Highway Factors Attachment – Preliminary Report 70 MPH Speed Limit Study dated March 4, 2014

Mount Pleasant, PA

HWY20MH002

(16 pages)

Preliminary Report

70 MPH Speed Limit Study

March 4, 2014

Prepared for

Pennsylvania Turnpike Commission

Prepared by:

URS

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Introduction

On Nov 25, 2013, Governor Tom Corbett signed into law House Bill 1060 (also known as Act 89), Pennsylvania's most comprehensive piece of state transportation legislation in decades. One provision of the bill was the increase in the statutory speed limit allowed on freeways in the Commonwealth. Specifically, the act revised Sections 3362(a) and (c) and 3363 of the Vehicle Code (Title 75) as follows:

§ 3362. Maximum speed limits.

(a) General rule.--Except when a special hazard exists that requires lower speed for compliance with section 3361 (relating to driving vehicle at safe speed), the limits specified in this section or established under this subchapter shall be maximum lawful speeds and no person shall drive a vehicle at a speed in excess of the following maximum limits:

(1) 35 miles per hour in any urban district.

(1.1) 70 miles per hour for all vehicles on freeways where the department has posted a 70-miles-per-hour speed limit.

(1.2) 25 miles per hour in a residence district if the highway:

(i) is not a numbered traffic route; and

(ii) is functionally classified by the department as a local highway.

(2) 55 miles per hour in other locations.

(3) Any other maximum speed limit established under this subchapter.

(b) Posting of speed limit.--

(1) No maximum speed limit established under subsection (a)(1), (1.2) or (3) shall be effective unless posted on fixed or variable official traffic-control devices erected in accordance with regulations adopted by the department which regulations shall require posting at the beginning and end of each speed zone and at intervals not greater than one-half mile.

(2) No maximum speed limit established under subsection (a)(1.1) shall be effective unless posted on fixed or variable official traffic-control devices erected after each interchange on the portion of highway on which the speed limit is in effect and wherever else the department shall determine.

(c) Penalty.--

(1) Any person violating this section is guilty of a summary offense and shall, upon conviction, be sentenced to pay a fine of:

(i) $42.50 for violating a maximum speed limit of 65 miles per hour or higher; or

(ii) $35 for violating any other maximum speed limit.

(2) Any person exceeding the maximum speed limit by more than five miles per hour shall pay an additional fine of $2 per mile for each mile in excess of five miles per hour over the maximum speed limit.

(June 13, 1995, P.L.57, No.9, eff. 30 days; Dec. 21, 1998, P.L.1126, No.151, eff. 60 days; June 26, 2001, P.L.734, No.75, eff. 60 days; Nov. 25, 2013, P.L.974, No.89, eff. imd.)

§ 3363. Alteration of maximum limits.

On highways under their respective jurisdictions, local authorities subject to section 6109(e) (relating to specific powers of department and local authorities) or the department, upon the basis of an engineering and traffic investigation, may determine that the maximum speed permitted under this subchapter is greater or less than is reasonable and safe under the conditions found to exist upon any such highway or part thereof and establish a reasonable and safe maximum limit. The maximum speed limit may be made effective at all times or at times indicated and may vary for different weather conditions and other factors bearing on safe speeds. No maximum

speed greater than 55 miles per hour shall be established under this section except on highways listed in section 3362(a)(1.1) (relating to maximum speed limits), where the maximum speed for all vehicles shall not be greater than 70 miles per hour.

Note: Act 89 amended subsecs. (a) and (c). See the preamble to Act 89 in the appendix to this title for special provisions relating to legislative findings and declarations.

