	0.000
Generic Cable	Count	3	1	0	0
	Rate*	0.018	0.006	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
No Barrier (60 months)	Count	3	1	0	1
	Rate*	0.045	0.015	0.000	1.489
3-Strand High-Tension	Count	1	0	1	0
	Rate*	0.010	0.000	1.045	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

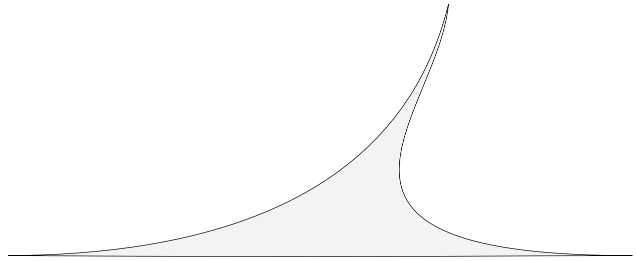
Four cross-median incidents have occurred since this cable n

- Three incidents involved vehicles that overturned.
- Three collisions were vehicles traveling eastbound.
- None of the cross-median incidents involved other vehicles.

I-90 East Moses Lake

Milepost: 179.70 to 192.10

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Dec 2005	179.70	192.10	12.40	74



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	34	8	3	0
	Rate*	0.148	0.035	1.308	0.000
3-Strand High-Tension	Count	82	60	2	2
	Rate*	0.287	0.210	0.701	0.701

Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	9	0	1	0
	Rate*	0.039	0.000	0.436	0.000
3-Strand High-Tension	Count	7	4	1	0
	Rate*	0.025	0.014	0.351	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

There have been seven cross-median incidents since this cab
resulted in a fatal injury.

- Two fatal collisions have occurred in this segment; neitl
- A fatal collision in 2007 involved an eastbound vehicle,
vehicle rolled several times, but did not contact the cab
- In 2008, a motorcycle collision occurred where the vehi
was ejected, which resulted in fatal injuries.

I-90 Spokane

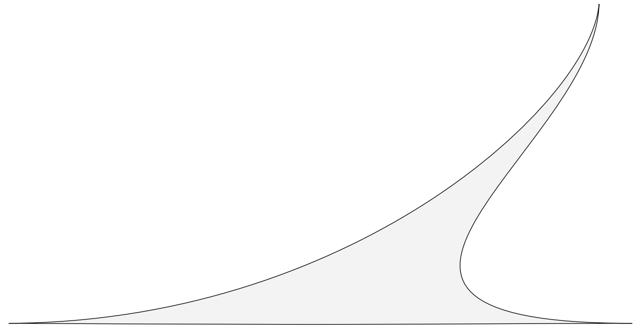
Milepost: 292.18 to 299.46

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Oct 2004	292.18	293.91	1.73	78
	Oct 2004	293.92	295.91	2.00	87
	Jul 2005	296.33	299.46	3.13	78

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	36	7	6	2
	Rate*	0.053	0.010	0.887	0.296
3-Strand High-Tension	Count	204	164	2	0
	Rate*	0.211	0.170	0.207	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	23	2	6	1
	Rate*	0.034	0.003	0.887	0.148
3-Strand High-Tension	Count	16	7	0	0
	Rate*	0.017	0.007	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

There have been 16 cross-median incidents since this cable n

- 11 of the 16 incidents have been in the westbound trave
  a serious or fatal injury.

SR 99 Tukwila

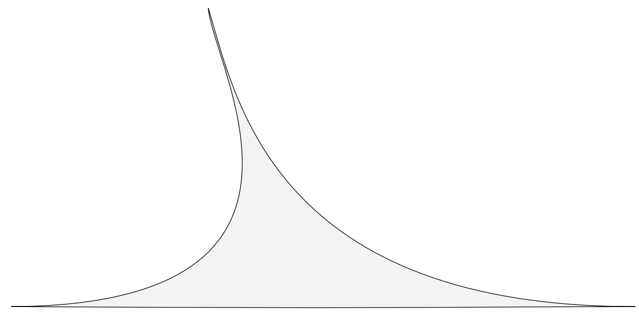
Milepost: 23.24 to 25.92

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Sep 2006	23.24	25.92	2.68	64

