CONCEPT DEVELOPMENT REPORT

ROCKFALL MITIGATION OF ROUTE I-80 WESTBOUND
MILEPOSTS 1.04-1.45
TOWNSHIP OF HARDWICK
WARREN COUNTY

SEPTEMBER 2011

PREPARED FOR

New Jersey Department of Transportation
Division of Project Development
1035 Parkway Avenue
E & O Building, P.O. Box 600
Trenton, NJ 08625

Phone: (609) 530 - 8078
Fax: (609) 530 - 3595
Contact: Bhavesh Shah

PREPARED BY

HNTB Corporation
Camden Ferry Terminal Building
2 Aquarium Drive, Suite 310
Camden, NJ 08103

Phone: (856) 536 - 3400
Fax: (856) 536 - 3401
Contact: Samir Mody, P.E.

TABLE OF CONTENTS

TABLES

APPENDICES

DIVISION OF PROJECT DEVELOPMENT

NORTH REGION

CONCEPT DEVELOPMENT REPORT

ROUTE I-80, ROCKFALL MITIGATION

M.P. 1.04 TO M.P. 1.45

TOWNSHIP OF HARDWICK, WARREN COUNTY

SECTION I - INTRODUCTION

A. Foreword

This report documents the results of the Concept Development Phase for the Route I-80 Rockfall Mitigation project. The existing rock slopes along this stretch of Route I-80 range in height from 80 feet to over 100 feet. In the past there have been numerous reports of rockfalls, which have resulted in rock reaching the roadway, causing accidents, and damaging the existing median barrier curb. In addition, NJDOT maintenance crews routinely remove rock from the roadway. These rock cuts are currently ranked the highest priority within the NJDOT's Rockfall Hazard Management System.

Route I-80 is an east-west interstate freeway that connects the New Jersey Turnpike and New York City to the east with the western part of New Jersey and Pennsylvania to the west. The project site is located near the west end of Route I-80 in Hardwick Township, Warren County and is within the Delaware Water Gap National Recreation Area. The subject rock slopes lie along the north side of the westbound roadway while the Delaware River runs along the south side of eastbound roadway. The project needs as well as the problem assessments and proposed improvements are evaluated and discussed. Refer to Appendix A for the New Jersey Department of Transportation (NJDOT)'s problem statement and Appendix F for the straight line diagram showing the project site.

B. Original, Ongoing, and Successor Projects

The Delaware River Joint Toll Bridge Commission (DRJTBC) has undertaken two (2) distinct rehabilitation / reconstruction projects in the vicinity of the existing Route I-80 / Delaware River Bridge:

1. Delaware Water Gap (I-80) Toll Bridge Express E-ZPass/ORT Project - Provision of Open-Road Tolling (ORT) lanes along westbound Route I-80 at the existing toll plaza (west side of bridge), involving removal and replacement of two toll lanes with other modifications, September 2010 through June 2011
2. Delaware Water Gap (I-80) Toll Bridge Rehabilitation Project - Bearing Replacement and Superstructure Painting for the Route I-80 / Delaware River Bridge, January 2011 through November 2011

These projects do not alter the existing condition of the project area in this report. With the ORT project, DRJTBC had once closed three (3) out of seven (7) toll lanes and the queue was between one (1) and three (3) miles long during the peak hours. When four (4) toll lanes were closed, the queue during peak hours was up to seven (7) miles. The open-road toll lane has been open since November 22, 2010. A maximum of one toll lane was closed until June 2011. This project also included the construction of overhead sign structures along the Route I-80 westbound roadway near M.P. 0.65 and M.P. 1.5. Most of the work for these structures has been completed. Some electrical and median work was scheduled in late March 2011. Single lane closures were implemented during off-peak (mostly daytime) hours for a duration of 1 to 2 weeks.

The bearing replacement project is currently implementing a single lane closure on the Route I-80 westbound roadway between M.P. 1.6 and the toll plaza. This closure is expected to continue until November 2011. The schedule of the closure is as follows:

- Monday through Thursday 7:00 am to 3:30 pm
- Friday 7:00 am to 12:00 pm
- Saturday and Sunday 6:00 am to 6:00 pm

In addition, this project will require nighttime single lane closures between 9:00 pm and 5:00 am and bridge shutdowns at 15 minute intervals between 11:00 pm and 4:00 am. Both of these arrangements are scheduled between April and November of 2011. Further coordination with DRJTBC for updates of the above closure schedule is essential during the design and construction phases of this project so that impacts to traffic, due to toll plaza or lane closures, can be minimized.

In addition, NJDOT has awarded a project that includes construction activities on the Route I-80 eastbound roadway encompassing the same mileposts as this subject project:

- Route I-80 EB, Truck Weigh and Inspection Station, Mileposts 0.833 to 2.786 - November 2010 through November 2012

This project proposes cantilever sign structures along the Route I-80 eastbound roadway between M.P. 1.04 and M.P. 1.45. There is no direct impact to this subject project since all improvements proposed in that contract are on the eastbound roadway while the anticipated improvements discussed in this report are all along the westbound roadway.

After the completion of the Concept Development Report, this project will enter the Preliminary Engineering phase and eventually the Final Design and Construction phases. These successor projects will prepare the contract documents for construction bidding and actual construction of the mitigation measures.

C. Data Reviewed

During the data collection phase, specific sources were consulted to obtain information on the existing conditions of the project area and to determine areas of nonconformance with current design standards. The following information was obtained and reviewed:

- As-Built Plans
  - Route 46 (1953) Section 1, Dunnfield to Columbia, Grading, May 1952
  - Route 46 (1953) Section 1B, Dunnfield to Columbia, Paving, February 1953
  - Route 80 Section 1AB, From Delaware River Toll Bridge to Vicinity of Route 94, Widening, Resurfacing and Safety Improvements, October 1976
  - Route 80 Section 1AR, From Vicinity of River Road Interchange to West of Knowlton Road (C.R. 616), Concrete Slab Removal, Resurfacing and Related Safety Improvements, February 1993
  - Route I-80, From East of Delaware River to West of Knowlton Road, Contract No. 000053960, Resurfacing, October 2006
- General Property Parcel Maps
  - Route 46 (1953) Section 1, Dunnfield to Columbia, May 1952, Sheets 1-3 of 13
- Design Plans
  - Route I-80 EB, Truck Weigh and Inspection Station, Mileposts 0.833 to 2.786, September 2010

- Crash Records provided by NJDOT, Bureau of Safety Programs
    - Crash Analysis for Route I-80 M.P. 1.04 to M.P. 1.35, 01/01/2006 through 12/31/2008, dated May 28, 2010
    - Crash Analysis for Route I-80 M.P. 1.04 to M.P. 1.45, 01/01/2007 through 12/31/2009, dated November 8, 2010
- Traffic Counts provided by NJDOT and Delaware River Joint Toll Bridge Commission
- Epstein, Jack P. "Geology of the Ridge and Valley Province, Northwestern New Jersey and Eastern Pennsylvania." pages 69-91. "Field Studies of New Jersey Geology and Guide to Field Trips; 52nd Annual Meeting of the New York State Geological Association," Edited by Warren Manspeizer. Published by Geology Dept. of Newark College of Arts and Sciences, Rutgers University. Newark, NJ. 1980.
- National Park Service. *http://www.nps.gov/dewa/planyourvisit/the-water-gap.htm*
- New Jersey Geological Survey. Geologic Map of Eastern Parts of the Belvidere and Portland Quadrangles, Warren County, New Jersey. 1985
- United States Geological Survey. *http://3dparks.wr.usgs.gov/nyc/parks/loc32.htm*. July 22, 2003
- United States Geological Survey. *http://tin.er.usgs.gov/geology/state/sgmcunitphp?unit=NJSb%3B7*. "Bloomsburg Red Beds".

D. Design Standards

The following design standards were used to evaluate the existing roadway geometry:

- New Jersey Department of Transportation Design Manual – Roadway, NJDOT
- A Policy on Design Standards Interstate Systems (January 2005), AASHTO

The detailed roadway design standard criteria are listed in Appendix F.

The Rockfall Hazard Rating System (November 1993), FHWA NHI was used to evaluate the existing rock slope geometry. Refer to Appendix H for the rating of the site.

E. Characteristics of Roadways and Surrounding Area

Route I-80 is a four-lane divided highway with a posted speed limit of 50 mph. The existing roadway cross section consists of two (2) twelve-foot lanes with a two-foot inside shoulder and a four-foot (WB) / six-foot (EB) wide outside shoulder in each direction. There is no roadside area along the north side of the roadway as it is bordered by barrier curb along the edge of pavement. Along the south side of the roadway, beam guide rail exists for the first 0.07 miles at the west end of the project and barrier curb defines the pavement edge for the rest of the project area.

The topography of the area is mountainous. Route I-80 in this area is located between Mt. Tammany and the Delaware River. The project limits are located within the Delaware Water Gap National Recreation Area, part of the National Park Service.

The Route I-80 roadway alignment within the project location is oriented northwest to southeast; however, the highway is designated to run from west to east. Therefore, all directional descriptions in this report will use west and east orientation. The elevation of the roadway within the project location is in the 300-foot range.

F. Concept Development Scope Statement

There was no formal Concept Development Scope Statement form prepared for this project since it was not available at the start of the Concept Development phase; however, the scope for Concept Development followed the current Project Delivery Process activities.

G. CD Public Involvement Action Plan

There was no formal Concept Development Public Involvement Action Plan prepared for this project; however, NJDOT's Office of Community Relations initiated telephone and/or e-mail contact with:

- Hardwick Township Municipal Clerk
- Knowlton Township Municipal Clerk
- National Park Service officials stationed at the Delaware River Water Gap National Recreation Area

The purpose of the contact was to inform officials that NJDOT was in the process of conducting a Concept Development study of the area to investigate rockfall mitigation solutions and to offer Officials Briefings individually or in a mutually agreeable location for a combined briefing.

Results of the Public Involvement efforts are documented in Section V.A.

SECTION II - PURPOSE AND NEED

A. Purpose

The purpose of the I-80 Rockfall Mitigation M.P. 1.04 to M.P. 1.45 project is to reduce the frequency and severity of rockfall events which directly impact Route I-80 within these milepost limits, such that this location can be removed from the NJDOT Rockfall Hazard Management System's listing of High Priority locations.