Because of this Provision, the Pennsylvania Turnpike Commission (PTC) requested URS to perform a study of the current PTC facilities. The purpose of this study was to determine which areas of the turnpike system are suitable for instituting a 70 mph legal speed limit. Specifically, the PTC requested URS to review the following:

- **Design Considerations** – a review of geometric and crash rate parameters which could impede the increase in speed limits
- **Standards Review** – a review of Turnpike Standards (Highway , Bridge, ITS and Maintenance and Protection of Traffic) which could be affected by the 70 MPH speed limit change
- **Coordination with Pennsylvania State Police (PSP) and the Pennsylvania Department of Transportation (PennDOT)** – PSP coordination is to obtain their perspective on the areas of proposed speed limit increase to identify areas of concern. PennDOT coordination includes the department's analysis methodology and coordination of the speed limit change on the Commonwealth's Interstate System.

Scope of Preliminary Report

This preliminary report outlines the methodology proposed to address each of the engineering analyses suggested by the Department's guidance for 65 mph speed limits and the results of the horizontal curvature review on all of the roadways on the system. The final report will document the results of the full engineering review, the Standards Review and the PSP / PennDOT Coordination.

Approach to Engineering Analysis

There are no specific state/ national guidelines or regulations pertaining to evaluating the raising of a statutory speed limit on interstates. Within the traffic engineering community the general approach to setting non-statutory speed limits involves a base speed limit set according to the 85th percentile speed and consideration of the design speed for the road, or other criterion.

URS reviewed approaches used in other states and previous statutory speed limit study's to determine the approach for this study. Below is the result of this review:

1.1 Approaches in other states

PennDOT conducted a National Survey on the analysis/engineering that other states followed to increase maximum speed limits. Some general conclusions from the survey included:

- A few States used design speeds as criteria for increasing speeds
- Many states relied on crash data to identify problematic sites
- Some states evaluated interchange design, spacing and congestion
- No states considered truck car speed differential
- Several states reviewed 85th percentile speeds

Including the State Police in the process and coordination with the media on the reasons why the speed limit is changing are among the best practices that were identified in the national survey

1.2 Previous 65 MPH criteria

PennDOT had established criteria in the mid 1990's when the state increased the statutory speed limit to 65 mph. This methodology is outlined in the Department's Publication 46 *Traffic Engineering Manual* (Section 11.3 Speed Restrictions), dated January 2013. Pub 46 also developed a "Study Elements that Suggest a Speed Limit Below 65 mph" guidelines in the Chapter 11 Appendix.

1.3 Coordination with PennDOT on Analysis

URS and PTC staff participated in two coordination calls with PennDOT pertaining to the 70 mph speed limit analysis. At the time of this report, PennDOT had not finalized their guidelines for establishing 70 mph speed limits for the Department's facilities. The preliminary discussions did consider elements of the Pub 46 guidelines.

1.4 Selected Analysis Elements

URS adopted and slightly revised the study elements identified in PennDOT's Pub 46, Chapter 11 Appendix entitled "Study Elements that Suggest a Speed Limit Below 65 mph. The only revision to these elements was changing the design speed consideration to 75 mph from 70 mph. Provided below is the outline of these elements:

Study Elements that Suggest a Speed Limit Below 70 mph

Design Considerations

1. Design speed less than 75 mph.
2. Long sections where stopping sight distance is substandard, particularly on horizontal curves where sight distance is restricted by concrete median barrier.
3. Numerous curves where the degree of curve or the superelevation is a problem for 75 mph.

4. Grades where trucks typically travel at speeds of 50 mph or slower without a truck climbing lanes.
5. Presence of bridges that are 200 feet or less in length and less than 34 feet wide, or are over 200 feet long and less than 31 feet wide.
6. Short acceleration lanes that create substantial speed differentials, especially at locations where heavy traffic volumes or limited sight distance exist.
7. Lane drop tapers that are less than 50:1.

Maintenance

8. A road surface that encourages extensive speed differentials or may cause drivers to lose control at 70 mph.
9. Skid numbers below 30.
10. Frequent shoulder drop-offs of 2 inches or more, where drivers running onto the shoulder may be likely to lose control.
11. Substandard size or condition of signs.

Miscellaneous

12. Interchanges so close that excessive merging and diverging movements or excessive number of lane changes occur.
13. An abnormally high crash or fatality rate.
14. Engineering judgment suggests that physical characteristics would make the section unsafe for a 70-mph speed limit.