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	11	4	1	0
	Rate*	0.071	0.026	0.648	0.000
3-Strand High-Tension	Count	21	14	1	1
	Rate*	0.134	0.089	0.637	0.637

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	2	1	0	0
	Rate*	0.013	0.006	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

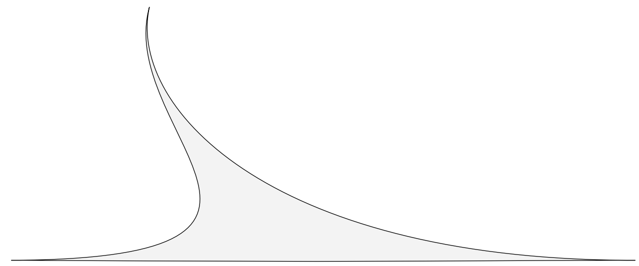
No cross-median incidents have occurred since this cable me

- A fatal motorcycle collision occurred in 2008. A northbo speed and was reported doing wheelies prior to losing c separated from the motorcycle, entered the median, ar
- 0.14 miles of this segment has a posted speed of 40 mp

US 101 Olympia to SR 3

Milepost: 350.22 to 366.76

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Apr 2007	363.93	366.76	2.83	57
4-Strand High-Tension	Oct 2010	350.22	353.18	2.96	14
	Oct 2010	353.67	355.98	2.31	14
	Oct 2010	356.91	357.14	0.25	14
	Oct 2010	358.00	359.88	1.88	14
	Oct 2010	360.38	360.57	0.19	14
	Oct 2010	361.53	362.00	0.47	14



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	21	9	1	1
	Rate*	0.078	0.034	0.373	0.373
3-Strand High-Tension	Count	43	32	0	0
	Rate*	0.172	0.128	0.000	0.000
No Barrier (60 months)	Count	28	14	0	1
	Rate*	0.076	0.038	0.000	0.271
4-Strand High-Tension	Count	14	9	0	0
	Rate*	0.166	0.107	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	4	0	0	1
	Rate*	0.015	0.000	0.000	0.373
3-Strand High-Tension	Count	4	1	0	0
	Rate*	0.016	0.004	0.000	0.000
No Barrier (60 months)	Count	6	3	0	0
	Rate*	0.016	0.008	0.000	0.000
4-Strand High-Tension	Count	1	1	0	0
	Rate*	0.012	0.012	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

There have been five cross-median incidents since this cable
were recorded in any of these incidents.

- Four of the cross-median incidents occurred in the 3-str
the 4-strand high-tension portion of the segment.
- The cross-median incident that occurred in the 4-strand high-tension system involved a vehicle that struck the cable barrier anchor and broke-away as per the design. (A vehicle impact to the anchoring point of a cable median barrier system is not expected to restrain a vehicle.)
- All four 3-strand high-tension cross-median incidents occurred in the southbound travel direction. Of the 43 3-strand high-tension cable median barrier impacts, 26 occurred in the southbound travel direction.
- The 4-strand high-tension portion of the segment had 10 of the reported 14 impacts to the cable median barrier, which occurred in the northbound travel direction.

SR 167 Sumner

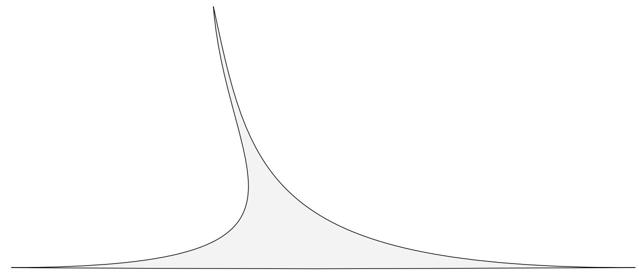
Milepost: 6.86 to 11.44

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	6.86	11.44	4.58	67

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	46	29	2	0
	Rate*	0.073	0.046	0.318	0.000
3-Strand High-Tension	Count	68	49	0	1
	Rate*	0.092	0.066	0.000	0.135