The following sections summarize the existing conditions and project needs. The final Project Purpose and Need Statement is included in Appendix A. Data substantiating these needs can be found in Section III, Appendix G, and Appendix H of this report.

B. Rockfall Needs

The existing rock cut areas along the westbound direction of Route I-80 within the project limits exhibit large overhangs, steep vertical faces, loose boulders, and rock blocks, which have resulted in rock toppling down and landing on the shoulder and roadway lanes and washouts along the adjacent Route I-80 roadway. Documented instances of these occurrences have led to accidents caused by rock debris on the highway and have required lane closures and the deployment of NJDOT Maintenance forces to conduct clean-up activities. Traffic Operations North reported two (2) rockfall related incidents between February 2003 and March 2008 within the project limits that resulted in lane closures:

- 4/15/07 5:59 PM to 7:42 PM: WB lanes closed due to wall collapse / mud slide near M.P. 1.5. State Police were on site with a detour. Two (2) crashes (one EB and one WB) also occurred in this area at the time of this incident.
- 4/15/07 10:04 PM to 4/16/07 11:04 AM: Right lane WB closed due to washout near M.P. 1.5.

NJDOT Bureau of Safety Programs crash data for January 2007 to December 2009 also shows that there were 81 crashes within the project limits for that period. This section of Route I-80 has a crash rate of 4.52 crashes/mvm (million vehicle miles), which is 58% greater than the statewide crash rate for the year 2009 of 2.86 crashes/mvm.

The state police reported two crashes that were caused by rockfall:

- 10/7/10 10:54 PM: A semitrailer hit a large rock in the road near M.P. 1.2
- 10/7/10 11:05 PM: A passenger car hit a boulder in the road near M.P. 1.0

NJDOT Maintenance also indicated in a telephone interview on December 6, 2010 that a 7-ton rock fell onto Route I-80 and went through the concrete median barrier near M.P. 1.0 about five or six years ago, resulting in a traffic accident. In addition, the maintenance department removes rock pieces weighing about 30 to 50 pounds approximately every two months. These events have not resulted in any documented vehicular incidents. See Appendix I for the telephone memo dated December 6, 2010.

There are substandard rock catchment zones along this section of Route I-80 that are believed to be a contributing factor in the problems. The rock catchment zones are too narrow because the rock slope is too close to the roadway. The catchment area widths vary along the rock slope, ranging from virtually no catchment area to approximately 40 feet wide.

C. Roadway Needs

The Route I-80 roadway carries several safety deficiencies that also contribute to high crash rates. These safety deficiencies include substandard sight distances, narrow shoulder width, and substandard horizontal radii. The substandard sight distances exacerbate the rockfall problem as they limit the reaction time for a driver to maneuver around the fallen rock. The probability of crashes after rockfall events is high because of the substandard sight distance. Detailed descriptions and discussion of the substandard geometry elements are provided in Section III.

D. Goals and Objectives

Goals and objectives for this project include:

- Implement cost effective rockfall mitigation measures that will address the stated purpose.
- Avoid, minimize, or mitigate impacts to environmentally sensitive areas, including Federal and State parklands, wetlands, water resources, etc.
- Minimize impacts to traffic during the construction phase.
- Implement where feasible, cost effective geometric roadway and drainage improvements, as related to the rockfall mitigation measures that will reduce or eliminate controlling substandard design elements.

SECTION III - EXISTING INVENTORY AND CONDITIONS

A. Existing Rock Inventory and Condition

1. Rock Slope Areas

The project site has been subdivided from the western to the eastern limits into four (4) areas based on variation of rock conditions:

- Area A – M.P. 1.04 to M.P. 1.15
- Area B – M.P. 1.15 to M.P. 1.25
- Area C – M.P. 1.25 to M.P. 1.35
- Area D – M.P. 1.35 to M.P. 1.45

See Appendix E for the Design Influence Plan illustrating these areas.

2. Rock Slope Condition

Matthew Riegel (Manager Geotechnical Services, HNTB), John Szturo (Sr. Engineering Geologist, HNTB), Brian Felber (Engineer, Geotechnical Services, HNTB), Andrew Salmaso (Janod Inc., a rockfall mitigation contractor), and John Jamerson (Engineering Geologist, NJDOT) conducted a reconnaissance on July 20, 2010. No climbing gear or specialized access equipment was utilized for the inspection. The outside lane and partial shoulder of Route I-80 westbound were closed to allow access to view the rock slope from the bottom. No field measurements were taken. An additional reconnaissance was performed on November 30, 2010 with Norm Norrish (Partner, Wyllie & Norrish), in addition to the abovementioned excluding Andrew Salmaso, with the focus to further examine Area D. Additional visits to the site were performed to measure discontinuities and various features.

Above and upslope of the concrete barrier along the north side of the westbound roadway, some areas have a stone wall roughly two (2) to four (4) feet in height composed of stacked stones roughly one (1) to four (4) feet in diameter, which have been placed on the fill. Construction of this stacked stone (designated as Rock Slide Barrier on the as-built plans) likely predates Route I-80, and is associated with US 611 and then Route 46, whose alignments followed the existing Route I-80 prior to the conception of the interstate highway program.

Minimal seepage from the rock was observed at the time of the initial reconnaissance when the weather was sunny and warm. Subsequent visits revealed moderate ice accumulated on the rock face and water flowing in the drainage ditch located directly behind the existing stacked stone wall. The upper portions of the slopes were too high and distant to clearly see any indication of seepage.

A literature search was performed to review the geology of the project area. The site is located at the Northeastern face of the Delaware Water Gap, a narrow gap at the New Jersey / Pennsylvania border where the Delaware River cuts through a large ridge of the Appalachian Mountains between Mt. Tammany on the New Jersey side and Mt. Minsi on the Pennsylvania side.

The mountains were formed from horizontal sedimentary beds which were folded approximately 250 million years ago. Headward erosion of the Delaware River over millions of years created the gap as water flowing down the mountain eroded through the ridge. Glaciers have advanced and retreated over the project location numerous times, with the last retreat of the Wisconsin Glaciation occurring approximately 20,000 years ago. Glaciers were a source of historic water flows at many times today's rates. The former large flows also helped form the gap and topography of the area today. The severe downcutting and relatively resistant rock have produced the steep slopes of the gap.

The highest elevation of Mt. Tammany upslope of the roadway is 1,549 feet, nearly 1,250 feet above the roadway. The slope varies locally from approximately 1H:10V to 3H:1V.

Below are generalized descriptions of the rock types present on site:

Bloomsburg Red Beds are shown on Figure 3 in Appendix H as "sb." This formation consists primarily of siltstone, with sandstone appearing secondarily, and mudstone, conglomerate, and shale may also be present. The formation originated in the Middle to Upper Silurian Period. Grayish-red and green are commonly appearing colors. The unconfined compressive strength of intact rock is estimated to range between 1,400 psi and 32,000 psi[1]. Bedding varies from thin to thick. The rock can be described as massive siltstone, sandstone, and localized conglomerate with quartz pebbles[2].

Shawangunk Formation is older and more prevalent at the project site. It consists of three members (layers) shown on Figure 3 in Appendix H as "Sst" or Tammany Member, "Ssl" or Lizard Creek Member, and "Ssm" or Minsi Member.

The Tammany Member is described as medium to medium-dark gray fine to coarse grained conglomerate comprised of quartz and argillite pebbles up to two inches long. The Quartz cement and aggregate result in this rock's ability to be highly resistant to mechanical and chemical erosion and weathering.

The Lizard Creek Member is medium to dark gray or olive with sandstone, siltstone, and shale. It may also be distinguished from the other two members as vegetation can be found more readily in its location. The shales of this member are similar to the locally called "Pencil Shale" or Martinsburg Formation.

The Minsi Member consists of light to medium-dark gray or olive quartzite, conglomerate, quartz, chert, and argillite[3]. The strength of this formation is estimated to range from 1,000 psi to 55,000 psi[1].

Martinsburg Formation The Ramseyburg Member of the Martinsburg Formation is present on site, but not visible because it is covered with Talus. The rock is described as medium to dark Claystone Slate alternating with light to medium gray Greywacke Siltstone[3]. This material is estimated to have an unconfined compressive strength of intact rock of 200 psi to 30,000 psi[1].

Weathering and erosion have resulted in raveling, spalling, and toppling. The erosion is hastened by running water and the freeze-thaw cycle. Isolated areas of the weaker shale are differentially weathering, which may over time cause undercutting. Climate variations can also hasten rockfall, with colder or warmer than average weather and larger rainfall events.

Below is a detailed description of the rock slope condition in each of the designated slope areas. Refer to Appendix E for photos of these areas.

---

[1] AASHTO. Bridge Design Specifications. 17th Ed. Page 4.4.8.2.2

[2] United States Geological Survey. http://tin.er.usgs.gov/geology/state/sgmc-unit.php?unit=NJSb%3B7 "Bloomsburg Red Beds."

[3] Epstein, Jack P. "Geology of the Ridge and Valley Province, Northwestern New Jersey and Eastern Pennsylvania." pages 69-91. "Field Studies of New Jersey Geology and Guide to Field Trips; 52nd Annual Meeting of the New York State Geological Association," Edited by Warren Manspeizer. Published by Geology Dept. of Newark College of Arts and Sciences, Rutgers University. Newark, NJ. 1980.

a. Area A (MP 1.04 to M.P. 1.15)

Area A is at the western limit of the project. Along the north side of the westbound roadway, the entire area consists of an existing concrete barrier curb in front and below the abovementioned dry placed stone wall (approximately 2 feet higher than the top of the barrier) acting as a rock slide barrier. The stone wall rises (up to 4 feet above the top of the barrier) east of M.P. 1.10. In the western portion of Area A, it is wooded with limited to no catchment area. In the eastern portion, it has a moderately large natural catchment area, roughly 10 to 20 feet wide. As-Built plans show that the stone wall extends roughly four (4) feet below the top of barrier curb.