In reviewing with the PTC, the Maintenance elements listed above were not seen as an issue on the turnpike facilities. Also, the primary elements were agreed to be the design speed of the roadways and any abnormal crash rate information for sections of the roadways.

Methodology Developed

To evaluate the Turnpike roadways under the design elements listed above, URS identified methodologies for each. Below is a breakdown of the elements requiring specific methodology.

ELEMENT 3 - Horizontal curves with a design speed less than 75 mph based on the radius of the curve and the superelevation rate.

The basic formula that governs vehicle operation on a curve is a function of the:

- Velocity in miles per hour
- Radius in feet
- Superelevation rate (*e*)
- and side friction factor (*f*)

Equation 3-8 in Chapter 3 of the 2004 edition of the AASHTO Policy on Geometric Design of Highways and Streets (AASHTO) gives the basic formula as:

$$\frac{0.01\,e + f}{1 - 0.01\,e\,f} = \frac{V^2}{15\,R}$$

e in this equation expresses the superelevation rate as a whole number of the percentage. For example 8 is used for an 8% or 0.08 superelevation rate. For simplicity in this analysis, e is assumed to denote the decimal equivalent (0.08) of the superelevation rate and so the 0.01 coefficient will be dropped.

As noted in AASHTO, the product of (*e f*) in this formula is always small, so the term (1 – 0.01 *e f*) is nearly equal to 1.0 and is normally omitted in highway design.

With these two modifications the basic equation can be restated as:

$$e + f = \frac{V^2}{15\,R}$$

Side Friction Factor (*f*)

The side friction factor represents the vehicle's need for side friction to resist unbalanced forces on the vehicle. Since there is a wide variation in vehicle speeds on curves, there is almost always an unbalanced force regardless of the amount of superelevation. This force results in the tire side thrust, which is counterbalanced by friction between the tires and the pavement surface, developed by distortion of the contact area of the tire. The way a driver experiences a higher *f* is feeling a greater centrifugal force pulling them to the outside on a curve. The upper limit on f is the point at which the tire would begin to skid, but, because highway curves are designed to avoid skidding conditions with a margin of safety, the f values used in design should be substantially less that the coefficient of friction at impending skid.

AASHTO sites a number of studies (including one from 1940 on the Pennsylvania Turnpike that concluded that side friction factor should not exceed 0.10 for design speed for 70 mph and higher) and summarizes that data in Exhibit 3-10. AASHTO Exhibit 3-15 contains a table on which an f_{max} for a 75 mile per hour design speed is listed as 0.09. The solid line in AASHTO Exhibit 3-10 (which is repeated in Exhibit 3-12) shows that the Side Friction Factors Assumed for High Speed Design (f_{max}) vary directly with design speed, with values of 0.14 at 50 mph and 0.08 at 80 mph, which also confirms the design value of f_{max} for a 75 mile per hour design speed equals 0.09.

To evaluate a curve of known radius, known superelevation rate at a given design speed, the required friction factor can be calculated based on the following restatement of the equation above-

$$f = \frac{V^2}{15\,R} - e$$

If this factor is greater than the f_{max} for the Design Speed, then curve is not safe for the design speed.

To illustrate this, preliminary data that was provided by the PTC was reviewed and the *f* factor for each of these curves (radius – superelevation rate combinations) at 75 mph was computed.

When designing a new roadway, tables included in AASHTO are consulted to determine the appropriate superelevation rate. There are five different tables each based on the maximum superelevation rates ranging from 0.04 to 0.12, in 0.02 increments. Each table shows the distribution of the superelevation rates over the range of radii for each design speed. These rates are distributed over the range of the radii to balance the superelevation and friction factors, rather than using the f_{max} for all curves. This is done so the maximum "centrifugal force" is felt by the drivers only at the minimum radius.

As can be seen in Figure 1, many of the *f* values computed for the radius and superelevation evaluated, fall below the line designating an f_{max} of 0.09 but they are not as low as recommended by the AASHTO 0.08 table.