Cross Median Collision:		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	2	1	0	0
	Rate*	0.003	0.002	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

No cross-median incidents have occurred since this cable me

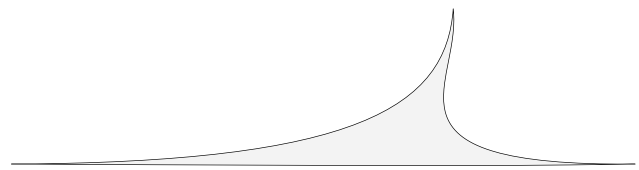
- 46 of the 68 cable median barrier impacts occurred in tl

I-182 Pasco

Milepost: 12.30 to 14.35

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Nov 2007	12.30	14.35	2.05	50

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	15	7	3	0
	Rate*	0.128	0.060	2.554	0.000
3-Strand High-Tension	Count	24	20	1	0
	Rate*	0.224	0.187	0.935	0.000



Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	5	1	2	0
	Rate*	0.043	0.009	1.703	0.000
3-Strand High-Tension	Count	4	3	1	0
	Rate*	0.037	0.028	0.935	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

Four cross-median incidents have occurred since this cable m

- An eastbound vehicle sideswiped an eastbound semi-tr
  came to rest on the westbound shoulder. No other vehi
- An eastbound passenger car sideswiped the front steeri
  sent the semi-tractor combination out of control into th
  barrier and came to rest in the westbound travel lanes.
- A westbound vehicle impacted the passenger side of another westbound vehicle, sending it into the median and across the cable barrier. This vehicle came to rest on the westbound shoulder. No other vehicles were involved.
- A westbound vehicle lost control and entered the median, passed through the cable median barrier, overturned, and came to rest in the eastbound lanes on the driver's side. No other vehicles were involved.

US 195 E White Road to Junction I-90

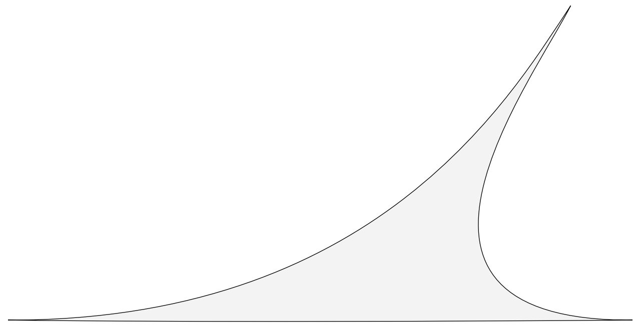
Milepost: 90.86 to 95.73

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	######	90.86	95.73	4.87	7

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	7	5	0	0
	Rate*	0.055	0.039	0.000	0.000
4-Strand High-Tension	Count	1	1	0	0
	Rate*	0.060	0.060	0.000	0.000

Cross Median Collision		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

No cross-median incidents have occurred since this cable me

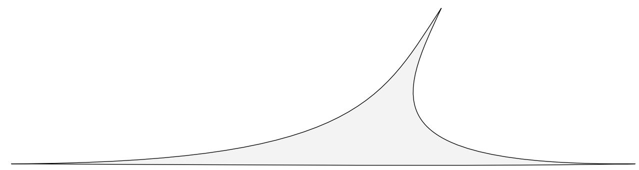
- There has only been a single cable median barrier collisi injuries were reported in this incident.