The 2009 rockfall hazard rating for this area is 406 out of 1000 (see Appendix H). Occasional large rocks up to five (5) feet in diameter were found at the toe of slope, indicative of active rockfall. Several trees appear to have been damaged by recent rockfall activities. The trees, existing barrier curb, and the stone wall are providing limited and inadequate rockfall protection. The potential for rockfall rolling through or bouncing over this catchment area and reaching the roadway is feasible, and should be further investigated through rockfall simulation modeling during the Preliminary Engineering phase of this project. Also, the existing stacked stone wall allows for the potential of secondary projectiles reaching the roadway as a result of falling rock striking the wall and causing the stone wall to dislodge and topple. Mass movements in this area have been active in the past and often associated with wash-out occurrences from the upland areas.

In the eastern half of Area A between approximately M.P. 1.11 and M.P. 1.15, a 4-foot wide concrete drainage ditch runs parallel to the roadway directly behind the stone wall. The drainage ditch ends at a corrugated metal pipe, approximately 18 inches in diameter, which crosses under Route I-80 and discharges into the Delaware River. It appears that the ditch was constructed as a concrete channel to capture water seepage from the rock face. Recent field investigation indicates that the concrete lining is broken or covered with soil in many areas; however, portions of the concrete channel remain intact. Palustrine forested wetlands exist along the ditch. The photographs in Appendix E show the drainage ditch, corrugated metal pipe, and some recent rockfall illustrated by the newly broken tree trunks.

Rock discontinuity and bedding orientations were considered favorable given that the joints are generally sloping away from the face and into the rock mass. The height and inclination of the slope in this area ranges from approximately 900 to 1,100 feet and 1H:1V to 3H:1V, respectively. Rock at this location is primarily quartzite and siltstone. Fracture spacing ranges from six (6) inches to six (6) feet, with a fracture thickness of roughly three (3) to six (6) inches. Joint weathering varied from slight to moderate with no apparent infilling or slickensides. Generally, the rock is slightly weathered with the majority of the rock face covered by soil and wooded vegetation with many cobbles and boulders six (6) inches to three (3) feet in diameter. Further investigation is required during the Preliminary Engineering phase to verify if this entire height is part of the source contributing to rockfall and if the rockfall is capable of reaching the roadway.

b. Area B (M.P. 1.15 to M.P. 1.25)

Area B is similar to Area A with regards to the rock and slope conditions. The north side of the westbound roadway remains bounded by the existing barrier curb as in Area A. However, the stone wall behind the barrier stops at the end of Area A, resumes after 60 feet into Area B, and then terminates through the last 75 feet of Area B. It is anticipated that most of the rockfall was generated from a very large (roughly several hundred feet) vertical rock face at a distance back from the roadway. A gentle slope with vegetation, soil, and some talus separates the rock face and the roadway. This acts as a catchment area and ranges from 3 feet to 40 feet wide. The existing barrier curb with stone wall and vegetation on the gentle slope is serving as some degree of rockfall protection.

Within Area B, between approximately M.P. 1.18 and M.P. 1.21, a 4-foot wide concrete drainage ditch exists. The drainage ditch does not appear to have an outfall. Similar to the ditch in Area A, it appears to be partially broken or covered with soil. Palustrine forested wetlands exist along the ditch as well. The photographs in Appendix E show the drainage ditch, corrugated metal pipe, and some recent rockfall illustrated by the newly broken tree trunks.

The 2009 rockfall hazard rating for this area is 630 out of 1000. The rock discontinuity and bedding orientations were considered generally favorable because they are sloped away from the face into the rock mass. The height and inclination of the slope in this area ranges from approximately 900 to 1,100 feet and 1H:1V to 2H:1V, respectively. Rock at this location is primarily siltstone and quartzite with some shale. Fracture spacing is generally one (1) to six (6) feet, with a fracture thickness of roughly one-quarter (0.25) inch to two (2) inches. Joint weathering varies from slight to moderate with no apparent infilling or slickensides. Generally, the rock is slightly weathered.

During the July 20, 2010 site investigation, it was noted that water was leaking from the existing drainage ditch onto the Route I-80 pavement through a joint in the concrete barrier. A puddle was formed in the shoulder near the said joint and ice has been reported to develop at this location by NJDOT maintenance personnel.

c. Area C (M.P. 1.25 to M.P. 1.35)

The existing barrier curb continues throughout Area C, but the stacked stone wall is only present in the eastern portion of the area. In the western portion of Area C, there is a compound rock slope with a vertical face immediately adjacent to the roadway and variable slopes above. The near vertical face is approximately 100 feet tall and three (3) to six (6) feet away from the edge of roadway. The exposed rock mass is fairly massive and not considered to contribute greatly to past rockfall events; however, NJDOT has reported that rockfall events occurred at the western end of the face which impacted and damaged the existing barrier curb. Additionally, NJDOT has removed large rock blocks from this face in the past, which they believed to have a risk of falling and impacting the road. Due to the limited distance between the face and the roadway, rockfall from above the vertical rock face is believed to be capable of launching off the crest and into the roadway due to the inadequate catchment area.

The eastern portion of Area C has an existing gabion wall roughly 18 feet high and 85 feet long. Based on a review of as-built drawings and observed site conditions, the wall is inferred to be approximately nine (9) feet wide and founded roughly one (1) foot below the ground surface. According to NJDOT maintenance, this gabion wall was built in approximately 2007 or 2008 after a small landslide. It appears to be in satisfactory condition and is effectively mitigating some degree of rockfall. The vertical rock face in this area is setback further from the roadway while the gabion wall is at a similar offset to the vertical face in the western portion of Area C.

The 2009 rockfall hazard rating for this area is 662 out of 1000. Rock discontinuities and bedding orientation were considered generally favorable because they are sloped away from the face, but only dip into the face slightly as they are near horizontal. The height and inclination of the slope in this area ranges from approximately 1,000 to 1,200 feet and 1H:10V to 2H:1V, respectively. Rock at this location is principally siltstone. Fracture spacing is generally two (2) to twenty-four (24) inches, with a fracture thickness of roughly one-tenth (0.1) to one (1) inch. Joint weathering varied from slight to moderate with no apparent infilling or slickensides. Generally, the rock is slightly weathered. An overhanging knob of rock is present roughly two-thirds of the way up the lower slope, and is considered to be a hazard by NJDOT. Further investigation is required during the Preliminary Engineering phase to verify if this entire height is part of the source contributing to rockfall and if the rockfall is capable of reaching the roadway.

d. Area D (M.P. 1.35 to M.P. 1.45)

Area D contains the same roadside features as the other areas, namely barrier curb and the stone wall which rises two (2) to three (3) feet above the barrier curb. This area is characterized by a long, tall talus slope. The talus slope consists of blocky rock fragments up to ten (10) feet by ten (10) feet by five (5) feet. Area D consists of an extensive 450-foot high talus slope bounded by an oblique trending cliff-forming outcrop that is some 200 feet high. Talus blocks are angular and consist of strong quartzite and conglomerate with little fine material between the blocks. Figure 1 of the Risk Assessment Report in Appendix N shows the existing catchment conditions along westbound Route I-80 within Area D. The natural talus slope below the cliff rests at an angle of 35° to 37°, typical for deposits comprised of strong, angular rock blocks.

It appears that the toe of the talus was excavated at some locations to create the footprint for the highway when Route I-80 was constructed. Consequently, at such locations the lower portion of the talus is steepened from 37° to 45° using placed rock, below which stacked and locally-grouted rock boulders are present to act as a rockfall barrier. The talus slope is also projected to extend under the entire width of the Route I-80 roadway with its toe at the bank of the Delaware River. There is no existing boring information available at the time of this report. As-built drawings indicate that the depth to rock is roughly two (2) feet below the top of pavement. The depth of rock below the talus slope is believed to be shallow.

The 2009 rockfall hazard rating for this area is 422 out of 1000. The talus slope was formed by rock falling from the overhead source area to a marginally stable slope. The surface of the talus slope is likely comprised of Shawangunk Formation rocks including sandstone, siltstone, shale, quartzite, and conglomerate. The talus appears to be stable, with no distress or instability noticed in the slope or roadway. A few trees are growing on the slope. The age or source activity of the talus slope is unknown. Based on the literature search, the source area is believed to be from the Shawangunk Formation, likely quartzite and conglomerate.

The literature search revealed that the bedrock below the talus slope is from the Martinsburg Formation and is likely of less strength and more susceptible to weathering. The largest rock on the talus slope appears to be about ten (10) feet by ten (10) feet by five (5) feet, estimated to weigh roughly 37 tons. At the toe of slope, individual rocks roughly two (2) to three (3) feet in diameter were previously placed. This is evident by the holes drilled in the rock for lifting purposes and the grout found in the open spaces.

A risk assessment study was performed for Area D to estimate the probability that rockfall will be generated and the impact to Route I-80. The report produced as a result of this study was submitted to NJDOT in January 2011 and is included in Appendix N. The results show that a 4-foot diameter boulder can be expected to cause injuries or damage about once every 4 to 5 years while an 8-foot diameter boulder would do so about once every 30 to 35 years. In addition, the conclusion is that:

- It is unlikely for a 4-foot boulder to reach Route I-80 in a rockfall event (3% probability); it would take the falling of a relatively large boulder to reach Route I-80.
- The likelihood of a large boulder falling is low, but the probability of such event causing damage and injuries is high.

3. Rockfall History

NJDOT provided limited rockfall event data, and the actual frequency of rock activity is unknown. Although rockfall may not be active or prevalent, the area of this project has the greatest potential for catastrophic rockfall events. The entire talus slope from the upper rock outcrop to the Delaware River has been formed over geologic time by rocks detaching from the outcrop and moving downward to form the present slope. This rock movement is expected to continue over time and to impact Route I-80 which was constructed over the slope. Currently, there is no rockfall mitigation and the existing catchment is limited to the stone wall along the roadway.

NJDOT Maintenance expressed that the rockfall events usually happen after heavy rain in the spring and they are mostly located in Areas A and B (west of the rock face in Area C) in the westbound lanes. In addition, the maintenance crew removes rock pieces of about 30 to 50 pounds about every two months. A detailed description of rockfall events is included in Section II.B of this report.

B. Existing Roadway Inventory and Condition

The functional classification of Route I-80 is Rural Interstate as published in the NJDOT Straight Line Diagrams (Appendix F).