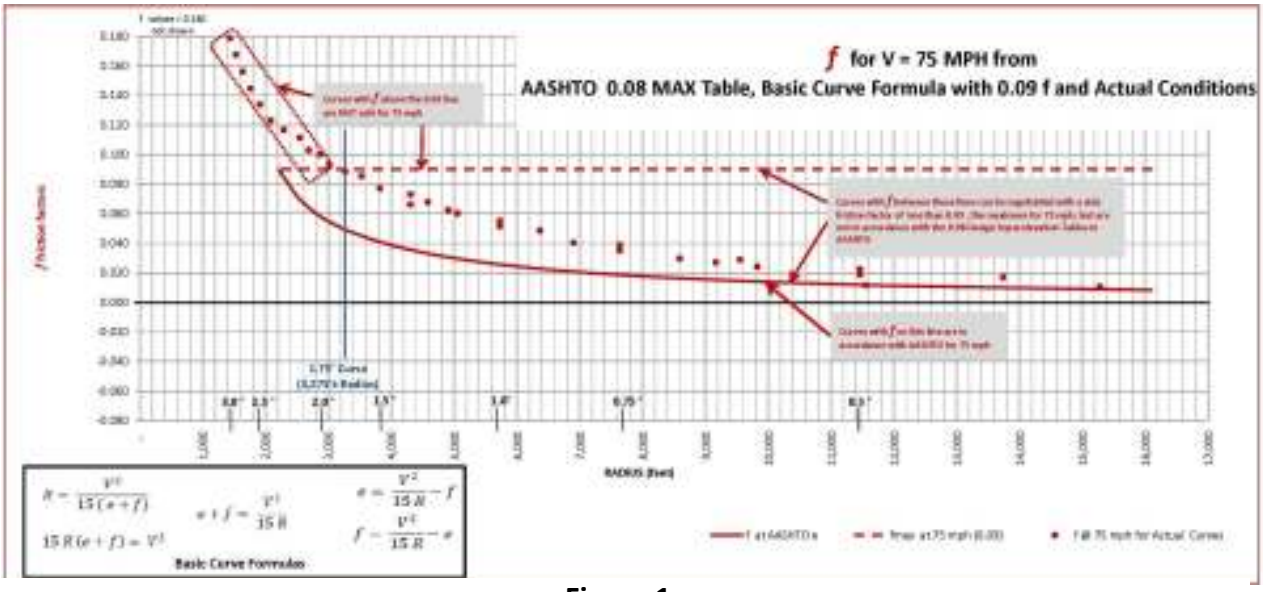

Figure 1

URS recommended that each curve on the Turnpike System be evaluated to identify curves which fall within this range. These curves can be included within the 70 mph speed zones without any additional signing. Depending on the actual f_{max} ,location, and frequency of curves with an f_{max} greater than 0.09, curve sections could be included in either a lower speed zone or a curve warning sign with an advisory speed sign will be installed to warn drivers.

DATA REQUIREMENTS:
Curve radius and superelevation rates.

ELEMENT 2a - Horizontal curves with stopping sight distance less than that required for a design speed of 75 mph.

Evaluation of this element will be based on equation 3-38 of AASHTO. This equation is:

$$HSO = R\left(1 - \cos\frac{28.65\ S}{R}\right)$$

Where R = Radius of Curve = 5730 / Degree of Curve

HSO = Horizontal Sightline Offset (The distance between the centerline of the inside lane and the obstruction)

S = Sight Distance. **For 75 mph, the required Stopping Sight Distance is 820 feet**.

When this equation is evaluated for an "HSO" distance of 10 feet (for a narrow 4 foot inside shoulder and 6 feet for half of a lane), the critical radius of a curve to provide a stopping sight distance of 820 feet is calculated to be approximately 8,404 feet, or 0.68°. A 10 foot "M" distance on a 1.00° curve provides only 677 feet of sight distance, less than is required for 75 mph.