SR 240 Richland

Milepost: 37.92 to 38.31

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2007	37.92	38.31	0.36	55

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	3	1	0	1
	Rate*	0.122	0.041	0.000	4.056
3-Strand High-Tension	Count	6	4	0	0
	Rate*	0.218	0.145	0.000	0.000



Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000
3-Strand High-Tension	Count	2	1	0	0
	Rate*	0.073	0.036	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

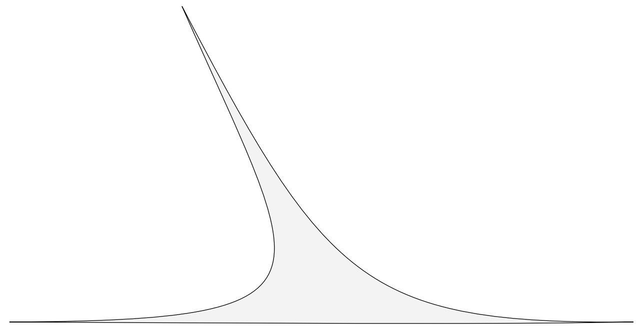
There have been two cross-median incidents since this cable

- In 2009, a westbound vehicle struck an animal in the tra where it struck the cable median barrier and a concrete entered the eastbound lanes, where it came to rest. No
- In 2010, a driver in a westbound vehicle fell asleep, ent barrier anchor point, and crossed the median into the e into the cable median barrier on the eastbound side of

SR 303 Ridgetop Boulevard vicinity

Milepost: 7.25 to 7.61

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	Oct 2010	7.25	7.61	0.36	14



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	2	1	1	0
	Rate*	0.104	0.052	5.203	0.000
4-Strand High-Tension	Count	2	2	0	0
	Rate*	0.452	0.452	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	1	0	1	0
	Rate*	0.052	0.000	5.203	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

No cross-median incidents have occurred since this cable me

- Both reported cable median barrier collisions occurred
- Each incident was within 0.01 of a mile of the other; ho
in time.

SR 395 Wandermere Road to Half Moon Road

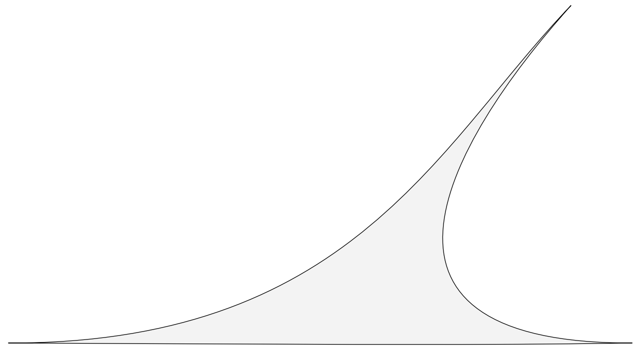
Milepost: 168.54 to 172.31

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
4-Strand High-Tension	Oct 2010	168.54	172.31	3.79	14

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	17	7	1	1
	Rate*	0.155	0.064	0.911	0.911
4-Strand High-Tension	Count	2	2	0	0
	Rate*	0.077	0.077	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	4	0	0	1
	Rate*	0.036	0.000	0.000	0.911
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

No cross-median incidents have occurred since this cable me

- Both reported cable median barrier collisions occurred and the other in 2011.

SR 410 Sumner

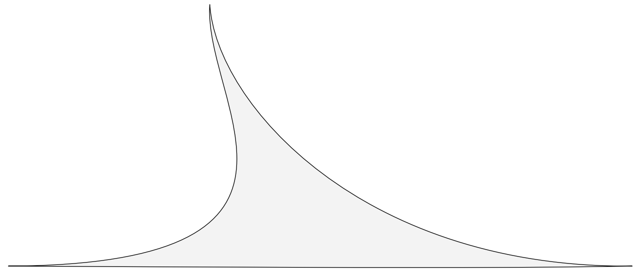
Milepost: 9.51 to 11.42

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	9.51	11.42	1.91	67

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	19	10	2	0
	Rate*	0.102	0.054	1.077	0.000
3-Strand High-Tension	Count	40	31	0	1
	Rate*	0.198	0.154	0.000	0.496

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	3	2	0	0
	Rate*	0.016	0.011	0.000	0.000
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT



Notes:

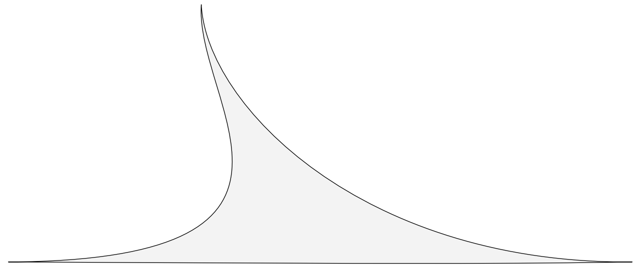
No cross-median incidents have occurred since this cable me