Cross-sectional data for Route I-80 was developed through a review of the as-built plans and field observations. Route I-80 (designated as an east-west highway) generally runs in the northwest-southeast direction in the project area. It is a divided roadway with two (2) travel lanes, an inner shoulder, and an outer shoulder in each direction. The horizontal alignment generally consists of two back-to-back horizontal reverse curves with a 6% maximum superelevation and a posted speed limit of 50 mph. The vertical alignment consists of mild slopes averaging about 1%. A profile low point in the project area exists near M.P. 1.30. Concrete barrier curb is present along the right side of the westbound roadway for the entire project limits. The eastbound roadway is protected by beam guide rail from the western limit of the project to M.P. 1.13 and by barrier curb from M.P. 1.13 to the eastern limit of the project. Highway lighting is present throughout the project area. The project area exhibits several substandard geometric features which are discussed in the following sections.

The roadway and its roadside appurtenances are generally in good condition. The pavement is in good condition as it was resurfaced in 2004.

C. Summary of Existing Deficiencies

The condition of the Route I-80 roadway is generally good. Existing deficiencies of the roadway as observed include:

- Minor chipping on existing median concrete barrier
- A minor water puddling problem in the right shoulder near M.P. 1.15
- A short tangent between reverse horizontal curves near M.P. 1.25

D. List of Substandard Design Elements

The Concept Development process included a review of the existing roadway geometry and identified the following CSDE's for a design speed of 55 mph:

Table 1 – Substandard Inside Shoulder Width

Mile Post	*Dir.*	*Description*	*Existing*	*Required*
1.04-1.45	EB	Route I-80	2.25'	4' Min. 5' Desirable
1.04-1.45	WB	Route I-80	2.25'	4' Min. 5' Desirable

Table 2 – Substandard Outside Shoulder Width

Mile Post	*Dir.*	*Description*	*Existing*	*Required*
1.06-1.45	WB	Route I-80	4'	10' Min. 12' Desirable
1.15-1.17	EB	Route I-80	6.33'-10'	10' Min. 12' Desirable
1.17-1.45	EB	Route I-80	6.33'	10' Min 12' Desirable

Table 3 – Substandard Horizontal Curve Radius

Mile Post	*Dir.*	*Description*	*Existing*	*Required*
1.04-1.11	EB/WB	Route I-80	1000'	1060'
1.22-1.25	EB/WB	Route I-80	800'	1060'
1.27-1.34	EB/WB	Route I-80	1000'	1060'

Table 4 – Substandard Horizontal Stopping Sight Distance

Mile Post	*Dir.*	*Description*	*Existing*	*Required*
1.04-1.11	WB	Route I-80	258'	495'
1.11-1.22	WB	Route I-80	305'	495'
1.22-1.25	WB	Route I-80	231'	495'
1.27-1.34	WB	Route I-80	418'	495'
1.40-1.45	WB	Route I-80	353'	495'
1.11-1.22	EB	Route I-80	444'	495'
1.22-1.25	EB	Route I-80	336'	495'
1.27-1.34	EB	Route I-80	258'	495'

Table 5 – Substandard Vertical Curve Stopping Sight Distance

Mile Post	*Dir.*	*Description*	*Curve Type*	*Existing*	*Required*
1.19-1.21	EB	Route I-80	Sag	<495’ *	495’

* The vertical curve does not meet design standard values, but the sight distance is unlimited because it is a sag curve with street lights.

E. Management Systems Input

Information was collected from the various NJDOT management system units and is summarized below.

Table 6 – Management System Summary

Unit *Management System*	*Input and Rating*
Bureau of Systems Planning Congestion Management System (CMS)	Ranking on CMS is Medium. This section of roadway is “very congested” in the summer. It is within the top 20% of the state’s roadways.
Pavement Management Unit Pavement Management System (PMS)	International Roughness Index (IRI) is 84 for EB and 91 for WB. Both roadways are rated good. Surface Distress Index (SDI) is 5.00 for both EB and WB. Both roadways are rated good.
Structural Engineering Bridge Management System (BMS)	No bridges are present. A pipe less than 5 feet long exists in the site but there is no data.
Safety Programs Safety Management System (SMS)	Crash rate is above the statewide average for the year 2009.
Project Planning and Development Drainage Management System (DMS)	No flooding is on record. The project site is not on the DMS ranking list.
Geotechnical Engineering Rockfall Hazard Rating System Geotechnical Data Management System (GDMS)	The project area consists of 4 rock cuts. These rock cuts are currently ranked the highest priority within the Department’s Rockfall Hazard Management System. Existing soil boring information for retaining wall near the northern terminus of the project is available.
Traffic Operations North (Incident)	Clean-up crew was required for three incidents due to rockfall.
Traffic Engineering and Investigations	No recent or pending work orders or jobs.
Transportation Data Development	Traffic counts were taken in January 2010.

According to the information, the project site exhibits the following characteristics:

- Very heavy seasonal traffic
- Very good pavement surface
- Relatively high crash rate
- Good pavement drainage system
- Consists of four rock slopes that require occasional clean-up on the roadway

Refer to Appendix G for all NJDOT Management Systems data.

F. As-Built Plans, Right-of-Way Maps, and Jurisdiction Map

As-Built Plans used in this project include the following:

- Route 46 (1953) Section 1 Dunnfield to Columbia, Grading (May 1952). Layout and Key Map, Typical Sections, and Plan and Profile. Sheets 1, 4, and 6-7 of 131.
- Route 46 (1953) Section 1B Dunnfield to Columbia, Paving (February 1953). Layout and Key Map, Typical Sections, and Plan and Profile. Sheets 1, 4, and 6-7 of 84.
- Route 80 Section 1AB From Delaware River Toll Bridge to Vicinity of Route 94, Widening, Resurfacing and Safety Improvements (October 1976). Key Sheet, Typical Sections, Construction Plans, Profiles, and Tie and Grade Sheets. Sheets 1, 12, 22-23, 49-51, and 64-65 of 212.
- Route 80 Section 1AR From Vicinity of River Road Interchange to West of Knowlton Road (Co. Rt. 616), Concrete Slab Removal, Resurfacing and Related Safety Improvements (February 1993). Key Sheet, Typical Sections, and Construction Plans. Sheets 1, 11, and 19-20 of 79.
- Route I-80 From East of Delaware River to West of Knowlton Road, Contract No. 000053960, Resurfacing (October 2006). Key Sheet, Typical Sections, Construction Plans, and Traffic Striping Plans. Sheets 1, 13-14, 41-42, and 96-97 of 156.

Right-of-Way Plans used in this project include the following:

- Route 46 (1953) Section 1 (FREEWAY) Dunnfield to Columbia (May 1952). General Property Parcel Maps. Sheets 2-3 of 13.

Refer to Appendix B for the plans. There is no applicable jurisdictional limit map for this project.

SECTION IV - TRAFFIC AND CRASH SUMMARY

A. Traffic Data

The principal source of traffic volume data was acquired from the Delaware River Joint Toll Bridge Commission (DRJTBC). The following westbound data was provided and the detailed data is included in Appendix D.

- Hourly toll volume data with vehicle classification for one week in January 2010 and one week in July 2010. Data was provided for 12 categories and summarized into car and truck volumes for each toll lane and the combination of all toll lanes.
  - Class 00 – Non-revenue
  - Class 01 – Auto
  - Classes 02-07 – Trucks with 2-7+ axles
  - Classes 11-13 – Autos plus trailers with 1-3 axles
  - Class 15 – Unclassified
- Monthly and yearly Average Daily Traffic (ADT) volume data from January 2005 to April 2010

According to Mr. Charles Stracciolini of the DRJTBC, toll gates at the westbound toll plaza would minimize the number of toll cheating vehicles to less than 0.5% of total volume. Because this number was not quantified and represents a minimal number of trips (less than the amount of expected daily variation in traffic), no adjustment was made to the data. Traffic volumes were found to be consistent between all of the data sets provided by DRJTBC, in the range of approximately 20,000 to 30,000 vehicles per day in either direction.

Eastbound volumes were also obtained as a check on westbound volumes. Hourly data was available from a traffic counter for one week in April 2010 and one week in July 2010. Data was provided for left and right lanes but not classified by vehicle type. January 2010 data was requested but not available from the traffic counter. Monthly and yearly eastbound ADT volume data was included with the westbound data from January 2005 to April 2010. The eastbound data was found to be consistently of the same magnitude as the westbound data (monthly ADT within 0.5%, annual ADT within 1-2%).

Additional background data was obtained from NJDOT record counts to be used as a check against DRJTBC data, and is included in Appendix D.

- Bi-directional hourly volumes at M.P. 1.5 from 4:00 pm Monday, January 18, 2010 to 1:00 pm Thursday, January 21, 2010. Data includes AM and PM peak hours and peak volumes to the nearest 15 minutes.
- Bi-directional monthly and yearly ADT volume data with vehicle classification for Year 2009. Data was provided for 14 categories including "unclassified."

The January 2010 midweek westbound volumes measured by NJDOT at M.P. 1.5 were found to be more than 70% higher than the westbound volumes measured at the DRJTBC toll plaza during the following week. Reasons for this difference are unclear; similar volumes would be expected because there are no interchanges with through streets between the two data collection locations. Because the westbound DRJTBC data is based on toll transactions, it is assumed to be more reliable than NJDOT volumes obtained from automated traffic recorders (ATRs) or that there was an anomaly during the NJDOT count. As with the DRJTBC data, the NJDOT volumes were found to be consistent in both directions (daily volumes within 0.5%).

The data measured by NJDOT at M.P. 8.3 was used as a check on vehicle classification measured by the DRJTBC. Volumes at M.P. 8.3 were not analyzed because they were collected east of Interchange 4, a major interchange where traffic is split between Route I-80, the Portland-Columbia Toll Bridge, US Route 46, and NJ Route 94.

Based on two weeks of hourly classified DRJTBC westbound data, the overall Year 2009 truck percentage was approximately 14%. The truck percentage was calculated to be 15% based on the January data and 13% based on the July data. As a check, the NJDOT classification count conducted at M.P. 8.3 in Year 2009 indicated that approximately 86% of vehicles were classified as passenger cars or 2-axle 4-tire vehicles, 13% of vehicles were classified as buses or vehicles with at least 3 axles, and the remaining 1% of vehicles was either unclassified or 2-axle 6-tire vehicles. Therefore, the NJDOT classification data correlates well with and supports the DRJTBC data.