In sections where there is a median barrier, it will be assumed to be a sight obstruction. The HSO will be assumed to be six feet, half the inside lane width, plus the width of the inside shoulder. In steep cut sections and other areas where there may be obstructions on the outside of the inside of curves, the HSO will be assumed to be the distance between the middle of the outside lane and the sight obstruction.

DATA REQUIRED:
Curve Radius and Inside shoulder widths and/or distance to obstructions at each curve

ELEMENT 2b - Vertical curves with stopping sight distance less than that required for a design speed of 75 mph.

The sight distance provided by a vertical curve is a function of the algebraic difference in the grades and the length of the vertical curve that connects them. AASHTO provides equations to evaluate the sight distances of sag and crest vertical curves with sight distances greater than and less than the length of the vertical curve.

DATA REQUIRED
Vertical grades and curve lengths

ELEMENT 3 - Bridges that are either 200 feet long or shorter and are less than 34 feet wide and bridges that are longer than 200 feet and are less than 31 feet wide.

DATA REQUIRED:
Locations of Bridges that are:

- 200 feet long or shorter and less than 34 feet wide
- Longer than 200 feet and are less than 31 feet wide.

ELEMENT 4 - Acceleration and deceleration lanes that are too short for a 75 mph design speed

The existing plans will be reviewed to determine the length of these lanes as they exist today, and these lengths will be compared to the values provided in AASHTO Exhibits 10-70 and 10-73.

DATA REQUIRED:

- Grade of mainline section
- Locations and lengths of acceleration and deceleration lanes

- Design Speed of critical approach (for acceleration ramps) or departure (for deceleration ramps) curve of ramp.
- Grade of ramps

ELEMENT 5 - Lane drop tapers that are too short for a 75 mph design speed

The existing plans will be reviewed to determine the length of these tapers as they exist today, and they will be compared to the values provided by the equation

$$L = W\,S$$

Where L = Length of the Taper
W -= Width of lane to be dropped (12 feet)
S = Design Speed (75 mph)
So the minimum L for 75 mph and 12 feet = 75 x 12 = 900 feet

DATA REQUIRED:
Locations and lengths of existing tapers

ELEMENT 6 – Crash Rates

The "2008-2010 Crash Cluster Report", dated August 26, 2011 report prepared by Orth-Rodgers & Associates, Inc, for the PTC will be used as the basis of Crash Analysis. This report list approximately 25 specific areas of the turnpike with identifiably higher crash rates. For these areas, there is discussion of the types and patterns of the crashes, along with other discussion. This report will be reviewed to determine if any areas that are being recommended for a 70 mph Speed Limit are included in the Crash Clusters. If they are, the crash record will be reviewed and a judgment will be made to determine if an increase in speed will exacerbate the identified crash record. This judgment will inform the final recommendations.

DATA REQUIRED:
The "2008-2010 Crash Cluster Report", dated August 26, 2011 report prepared by Orth-Rodgers & Associates, Inc

Horizontal Curvature Evaluation
The curve evaluation included the following facilities:

- Turnpike Mainline
- Northeast Extension
- Mon-Fayette Expressway (PA Turnpike 43)
- Southern Beltway (PA Turnpike 576)
- Beaver Valley Expressway (I-376)
- Amos K. Hutcheson Expressway (PA Turnpike 66)

All of the curves on the these facilities were reviewed, and for each curve of the main roadway the following information was noted:

- Location
- Degree of Curve
- Superelevation Rate

In a few cases, the only available data for the curve was from a resurfacing contract and no superelevation rates were given in the plans. In these cases, the rate was estimated based on the rate for nearby curves with similar degrees of curvature.