- In 2009, a westbound motorcyclist lost control, left the operator and motorcycle collided with the cable media

SR 512 Puyallup

Milepost: 2.48 to 11.99

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Apr 2007	2.48	11.99	9.51	44
4-Strand High-Tension	######	2.48	11.99	9.51	7



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	102	48	7	2
	Rate*	0.078	0.037	0.537	0.153
3-Strand High-Tension	Count	210	155	3	6
	Rate*	0.220	0.162	0.314	0.628
4-Strand High-Tension	Count	38	29	0	0
	Rate*	0.238	0.181	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	25	10	6	1
	Rate*	0.019	0.008	0.460	0.077
3-Strand High-Tension	Count	9	3	0	3
	Rate*	0.009	0.003	0.000	0.314
4-Strand High-Tension	Count	1	1	0	0
	Rate*	0.006	0.006	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

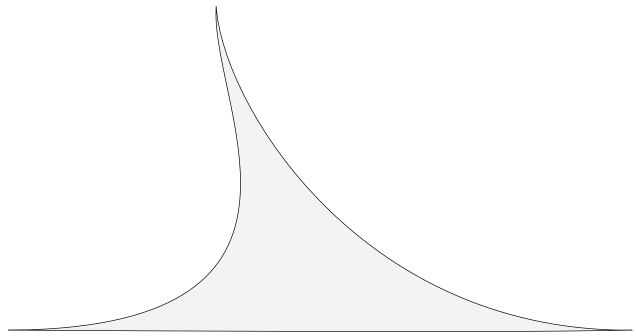
There have been a total of 10 cross-median incidents since tl

- Under the initial installation of a 3-strand high-tension s
  With this system, there were a total of six fatal collision
  in 2010.
- The 2010 fatality involved a motorcyclist, who became s
  by multiple vehicles in the travel lane. The uncontrolled
  contacting and then separating from the median barrier and coming to rest.
- The 4-strand high-tension system had a single cross-median incident in 2011. There were no injuries reported in this single-vehicle incident.

SR 522 Bothell

Milepost: 10.90 to 12.72

Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Jun 2006	10.90	12.72	1.83	67



All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	19	8	0	1
	Rate*	0.120	0.050	0.000	0.629
3-Strand High-Tension	Count	24	20	0	0
	Rate*	0.135	0.112	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	6	3	0	0
	Rate*	0.038	0.019	0.000	0.000
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.006	0.006	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

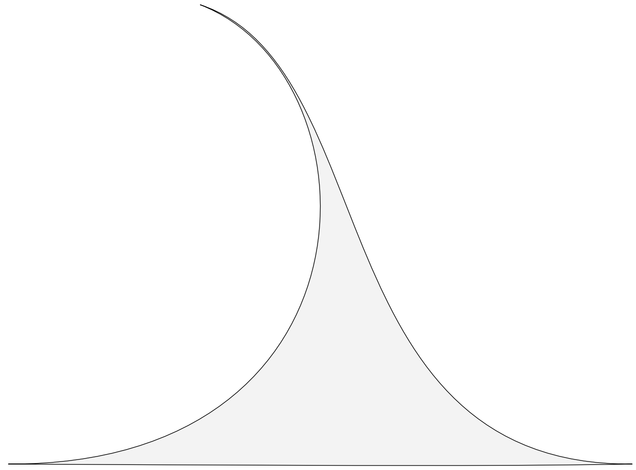
Notes:

There has been a single cross-median incident since this cabl

- A westbound vehicle lost control and skidded through t
  driver was found to be intoxicated. No other vehicles w

SR 539 Ten Mile Road

Milepost: 6.07 to 10.03



Barrier Type	Install Date	Begin MP	End MP	Length (miles)	Duration (months)
3-Strand High-Tension	Apr 2011	6.07	8.13	2.06	8
	Apr 2011	8.63	9.11	0.48	8
	Apr 2011	9.75	10.03	0.28	8