Volume data as received was expressed in units of vehicles. However, it is desirable to convert vehicles to passenger car equivalents (pce), which allows comparison of two traffic streams with different percentages of trucks and other heavy vehicles. According to traffic engineering theory, two traffic streams with different vehicle volumes but the same pce volumes are expected to behave more similarly than two traffic streams with the same vehicle volumes but different pce volumes. Based on Exhibit 23-9 of the Highway Capacity Manual – 2000 (HCM2000)[4] and as-built plans indicating a maximum westbound grade of 1.1% in the project area, each truck was assumed to be equivalent to 1.5 passenger cars to convert the DRJTBC volume data from units of vehicles to pce. There may be a steeper grade to the east of the project area, but in the westbound direction it is a downgrade, which would not affect truck performance negatively and therefore would not require the use of a higher passenger car equivalency factor.

Seasonal adjustment factors for each month were calculated from DRJTBC monthly data for year 2009, the most recent full year of available data. The annual ADT (AADT) was calculated as the average of the monthly ADTs weighted by number of days per month. The ratio of the monthly westbound ADT to the AADT is the seasonal adjustment factor for westbound volume data for that month. Both unadjusted and seasonally adjusted volumes are presented in Appendix D. AADT volumes should be used with caution due to the high degree of variation in traffic volumes from winter to summer, especially regarding high volumes on summer weekends.

According to NJDOT methodology[5], seasonal adjustment factors are used to calculate Annual ADT (AADT) based on average 24-hour weekday volumes from Tuesday-Thursday data. Presumably, different factors may apply to Friday-Monday due to weekend travel characteristics. However, monthly DRJTBC data does not provide ADT for each day of the week, so separate factors cannot be developed for each day of the week. Because volumes for every day of the week were observed to follow seasonal trends by being higher in summer and lower in winter, the monthly seasonal adjustment factor was applied to DRJTBC data from every day of the week to determine hourly volumes for the average month.

The predominant weekday traffic flow is eastbound during the AM peak period and westbound during the PM peak period, reflecting regional commuting patterns for Pennsylvania residents working in New Jersey and New York. On weekends, the predominant traffic flow is westbound in the morning and eastbound in the afternoon through evening, reflecting typical recreational patterns. Overnight Friday into Saturday volumes are heavier in the westbound direction until 3 am and Sunday into Monday volumes are heavier in the eastbound direction into the AM peak period; otherwise, volumes are similar from 10 pm to 4 am. Annual average hourly DRJTBC peak hour data are shown in Table 7; volumes are expressed in pce per hour and eastbound truck percentages are not available as explained in this section of the report.

[4] Transportation Research Board, Highway Capacity Manual 2000.

[5] "Seasonal Adjustment and Axle Correction Factors." Available online: http://www.state.nj.us/transportation/refdata/roadway/pdf/factors09.pdf, accessed November 3, 2010.

Table 7 – Peak Hour Volume Data - DRJTBC

		Monday	Tuesday-Thursday	Friday	Saturday	Sunday
WB peak hour	Time	5-6 pm	4-5 pm	5-6 pm	11 am-12 pm	12-1 pm
	Volume	2257	2362	2772	2293	2075
	Truck %	12%	12%	8%	5%	3%
EB peak hour	Time	6-7 am	6-7 am	6-7 am	5-6 pm	4-5 pm
	Volume	2633	2318	2102	1894	2680

The posted speed limit on Route I-80 near the Delaware Water Gap is 50 mph and the free flow speed is assumed to be 5 mph above the posted speed limit as per accepted traffic engineering practice. It is recognized that some of the geometry of Route I-80 in this area may result in travel speeds less than 55 mph, especially due to the volume of heavy trucks, but a detailed traffic speed analysis would be required to establish a lower free flow speed.

B. Traffic Operations

Levels of Service (LOS) and the corresponding volume thresholds for a free flow speed of 55 mph are given by Exhibit 23-2 in the HCM2000[4]. They are adapted below for a two-lane roadway:

LOS	Volume threshold (pce/hr), 2 lanes
A	1200
B	1980
C	2860
D	3820
E	4500

Westbound peak hour volumes correspond to LOS 'C', which describes traffic flow at or near the free flow speed of the freeway. There is limited maneuverability to change lanes and limited ability to absorb the effects of traffic incidents. Queues from the Pennsylvania toll plaza have been observed to extend through the project area toward Interchange 4 of Route I-80. When queuing occurs, the free-flow conditions typical of LOS 'C' break down to slow or stopped traffic, although the traffic demand at the project area remains less than the theoretical capacity of the roadway.

In summary, the existing conditions have the following characteristics:

- 22,000 to 34,000 vehicles per day AADT, lower during the week and higher on peak travel days (Friday and Saturday westbound, Friday through Sunday eastbound)
- ADT volumes are 15% lower than the annual average in January and 15% higher than the annual average in July and August
- 14% daily average trucks, as high as 60% to 65% during weekday overnight hours from 2-6 am when traffic volumes are lowest (from 200 to 300 vehicles per hour westbound)
- Westbound peak hours are during the weekday PM commute period and midday on Saturday and Sunday, while eastbound peak hours are during the weekday AM commute period and evening on Saturday and Sunday
- Peak hour volumes from 2,100 to 2,800 vehicles per hour in two lanes, corresponding to LOS 'C' when accounting for truck percentages during those hours

C. Traffic Volume Forecasts

The scope of this project includes the mitigation of the potential rockfall condition for safety reasons; roadway improvements are to be a secondary benefit only if the mitigation improvements yield the opportunity for it. As discussed in Section VI, it is determined that roadway improvements are not to be included as part of the improvements; therefore, the traffic volume forecast is not required. Future year Design Traffic Volumes were obtained from the NJDOT on a memo dated May 11, 2011 found in Appendix D.

D. Crash Data Analysis and Crash Diagram

NJDOT maintenance stated in a phone interview that a motorist was killed by crashing into a 7-ton rock that broke through the median barrier on Route I-80 about five or six years ago. This happened near M.P. 1.0 in Area A.

NJDOT Bureau of Safety Programs compiled and analyzed crash data for the period from January 1, 2007 to December 31, 2009. The crash rate for this section of Route I-80 exhibits a relatively unsafe crash record as it is above the year 2009 statewide average for roadways with similar cross-section. The crash rate of 4.52 crashes/mvm (million vehicles miles) was above the Statewide Crash Rate for the year 2009 of 2.86 crashes/mvm. A review of the Detail of Motor Vehicle Accidents Report provided by the NJDOT Bureau of Safety Programs shows that three (3) out of a total of eighty-one (81) crashes were caused by debris on the road. The crash data and collision diagrams are presented in Appendix C.

Prior to the aforementioned analysis, NJDOT Bureau of Safety Programs compiled and analyzed crash data for the period from January 1, 2006 to December 31, 2008 for Route I-80 between M.P. 1.04 to M.P. 1.35. This section of roadway had a crash rate of 3.84 crashes/mvm, which was above the Statewide Crash Rate for the year 2008 of 2.93 crashes/mvm.

Two recent crashes located on Route I-80 westbound occurred on October 7, 2010. Both crashes (M.P. 1.0 and M.P. 1.2) happened within or near Area A. According to the police reports, the rockfall events happened before the accidents. The first crash involved a semitrailer truck and the second crash involved a passenger car. Based on the description from the NJDOT maintenance crew, a very large boulder rolled down the rock slope onto Route I-80. Both accidents were caused by the same boulder. Both vehicles had extensive damage. See Appendix I for the e-mail from the maintenance crew.

As noted in the following sections, Route I-80 westbound provides substandard horizontal sight distance in most of the project area. This substandard sight distance, combined with the potential rockfall, creates a severe hazardous condition as drivers do not have sufficient time to react to the rock in the road.

SECTION V - SOCIAL ECONOMIC AND ENVIRONMENTAL SCREENING

The majority of the environmental data in this section is based on the Environmental Screening by NJDOT dated February 15, 2011, a site visit on March 18, 2011, and the data resources from the New Jersey Department of Environmental Protection (NJDEP). See Appendix K for the Environmental Screening.

A. Community Outreach

1. Concept Development Public Involvement

Ms. Deborah Hirt of the NJDOT's Office of Community Relations initiated telephone contact with officials in Hardwick Township, Knowlton Township, and the Delaware Water Gap National Recreation Area. Ms.

Hirt also sent letters to the aforementioned officials offering to conduct briefings to share information about the project and solicit feedback from them. Hardwick Township and Knowlton Township officials declined a briefing citing that the project is in a remote area of the township and they feel the project does not directly impact residents.

On July 6, 2011, the NJDOT conducted an Officials Briefing with Mr. William L. Leonard, Jr., P.E., Chief, Strategic Planning and Project Management Office of the Delaware Water Gap National Recreation Area and the staff from the National Parks Service. NJDOT and HNTB staff presented an overview of the geological assessment and conditions in the project area as well as the concepts and alternatives studied during the Concept Development phase. Discussions also occurred regarding the timeline and process for the future of the project and future public involvement.

Copies of the minutes from this briefing with NPS officials along with correspondence between the NJDOT and Hardwick and Knowlton officials are included in Appendix J.

2. <u>Preliminary Engineering Public Involvement</u>

The Public Involvement Action Plan for this project will be initiated at the outset of the PE phase and is anticipated to include the following efforts:

- Initiate follow-up contact with Hardwick Township and Knowlton Township offering to hold Officials Briefings
- Conduct a follow-up meeting with NPS officials and provide them with color renderings simulating what the PPA will look like after construction.
- Advertise and conduct a Public Information Center during the early stages of the PE phase. Officials from Hardwick and Knowlton Townships, the Warren County Engineer, the National Park Service, DRJTBC officials, and emergency responders will be invited.
    - Advertisements will be placed in area newspapers in New Jersey and Pennsylvania.
    - Notices will be placed at Trail Heads within the Delaware Water Gap National Recreation Area and the Kittatinny Point Visitors Center.

The NJDOT plans to conduct a Public Information Center (PIC) during the early stages of the Preliminary Engineering phase of the project to provide information about the project and solicit feedback from area residents, motorists, and park visitors. A central and mutually agreeable location for the PIC will be chosen and advertisements for this meeting will be placed in area newspapers in New Jersey and Pennsylvania. In addition, notices will be placed at Trail Heads within the Delaware Water Gap National Recreation Area and the Kittatinny Point Visitors Center.