The basic curve equation was used as a basis to compute the following information-

- The Computed ***f*** for the curve at 75 mph (the assumed design speed for a 70 mph legal speed limit)
- The Computed Maximum Speed for the curve (V_{max}) based on the degree of curve, superelevation, and an ***f*** appropriate for the speed. Since the range of the equation to determine ***f*** factors is limited to between 50 mph and 80 mph, all curves with a computed maximum speed of 80 mph and above were reported at 80 mph.
- The Calculated ***f*** is the ***f*** calculated for the curve at V_{max}.
- The Suggested Speed Limit, which is 70 mph for all current 65 mph zones and the existing speed limits (55 mph or 45 mph) for all other speed zones.
- The Suggested Advisory Speed for all curves that have a V_{max} less than 75 mph. For those curves, the advisory speed was computed by subtracting 5 mph from V_{max} and rounding the remainder down to the nearest 5 mph increment.
- Table 2C-5 from the 2009 edition of the *Manual of Uniform Traffic Control Devices* (included on the next page), shows that if the advisory speed limit is less than the legal speed limit there are differing recommendations for Curve Signs, Advisory Speed Plaques and Chevrons (W1-8) depending on the differential in speeds. Table 2C-6 (also on the next page) shows the typical spacing for Chevrons around curves for different advisory speeds. These two tables were used together with the speed limit and advisory speed data to determine the need for Chevrons, and if they were needed, their typical spacing.

The material in Appendix A summarizes all of the data listed above, along with a graphic representation of the curve locations, maximum speeds, speed limits and crash clusters related to speed locations, summarized by Maintenance Districts. Based on these tables, the appropriate warning signage can be determined for each curve on the turnpike system.

Table 2C-5. Horizontal Alignment Sign Selection

Type of Horizontal Alignment Sign	Difference Between Speed Limit and Advisory Speed				
	5 mph	10 mph	15 mph	20 mph	25 mph or more
Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), and Combination Horizontal Alignment/Intersection (W10-1) (see Section 2C.07 to determine which sign to use)	Recommended	Required	Required	Required	Required
Advisory Speed Plaque (W13-1P)	Recommended	Required	Required	Required	Required
Chevrons (W1-8) and/or One Direction Large Arrow (W1-6)	Optional	Recommended	Required	Required	Required
Exit Speed (W13-2) and Ramp Speed (W13-3) on exit ramp	Optional	Optional	Recommended	Required	Required

Note: Required means that the sign and/or plaque shall be used, recommended means that the sign and/or plaque should be used, and optional means that the sign and/or plaque may be used.

See Section 2C.06 for roadways with less than 1,000 ADT.

Table 2C-6. Typical Spacing of Chevron Alignment Signs on Horizontal Curves

Advisory Speed	Curve Radius	Sign Spacing
15 mph or less	Less than 200 feet	40 feet
20 to 30 mph	200 to 400 feet	80 feet
35 to 45 mph	401 to 700 feet	120 feet
50 to 60 mph	701 to 1,250 feet	160 feet
More than 60 mph	More than 1,250 feet	200 feet

Note: The relationship between the curve radius and the advisory speed shown in this table should not be used to determine the advisory speed.

Crash Cluster Evaluation

The 2008-2010 Crash Cluster Report prepared by Orth-Rodgers & Associates Inc., reviewed several high incident areas using the PTC incident database system. Orth-Rodgers summarized and provided recommendations for every location that had an incident count of seven or more within the three year period. This safety study analyzes the crashes on I-70 Mainline and the Northeast Extension. The data does not include the crash history for MFE, BVE, and SB. Crash clusters pertaining to speed, heavy vehicle congestion, and horizontal and vertical features are flagged in the table below.