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (0 months)	Count	Roadway configuration not comparable			
	Rate*				
3-Strand High-Tension	Count	1	1	0	0
	Rate*	0.092	0.092	0.000	0.000

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (0 months)	Count	Roadway configuration not comparable			
	Rate*				
3-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

No cross-median incidents have occurred since this cable me
cable median barrier was a portion of a construction contrac
lane undivided roadway to a four-lane median-divided roadv

Initial Median Barrier Performance

By Cable Barrier Type – Divided Highway

Barrier Type	Install Date	Length (miles)	Duration (months)
Generic Barrier	Nov 1995 — Dec 2006	42.37	35 — 130
3-Strand High-Tension	Oct 2004 — Feb 2011	144.45	10 — 87
4-Strand High-Tension	Jun 2010 — May 2011	45.68	7 — 19

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	341	159	21	17
	Rate*	0.072	0.034	0.445	0.360
Generic Cable	Count	1118	861	19	10
	Rate*	0.139	0.107	0.236	0.124
No Barrier (60 months)	Count	829	418	64	23
	Rate*	0.081	0.041	0.624	0.224
3-Strand High-Tension	Count	1749	1386	22	13
	Rate*	0.175	0.138	0.220	0.130
No Barrier (60 months)	Count	202	110	7	4
	Rate*	0.114	0.062	0.396	0.226
4-Strand High-Tension	Count	95	75	0	1
	Rate*	0.205	0.162	0.000	0.216

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	78	23	7	10
	Rate*	0.017	0.005	0.148	0.212
Generic Cable	Count	56	20	6	6
	Rate*	0.007	0.002	0.074	0.074
No Barrier (60 months)	Count	198	71	36	15
	Rate*	0.019	0.007	0.351	0.146
3-Strand High-Tension	Count	75	41	5	5
	Rate*	0.007	0.004	0.050	0.050
No Barrier (60 months)	Count	29	7	4	1
	Rate*	0.016	0.004	0.226	0.057
4-Strand High-Tension	Count	1	1	0	0
	Rate*	0.002	0.002	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

Notes:

This summary aggregates cable median barrier performance by type where the highway was divided but featured no median barrier in the before period. The after barrier periods run until the commencement of subsequent barrier placement or until the end of January 2011.

Performance by Installation Sequence

Generic Cable — 4-Strand High-Tension

Barrier Type	Install Date	Length (miles)	Duration (months)
Generic Cable	Jul 1999 — Dec 2006	25.68	35 — 125
4-Strand High-Tension	Nov 2009 — Apr 2010	25.76	20 — 26

All Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	174	90	10	7
	Rate*	0.079	0.041	0.456	0.319
Generic Cable	Count	584	462	10	1
	Rate*	0.157	0.124	0.269	0.027
4-Strand High-Tension	Count	111	83	1	1
	Rate*	0.118	0.088	0.106	0.106

Cross Median Collisions		All	Non Injury	Serious Injury	Fatal
No Barrier (60 months)	Count	36	11	3	5
	Rate*	0.016	0.005	0.137	0.228
Generic Cable	Count	19	9	2	0
	Rate*	0.005	0.002	0.054	0.000
4-Strand High-Tension	Count	0	0	0	0
	Rate*	0.000	0.000	0.000	0.000

* Rates for All and Non Injury collisions are per 1 million VMT,
Rates for Serious Injury and Fatal are per 100 million VMT

For sequence of "From to To" a cable barrier type see below:	See Site Results:
Generic Cable – 3-Strand High-Tension	I-5 Blaine, page 49
3-Strand High-Tension – 4-Strand High-Tension	SR 512 Puyallup, page 76
Generic Cable – Generic Cable + 3-Strand High-Tension – 3-Strand High-Tension + Concrete Barrier	I-5 Marysville, page 42

Map of Cable Median Barrier by Type

Cable median barrier in place as of June 2011.