Further investigation also indicates that NJDEP Division of Parks and Forestry is responsible for Worthington State Forest and may need to be included in the Officials briefing and Pennsylvania Department of Transportation may need to be contacted if an overnight detour is necessary.

B. Noise and Air Quality

The project will not have a significant effect on traffic noise levels in the area.

The project is categorized by the Transportation Conformity Rule as exempt from the conformity requirements of the Clean Air Act; therefore, no air quality analysis is required.

C. Socioeconomics

The project is not anticipated to affect access to or use of any community facilities. The project will not isolate or require the acquisition or relocation of any residential properties, nor is it anticipated to adversely impact community cohesion, community facilities, residences, or existing land use patterns.

D. Cultural Resources

Research has yet to be conducted to identify whether the project area contains documented or potential historic structures or archaeological resources; however, rockfall mitigation projects are included on the current List of Undertakings Which Have Limited or No Effect on Cultural Resources in New Jersey. It should be noted that disturbance of the stacked stone walls along the highway, which are believed to pre-date Route I-80, may require coordination with the New Jersey Historic Preservation Office (NJHPO) since these activities are beyond normal rockfall mitigation measures.

E. Section 4(f) Properties

The project lies within the Delaware Water Gap National Recreation area and the Route I-80 right-of-way abuts lands of the National Park Service (NPS) and Worthington State Forest. Implementation of the Preliminary Preferred Alternative is not expected to require right-of-way from any of these resources. Verification of the right-of-way boundary and construction disturbance areas will occur during the next phase.

Historical Section 4(f) resources may also be present within the project area, but they have yet to be evaluated.

F. Highlands / Pinelands

The site is not located within the Highlands or Pinelands areas.

G. Wetlands

The aforementioned 4-foot wide drainage ditches within Areas A and B contain wetlands within or along their lengths. Areas of the rock face where seepage is relatively strong or constant also appear to qualify as wetland communities. These hillslope wetland areas, sometimes referred to as "spray cliff" communities are rare within the State of New Jersey and appear to provide habitats for a highly specialized plant community dominated by mosses and liverworts.

H. Reforestation

Reforestation rules may apply depending on the actual amount of tree removal, which will be determined during the Preliminary Engineering phase.

I. Floodplains

The environmental screening did not identify whether the project is expected to impact any floodplains.

J. Sole Source Aquifer

Sole source aquifers were not identified in the environmental screening.

K. Threatened / Endangered Species

According to the NJDEP Natural Heritage Program Priority Sites GIS data coverage, the entire project area is located within the Mt. Tammany priority site. According to the GIS data, the priority site consists of sheer cliffs, talus slope, and rocky outcrops of the Delaware Water Gap and contains two good quality natural communities, one state endangered plant species and six plant species of concern. The priority site encompasses almost 500 acres; therefore, the proximity of these natural communities and sensitive plant species in relation to the proposed improvements cannot be determined. It may, however, be possible that the spray cliff communities identified above are the "good quality natural communities" identified in the GIS data and may present habitats for rare, threatened, or endangered plant species.

Numerous wildlife species were identified in NJ Landscape Project Mapping. It is unlikely that impacts to most wildlife species listed would occur since the project will take place mainly along the curb and existing disturbed areas along Route I-80. Impacts to the Indiana bat may be of concern and timing restrictions or additional coordination may be needed because tree clearing is proposed.

L. Category 1 Waters

The screening did not identify whether any Category 1 waters exist within the project area; however, the Delaware River was identified as a Wild and Scenic River, which may necessitate coordination with NPS.

M. Vernal Pools

Vernal pools were not identified in the environmental screening.

N. Stormwater

The proposed improvements are anticipated to result in no additional impervious area and the flow is the same in both existing and proposed conditions; therefore, stormwater regulations are not applicable.

O. Hazardous Waste

A hazardous waste screening has not been performed for this project; however, it is unlikely that hazardous waste issues will be an environmental constraint for this project due to the type of disturbance planned.

P. Anticipated Environmental Permits and Approvals

It is anticipated that the project will require a freshwater wetlands General Permit No. 10A for disturbance to wetlands and transition areas associated with rock slope drainage and the aforementioned ditch. At this level of design, it is not possible to verify that the project would meet all conditions for this permit.

A Flood Hazard Area permit may also be required if the project will disturb riparian zones along the Delaware River.

The following agency coordination is anticipated as part of the environmental permits:

- Wild and Scenic River coordination (NPS)
- Threatened and endangered species coordination (Federal and State)
- Coordination with NJHPO

Q. Complete Streets Policy

The Complete Streets Policy is not applicable to this project site as it is along a rural portion of an interstate highway.

R. Environmental Summary and Probable NEPA Classification

As indicated above, several environmental constraints exist within the project area including freshwater wetlands and possible riparian zones, threatened / endangered species, and historical resources. The Delaware River, which lies in close proximity to Route I-80, is a component of the National Wild and Scenic Rivers system and the Route I-80 right-of-way lies within or adjacent to the Delaware Water Gap National Recreation Area and Worthington State Forest.

The probable NEPA classification was not indicated in the environmental screening; however, it is expected that the project can be processed as a Categorical Exclusion with appropriate technical studies including Ecology and Cultural Resources.

SECTION VI - EVALUATION OF CONCEPT ALTERNATIVES

A. Concept Alternatives

Rockfall mitigation concepts considered for this project fall into three major categories, including removal, reinforcement, and protection methods. Removal consists of excavating, scaling, and blasting; reinforcement includes rock bolts, dowels, or shotcrete; and protection encompasses fences, barriers, draped or anchored mesh, and sheds.

Different alternatives were considered in the four designated areas and are listed below.

1. <u>Areas A and B</u>

Mitigating rockfall at the source area is not feasible due to accessibility, cost, and environmental impact, and was not the intent of the NJDOT when the Concept Development study was initiated. It is recommended that mitigation be confined to the toe of slope given these constraints. The Alternatives considered include:

I. **No Action** – Accept the current risk.

II. **Protection - Rock Catch Fence** – Install rock catch fence between the existing stacked stone wall and the rock slope. The fence will be designed to a capacity capable of resisting a design rockfall impact, which will be based on rockfall simulation modeling performed in subsequent phases of this project. The rock catch fence may be coated with PVC to achieve color matching of the surrounding area as context sensitive design. This alternative will require a digital terrain model (DTM) with maximum 2-foot contour intervals to be utilized for rockfall simulation modeling. In addition, helicopter reconnaissance and ground reconnaissance of the cliff may be performed to confirm that no major potential instabilities are present.

III. **Protection - Heightened Concrete Barrier Curb with Energy Dissipation** – Replace the existing concrete barrier curb with a modified concrete barrier, which will be heightened to serve as both a standard traffic barrier and rockfall protection. It is anticipated that the height of this element will be between 42 and 72 inches with a final design developed in subsequent phases of the project. The existing stacked stone wall will be removed and the area directly behind the new barrier, which will serve as a catchment area, would be backfilled with granular fill or replaceable timber lagging will be attached to the rock slope side of the barrier as an energy dissipater. The new barrier may utilize coloring additives in the concrete and a formliner to provide a texture that matches the surrounding area as a context sensitive design element. Minor blasting may be needed to excavate an existing rock outcrop in Area B. See Appendix L for the related sketches of this alternative. This alternative will require a digital terrain model (DTM) with maximum 2-foot contour intervals to be utilized for rockfall simulation modeling. In addition, helicopter reconnaissance and ground reconnaissance of the cliff may be performed to confirm that no major potential instabilities are present.

2. Area C

The western portion of Area C (roughly M.P. 1.25 to M.P. 1.32) currently has no rockfall protection and rock can potentially reach the roadway. The eastern portion of Area C (roughly M.P. 1.32 to M.P. 1.35) currently has a gabion wall which was installed following a small landslide in approximately 2007 or 2008, according to NJDOT Maintenance. This wall is not anticipated to serve as rockfall mitigation. Cutting the slope back to achieve an adequate catchment area is not feasible due to accessibility, cost, and environmental impact, and was not the intent of the NJDOT. The following rockfall mitigation alternatives were considered:

I. **No Action** – Accept the current risk.

II. **Protection - Anchored or Draped Mesh on the Lower Slope** - Install wire mesh from just above the crest of slope and down onto the lower rock slope. Mesh may be coated in colored PVC that matches the surrounding area as context sensitive design. This alternative would only address the lower slope as a source area for rockfall and assumes an acceptance of the risk associated with rockfall from the upper slope.

III. **Protection - Rock Bolts and Anchored Mesh on the Upper and Lower Slopes** – Install anchored wire mesh on top of the upper rock slope and drape down to cover the entire rock slope. Spot rock bolting will be performed to anchor loose rock blocks.

IV. **Protection - Rock Catch Fence** - Install rock catch fence between the existing barrier curb and the rock slope. The rock catch fence may be coated in colored PVC to match the surrounding area as context sensitive design. This alternative would be less effective because the fence would have to be placed close to the lower slope and rockfall from the upper slope could potentially project over the fence. Further analysis would be required in subsequent phases of the project to assess the rockfall trajectories from the upper slope to determine the appropriate height of this element; however, it is anticipated that this solution would result in an unrealistically tall fence, so it was decided to estimate a lower fence and accept the risk associated with the upper slope.

V. **Protection - Hybrid System** - The hybrid system would consist of an energy barrier at the crest of the lower slope that would catch and funnel fallen rock. The bottom of the barrier will be connected to draped mesh, which will extend down the lower slope allowing rockfall to reach the toe of slope in a controlled manner. This alternative will require a digital terrain model (DTM) with maximum 2-foot contour intervals to be utilized for rockfall simulation modeling. During the Preliminary Engineering phase the following alternatives for the hybrid system will be considered:

- Terminate mesh about 5 feet above the ground to prevent snow from anchoring the bottom, which could result in overstressing of the mesh
- Use matching color vinyl mesh as context sensitive design
- Spot bolting is anticipated to be performed in addition to the hybrid barrier, to anchor isolated loose rock blocks
- Inspection during construction by a geotechnical / geologic specialist for placement of bolts is required
- Excavate the granular fill material behind the barrier curb and grade towards the toe of slope to provide a larger catchment capacity

- The use of lacing wire or a breakaway system at the bottom of the draped mesh portion of the hybrid barrier system may be considered during Preliminary Engineering

See Appendix L for two manufacturers' hybrid systems.