Milepost	Suspected Issues	Recommendations
T 96.7 - T 97.0	From above, it can be seen that the largest incident hotspot in this segment is at MP 96.8 in the westbound direction. Vehicles in that direction travel downhill while navigating a curve (the same factors apply to the other two mile points). Review of the police reports revealed that speeding was a major factor in these crashes along the curve. Many of the drivers were traveling above 70 mph when the crashes occurred. Inclement weather and poor roadway conditions also contributed in these cases. PTC engineering staff indicated that chevron signs were installed throughout the curve in the westbound direction. While the installation date has not been confirmed, the Google Earth image from 2010 shows the chevrons in place. Throughout the entire segment, the number of westbound crashes decreased significantly in 2009 and 2010 compared to 2008.	Continue monitoring the crash trend at this location. The initial data indicates that the newly installed chevron signs may have mitigated the problem. No immediate action is recommended unless crashes significantly increase.
T 102.0	In reviewing the police reports, it is believed that speed was the major contributing factor in a most of the crashes. Because of the 3% down grade, vehicles appear to be traveling at speeds too fast for conditions through this segment of the roadway and lose control under adverse conditions.	1. This segment should be considered for additional speed enforcement, however, this may be impractical as there may be no safe place for vehicles to be pulled over due to the guiderail at the edge of the shoulder, not only through the length of this segment, but for a significant further distance. 2. For this segment (101 .8-102.0), it is recommended that the eastbound direction be surveyed particularly in the median to confirm if adequate drainage capacity exists. Verification should be made to ensure ponding does not occur on the roadway at this narrow median section.
T 125.2 - T 128.1	A majority of the crashes at this mile point occurred in the eastbound direction during nighttime conditions. Review of the police reports indicated that vehicles traveling too fast for conditions contributed to the majority of the crashes.	Continue monitoring the crash trend for this segment. No further action is recommended at this time.
T 151.5	Review of the police reports reveal that improper driver behaviors contributed to most of the crashes, including DUI, speeding, driver distracted, etc. None of the crashes were caused by adverse roadway conditions. There was no discernable pattern to the accidents either by direction or other factors.	Continue monitoring the crash trend at this location. No further action is recommended at this time.
T 303.6 - T 303.7	The data shows that the majority of the crashes (11 out of 15) occurred under wet roadway conditions, including all ten of the westbound crashes. In the police reports, the drivers involved in the crashes stated that puddles in the roadway caused them to lose control of their vehicles. A review of Google Earth shows that the westbound shoulder has a closed drainage system in a cut section.	1. For this segment it is recommended that the roadway be surveyed to confirm if adequate drainage exists. Efforts should be made to eliminate ponding and rutting of the pavement, if found. 2. If the pavement has been in place for a significant period of time, another potential problem may be a low coefficient of friction. Skid resistance should be checked if drainage is not an apparent issue.
T 334.0 - T 334.5	The Turnpike section east of the Valley Forge Interchange is in the greater Philadelphia area. Compared to other sections located in more rural areas, traffic volumes of this section of the Turnpike are heavier and the roadways are generally more congested especially during peak travel periods. In addition, the driving behavior in this area tends to be more aggressive. Review of the police reports reveal that the rear end crashes were all due to high traffic volume, when traffic flow was in a stop-and-go condition and drivers lost patience or attention. Improper driving behavior or vehicle break downs also contributed to the other crashes.	The PTC is deploying an active Advanced Traveler Information System across the Turnpike. This area should be considered for more active dynamic messaging particularly in the westbound direction approaching the mid-county Interchange. In addition to travel times consideration should be given to other congestion management strategies including congestion detection and active dynamic messaging advising of slow or stopped traffic.

Milepost	Suspected Issues	Recommendations
T 336.0 - T 337.0	The crash data within this segment show a wide variety of crash types. Of the 56 crashes reported, twenty involved a vehicle hitting a fixed object either on the shoulder or in the median, and ten of the crashes were rear end type collisions. Review of the police reports revealed that heavy traffic congestion, aggressive driving behavior, mechanical problems, and adverse weather conditions were common contributing factors to these crashes. 66% of the crashes occurred during periods of congestion, and split almost evenly by direction. It should also be noted that the number of incident records significantly increased from 2008 to 2009. For MP 336.2 and 336.4 there were a high percentage of crashes occurring under wet roadway conditions in the eastbound direction. Police reports also mention standing water in roadway as a contributing factor.	1. MP 336.2 to MP 336.7 eastbound should be reviewed to see if any ponding or other drainage deficiencies exist. If problems are observed, have the roadway surveyed to determine the cause of the ponding. 2. The PTC is deploying an active Advanced Traveler Information System across the Turnpike. This area should be considered for more active dynamic messaging in both directions approaching the Fort Washington Interchange. In addition to travel times, consideration should be given to other congestion management strategies including congestion detection and active dynamic messaging advising of slow or stopped traffic ahead.
T 338.1 - T 338.9	All of the rear end collisions occurred in the westbound direction. 66% of the crashes occurred during periods of congestion, split almost evenly by direction. The eastbound exit is a two lane exit with the first lane forming 2000' prior to the gore and the second lane forming 1000' before the gore. With the exception of the curve warning sign with an advisory speed plate of 25 mph located 750 feet after the gore, there is no indication of an exit ramp, nor an advisory speed for the ramp. Additionally, the data shows an increasing number of incidents for each of the three study years.	1. Consideration should be given to installing a right hand curve warning sign with an advisory speed plate on the right shoulder of the eastbound exit ramp in the vicinity of the high mast lighting unit. 2. The PTC is deploying an active Advanced Traveler Information System across the Turnpike. This area should be considered for more active dynamic messaging for both directions approaching the Fort Washington Interchange. In addition to travel times, consideration should be given to other congestion management strategies including congestion detection and active dynamic messaging advising of slow or stopped traffic.
T 339.8 - T 340.1	The predominant accident pattern was in the westbound direction having 14 out of the 19 total crashes with 10 of those being rear end crashes. Only 4 of the 10 rear end crashes occurred prior to the Virginia Drive off ramp. There was no indication on the crash reports that any of those four were related to traffic exiting at Virginia Drive.	The PTC is deploying an active Advanced Traveler Information System across the Turnpike. This area should be considered for more active dynamic messaging for both directions approaching the Fort Washington Interchange. In addition to travel times consideration should be given to other congestion management strategies including congestion detection and active dynamic messaging advising of slow or stopped traffic.
A 66.8 - A 67.0	The lack of a median shoulder in the northbound direction, which is on the outside of a 3 degree curve potentially contributed to northbound crash pattern. There was no other discernable pattern.	1. Delineation plays a significant role in negotiating the curve. Check the existing pavement markings and delineators to ensure that they are up to PTC standards. 2. Consideration should be given to the installation of chevron signs for the northbound direction for the length of the curve (A66.8 to A67.1) assuming the signs can be mounted on the top of the barrier and not protrude beyond the footprint of the barrier.

Additional Analysis / Coordination to be performed

Prior to the final report, the following analyses will be performed and information will be developed:

- Stopping Sight Distance around median barrier on curves
- Stopping Sight Distance provided by vertical curves
- Presence of bridges that are 200 feet or less in length and less than 34 feet wide
- Presence of bridges that are over 200 feet long and less than 31 feet wide.
- Adequacy of acceleration and deceleration lane lengths for a 70 mph speed limit

- Lane drop tapers shorter than required for 70 mph
- A review of Turnpike Standards (Highway , Bridge, ITS and Maintenance and Protection of Traffic) which may be affected the 70 MPH speed limit change

Coordination is ongoing with PennDOT to determine the Department's analysis methodology and to coordinate the speed limit change in on the Commonwealth's Interstate System

Preliminary Recommendations

From our analysis of the horizontal curves, we offer the following recommendations;

1. Retain the existing speed limits in all sections where it is less than 65 mph.
2. Increase the speed limit to 70 mph in all sections where it is currently 65 miles per hour
3. Place a W1-2 (Curve Warning) sign in advance of all curves with an Advisory Speed of 65 mph in the new 70 mph zones.
4. Place a W1-2 (Curve Warning) sign with a W13-2 (Advisory Speed Plaque) for 60 mph in advance and W1-8 (Chevron Signs) at 160 foot spacing around of all curves with an Advisory Speed of 60 mph in the new 70 mph zones.
5. Place a W1-2 (Curve Warning) sign with a W13-2 (Advisory Speed Plaque) for 55 mph in advance and W1-8 (Chevron Signs) at 160 foot spacing around all curves with an Advisory Speed of 55 mph in the new 70 mph zones.

These recommendations are based on the work performed to date and may be modified based on the results of the ongoing analysis and coordination