3. Area D

As discussed in Section III, a risk assessment was conducted for Area D and the report (see Appendix N) considered five mitigation alternatives including:

I. No Action – Accept the current risk.

II. Removal / Reinforcement – Scaling, trim blasting, and rock bolting of the cliff-forming outcrop above the talus slope.

III. Protection – Excavating and reinforcing the toe of the talus slope to create an enlarged catchment area.

IV. Protection – Rockfall control fences located upslope of the existing barrier.

V. Protection – Combination of Alternative III and IV.

Detailed descriptions and comparisons with related figures of these alternatives are included in Appendix N. A plan showing the location of the different alternatives can be found in Appendix L.

B. Traffic Analysis

As stated in Section VI.F below, it is not feasible to improve the roadway geometry along with the rockfall mitigation work in this project, so there will be no change in the traffic pattern in the proposed condition. Therefore, the traffic analysis below focuses on the traffic during the construction. The Route I-80 westbound roadway consists of two travel lanes. Since it is not feasible to close down Route I-80 for a prolonged period of time for construction, the traffic analysis for all alternatives will focus on the impact generated by a single lane closure, right shoulder closure, and intermittent shut-down.

Throughout this section, the term "vphpl" stands for "vehicles per hour per lane," a measure of density. The term "pcephpl" stands for "passenger car equivalents per hour per lane." The concept of using passenger car equivalents (pce) is explained in Section IV of this report. For analysis purposes, density and volume are expressed in terms of pcephpl to normalize for the effect of trucks on traffic flow.

Suggested shoulder, lane, and roadway closure hours for Route I-80 westbound in the project area were provided by NJDOT in a July 2, 2010 memorandum included in Appendix L. Suggested lane and roadway closure hours are shown in Table 8. According to the memorandum, "Shoulders may be closed at any time during the day, but should be open from 6:00 AM to 9:00 AM and 3:00 PM to 7:00 PM for morning and evening rush hours."

Table 8 – Suggested Westbound Closure Hours (NJDOT)

Day(s)	Lane Closures	Roadway Closures
Monday-Thursday	8 pm – 6 am next day (Tue-Fri)	11 pm – 5 am next day (Tue-Fri)
Friday	9 pm – 8 am Sat	11 pm – 6 am Sat
Saturday	9 pm – 9 am Sun	11 pm – 6 am Sun
Sunday	9 pm – 6 am Mon	11 pm – 5 am Mon

In the course of determining theoretical roadway capacities, several sources were consulted as described in this section. Some of these sources expressed westbound volumes in terms of vphpl. In order to convert vphpl to pcephpl to determine roadway capacities, the daily average of 14% trucks was used along with the pce factor of

1.5 for heavy vehicles. The use of the daily average was determined after consideration of other average truck percentages, such as during lane closure hours only or during the middle of the overnight period.

As shown in Appendix D, weekday overnight westbound truck percentages were recorded to be as high as 60% to 65% during individual hours from 2 am to 6 am. However, these high truck percentages occurred during the hours of lowest total volume and were 200 to 300 vehicles per hour. Even using a truck percentage of 60% and a volume of 300 vehicles per hour, the volume would be 390 pce per hour, which is well under the capacity of a single lane of traffic and thus would not affect the results of queue analysis. In contrast, the hours at the beginning and end of the allowable overnight lane closure periods, such as 9 pm to 12 am on Fridays, had westbound truck percentages recorded to be from 4% to 14%. The use of a higher truck percentage during these hours would affect queue analysis results because the volumes are at or over 1,000 vehicles per hour and thus closer to the capacity of a single lane of traffic.

During weekday AM and PM peak periods, no lane or shoulder closure may be in place. The roadway capacity is therefore taken as 2,250 pcephpl, corresponding to a free flow speed of 55 mph as described in Section IV of this report.

To determine the theoretical capacity of a work zone on Route I-80 with a lane drop resulting in one lane open out of two total lanes, several prior studies were consulted as described below. The presence of the lane drop creates turbulence at and leading up to the merge point, which is the constraint on capacity through the work zone. Where applicable, it was assumed that lane width would remain 12 feet or greater through the work zone and that there would be a high level of work zone activity during lane closure hours. More details on the factors that are applied by each study's methodology are provided in Appendix D.

- Table 6-1 of the 1994 Highway Capacity Manual[6] cites an average capacity of 1,340 vphpl specifically for a two-lane roadway with one lane open through the work zone. Table 6-2 notes a range of observed capacities from 1,100 vphpl for pavement marker work (which is adjacent to travel lanes and done in the roadway) to 1,500 vphpl for barrier and guiderail installation or repair (which is farther from the travel lanes and done to the side of the roadway). Because rockfall mitigation is farther from the travel lanes and done to the side of the roadway, the high end of the range of observed capacities at 1,500 vphpl is considered appropriate for this project, which is equivalent to <u>1,605 pcephpl</u> using the daily average of 14% trucks.
- Chapter 22, page 22-7 of the HCM2000[4] cites an average capacity of 1,600 pcephpl for all short term work zones. The HCM2000 notes that capacity varies by up to 10% depending on work zone intensity. Because rockfall mitigation is not performed directly in the roadway adjacent to travel lanes, it would not be intense work, but the use of cranes and having personnel on rock faces may still be distracting. Therefore, capacity is adjusted upward by a marginal factor of 2% to <u>1,632 pcephpl</u>, but not the full 10% for work of lowest intensity.
- Chapter 8 of Benekohal et al.[7] applies a work zone reduction to free flow speed to determine capacity. As shown in Appendix D, the algorithm follows these steps:
  - The Route I-80 free flow speed is assumed to be 55 mph, or 5 mph above the posted speed limit as per accepted traffic engineering practice.
  - The right lane and shoulder closure would close 16 feet of roadway to travel, and equipment such as parked vehicles and cranes would use approximately 10 feet of that space to operate.

[6] Transportation Research Board, Highway Capacity Manual, 3rd Edition, 1994.

[7] Benekohal, Rahim, et al., "Evaluation of Construction Work Zone Operational Issues: Capacity, Queue, and Delay," 2003.

Therefore, the lateral clearance from the travel lane to the active work zone is assumed to be 6 feet. Assuming the maximum number of workers and equipment (15) allowed by the methodology, the intensity factor of the work zone is given by WIr = 15 / 6 = 2.5.

  - The reduction in free flow speed is given by SRL = 11.918 + 2.6766 * ln (WIr), which yields a reduction of 14.4 mph for an operating speed of 40.6 mph.
  - Figure 8-2 translates this operating speed into a work zone capacity, Cu_{o}, of approximately 1,630 pcephpl.

- Sarasua et al.[8] cites base capacities of 1,750 pcephpl when two or more lanes are open through a work zone and 1,425 pcephpl when one lane is open before adjusting for the type, intensity, length, and location of work zone activity. The adjustment factor varies from -146 to +146. Because rockfall mitigation is farther from the travel lanes and done to the side of the roadway, the high end of the range is considered appropriate for this project, which is equivalent to 1,571 pcephpl.
- Kim et al.[9] cites a base capacity of 1,857 vphpl and applies subtractive reductions:
  - -168 vphpl per closed lane and an additional -37 vphpl for a right lane closure
  - -9 vphpl per percentage of heavy vehicles, or -126 for the daily average of 14% trucks
  - +93 vphpl per foot of lateral clearance to barrier, which is assumed to be 1 foot
  - -34 vphpl per mile of work zone, or -68 vphpl for an closure that is assumed to be 2 miles long due to the horizontal geometry of Route I-80
  - The resultant capacity would be 1,551 vphpl, which is equivalent to 1,660 pcephpl using the daily average of 14% trucks.

The average of the five studies used to determine work zone capacity is 1,620 pcephpl using the underlined values, which is taken as the capacity of a short-term work zone with one lane closed out of two total lanes in the constrained Delaware Water Gap area of Route I-80.

In summary, the assumed westbound roadway capacity of Route I-80 is 4,500 pce/hr during weekday peak periods when there are no closures and 1,620 pce/hr during hours when there is a westbound right lane and shoulder closure.

Should overnight westbound roadway (both lanes) closures be required due to an unforeseen event, traffic would be detoured using the existing incident management route of the Portland-Columbia Bridge, to PA Route 611, back to Route I-80 in Delaware Water Gap. Hourly roadway volumes on these detour roadways should be obtained during the Preliminary Engineering phase of the project to allow capacity analysis of the westbound roadway closure. The analysis would assume that the full reserve capacities of these roadways would be available based on implementation of proper traffic control and the possible deployment of police traffic directors in certain locations.

[8] Sarasua, Wayne A., et al., "Development of a Methodology to Estimate the Interstate Highway Capacity for Short-Term Work Zone Lane Closures," SC Department of Transportation, 2005.

[9] Kim, Taehyung, et al., "A New Methodology to Estimate Capacity for Freeway Work Zones," 2000.

The queuing analysis was conducted according to FHWA methodology[10] and the worksheets are presented in Appendix D. The following assumptions were employed:

- Work zone length of 2 miles
- Westbound right lane / shoulder closure during NJDOT suggested hours (see Table 8)
- Lane width no less than 12 feet
- Posted work zone speed limit of 40 mph, 10 mph below the normal posted speed limit
- Work zone operating speed of 45 mph (posted speed limit plus 5 mph as per accepted traffic engineering practice)

It was also assumed that traffic would not divert from Route I-80 to other alternate routes just to avoid queuing when a lane is closed; in other words, the existing volume demands on Route I-80 would remain through the work zone. Potential alternate routes were examined to justify their exclusion from the queuing analysis:

- Portland-Columbia Bridge to PA Route 611
- US Route 46, Riverton-Belvidere Bridge, to PA Route 611
- NJ Route 94 and/or County Route 521, US Route 206, County Route 560, Dingmans Bridge, to US Route 209
- NJ Route 94 and/or County Route 521, US Route 206 and Milford-Montague Toll Bridge, to US Route 209

The alternate route following the Portland-Columbia Bridge to PA Route 611 is the existing designated incident management route and the proposed detour route for full roadway closures of Route I-80 westbound, should a closure be necessary due to an unforeseen event. In the event that Route I-80 is closed for a long-term period due to an unforeseen event and the Portland-Columbia Bridge is used as a detour route, appropriate traffic management steps would be taken to maximize the capacity of the detour. However, when Route I-80 westbound is open and there are no traffic management strategies employed, it is assumed that this alternate route would not be used by high volumes of queue-avoiding traffic for the following reasons:

- The capacity of the Portland-Columbia Bridge is limited by the number of lanes open at the toll plaza, which is a maximum of three westbound lanes
- Traffic continuing on PA Route 611 back to Route I-80 must make a left at a stop sign after exiting the bridge, which conflicts with through traffic on PA Route 611 northbound
- The route passes through residential and commercial areas in the towns of Portland and Delaware Water Gap
- There is only one lane on most of this route, except for a passing zone on Route 611 northbound
- Trucks with 102-inch wide trailers are prohibited from this part of Route 611 and would have to continue west to Route I-80 via PA Route 512 to PA Route 33, making the trip lengthy and time consuming.

[10] Walls, James III and Michael R. Smith. Life-Cycle Cost Analysis in Pavement Design, Chapter 3, "Work Zone User Costs." Report No. FHWA-SA-98-078, September 1998, FHWA.

The last three potential detour routes were excluded from queuing analysis for several reasons:

- The bridges are several miles south or north of the Route I-80 corridor, adding 20 to 60 miles of driving compared to staying on Route I-80
- The weight limits on the Riverton-Belvidere and Dingmans Bridges are 8 tons and 4 tons respectively, limiting those routes to cars only
- US Route 209 prohibits commercial vehicles north of Route I-80 and East Stroudsburg
- These routes would traverse narrow, curved, and hilly roadways passing through residential areas such as Belvidere and Newton, NJ

To conduct the queuing analysis, it was assumed that when demand exceeds capacity, traffic would queue in two lanes. Caution must be exercised in applying the queue lengths from this analysis to real world expectations, both along Route I-80 and along intersecting highways, due to the complex Interchange 4 to the east of the project area. Also note that Route I-80 westbound has three lanes east of the Delaware River Viaduct railroad bridge (Lackawanna Cut-Off), which may shorten the queue length but not the time to traverse the queue.

Because the DRJTBC data has been normalized to average annual hourly traffic volumes, the queue analysis was also run with volumes 15% higher to replicate summer weekends. The result of the analysis using NJDOT suggested lane closure hours for every day of the week is that queues would be expected on Friday nights, with the maximum queue length (time and distance) occurring between 10 pm and 12 am. Detailed queue analysis is presented in Appendix D and summarized below.

- Fall, Winter, Spring – Using annual average hourly volumes, the queue would last from 9:00 pm to approximately 12:25 am. Maximum queue length would be 3.4 miles and would take 30 minutes to traverse.
- Summer – Using annual average hourly volumes plus 15%, the queue would last from 9:00 pm to approximately 1:25 am. Maximum queue length would be 5.7 miles and would take 45 minutes to traverse.

Traffic volumes on all days were analyzed to determine the lane closure hours that would maximize the opportunity to close the westbound right lane and shoulder while keeping the risk low of potential queue formation. To determine the recommended westbound lane closure hours, a 10% buffer was established under the capacity of 1,620 pcephpl for a short-term work zone with one lane closed, yielding a buffered flow rate of 1,460 pcephpl. The use of a 10% buffer roughly corresponds to the threshold between Levels of Service (LOS) 'D' and 'E'. That threshold is the limit of traffic flow characteristic of LOS 'D', described in Chapter 13 of the HCM2000[4] as a condition where traffic maneuverability is more limited but there is still some ability to absorb minor traffic disruptions. The 10% buffer accounts for several factors:

- Daily variations in traffic flow
- Changes in level and type of work zone activity from day to day and between work stages
- Minor disruptions such as, but not limited to:
    - Emergency vehicle activity (driving or stopped)
    - Vehicles merging or changing lanes
    - Construction vehicles accessing the work area

The 10% buffer does not account for seasonal variation. Data shows that winter and summer volumes are as much as 15% lower or higher, respectively, than the annual hourly average volumes. Therefore, a second set of recommended westbound lane closure hours was developed for summer months. The recommended lane closure hours shown in Table 9 are based on volume analysis using the 10% buffered flow rate of 1,460 pcephpl outside the summer season (September 15 to May 15) and an additional 15% reduction (25% total) to 1,215 pcephpl during the summer season (May 16 to September 14) to account for summer volumes being 15% higher than the annual average. Note that these closures would not be implemented during holidays or high traffic days such as Pocono Raceway event weekends.

Table 9 – Recommended Westbound Lane Closure Hours

Day(s)	Allowable Fall, Winter, Spring Closures – 9/15 to 5/15	Allowable Summer Closures – 5/16 to 9/14
Monday-Thursday	8 pm – 11 am next day (Tue-Fri)	9 pm – 9 am next day (Tue-Fri)
Friday	11 pm – 8 am Sat	11 pm – 8 am Sat
Saturday	7 pm – 9 am Sun	8 pm – 9 am Sun
Sunday	6 pm – 11 am Mon	7 pm – 10 am Mon

The average westbound truck percentages during these allowable lane closure periods vary from 5%-6% during the Saturday-Sunday overnight period to 24%-26% during weekday overnight periods, for an overall average of 21% during all closure periods. This is more than the 14% daily average that was used to convert capacities determined from prior studies in terms of vphpl to capacities in terms of pcephpl. However, as previously stated in describing the methodology, the "fringe" hours of the closure with the highest volumes also have the lowest truck percentages, at or below the average 14%. Therefore, using truck percentages closer to 21% would penalize these "fringe" hours and may reduce the apparent availability of westbound lane closures.

Comparing the recommended lane closure hours in Table 9 to the suggested hours in Table 8, twenty-eight (28) more hours would be available for westbound closures each week during fall, winter and spring:

- Thirty (30) more allowable hours for right lane and shoulder closures:
  - 6-11 am Monday-Friday
  - 7-9 pm Saturday
  - 6-9 pm Sunday
- Two (2) more restricted hours with no right lane closures:
  - 9-11 pm Friday

Thirteen (13) more hours would be available for westbound closures each week during summer:

- Nineteen (19) more allowable hours for right lane and shoulder closures:
  - 6-10 am Monday
  - 6-9 am Tuesday-Friday
  - 8-9 pm Saturday
  - 7-9 pm Sunday
- Six (6) more restricted hours with no right lane closures:
  - 8-9 pm Monday-Thursday
  - 9-11 pm Friday

The recommended hours would allow westbound right lane and shoulder closures of at least 9 hours in length every day, and at least 12 hours in length on all days except Friday-Saturday overnight. It would be permissible to maintain a one-lane westbound work zone through the weekday morning rush hour due to the predominantly eastbound traffic split.

The allowable roadway closure hours presented in Table 8 were also reviewed. Based on the traffic volumes provided by the DRJTBC, it is recommended to shift the allowable roadway closure hours later to minimize diverted traffic volumes. For example, the average annual volume from 11-12 pm on Friday night is 1,119 pcephpl. The recommended hours for full roadway closures would preserve the same number of hours per week if full closures are considered for implementation (See below). Note that full closures would be of short duration (10 – 15 minutes) during rock scaling operations only and would allow residual queues to clear before a subsequent short term closure is implemented. No long term closures are expected unless an unforeseen event requires it.

- 12:00 am to 6:00 am Monday-Friday
- 12:00 am to 7:00 am Saturday-Sunday

C. Hydrology & Hydraulic Analysis

As described in Section III, a concrete drainage ditch runs parallel to the Route I-80 roadway in each of Areas A and B. The drainage ditch in Area A collects surface runoff from the rock slope and conveys it to an existing cross drain that discharges the drainage into Delaware River. Although the drainage ditch in Area B contains sediment that blocks the way to the nearest cross drains, the original intent is expected to have been the same as the ditch in Area A. In Areas C and D, the overland runoff appears to infiltrate into the ground behind the concrete barrier as the top of the barrier was set higher than the ground behind it. There is no report of flooding in the project area according to the NJDOT Drainage Unit of the Division of Design Services.

Note that none of the alternatives described in the earlier section proposes new pavement or impervious area. Therefore, the amount of flow generated by the drainage areas to the project site will remain the same in the final condition. For Areas A and B, Alternative II involves constructing a rock catch fence between the existing stacked stone wall and the existing ditch. The drainage flow and pattern will not be altered. In Alternative III, where the existing ditches are impacted by the proposed improvements, they will be re-graded to maintain the existing flow. Storm inlets will be proposed at the end of the ditches so that the surrounding area may be re-graded flat for access by maintenance crews. None of the alternatives in Areas C and D will change the existing drainage pattern. It is expected that storm runoff will continue infiltrating into the ground behind the concrete barrier.

As discussed earlier, it was observed on the site that water is puddling in the right shoulder of the westbound roadway near M.P. 1.15. This is due to water seeping through the concrete barrier. This condition can be corrected by installing an underdrain behind the concrete barrier to intercept the water. As the objective of this project is rockfall mitigation, drainage improvements would be limited to those that are caused by the proposed rockfall mitigation measures.

D. Right-of-Way Impacts and Review

The existing right-of-way plans were reviewed for the project area and are shown in Appendix B. It appears that the alternatives listed for Areas A and B will fall within the existing right-of-way of Route I-80. Right-of-way impacts are not anticipated in these areas.

Alternative III for Area C may extend beyond the existing right-of-way and may require access easements for construction. Alternatives II and IV for Area D will extend beyond the existing right-of-way; a construction easement will be required for Alternative II and parcel acquisition or construction and maintenance easements will be necessary for Alternative IV. Alternatives I, III, and V will be entirely within the existing right of way. If the Preliminary Preferred Alternative incorporates an alternative that extends beyond the state's right-of-way, the area of easements or parcel taking will be developed in the next phase of design. See "Improvement Plan Area D" in Appendix L for the plan showing the ROW impact.

E. Constructability and Staging Plans and Detour Plan

There is no constructability fatal flaw in any of the alternatives considered. A constructability comparison among all the alternatives in each area is provided in the Preliminary Preferred Alternative (PPA) section.

All of the proposed rockfall mitigation measures considered can be constructed with a right lane and right shoulder closure during the allowable lane closure hours discussed in the Traffic Analysis section above.

Following consultation with geotechnical staff and concept review of constructability concerns, the following methods for maintenance of traffic were considered:

- Westbound right lane and shoulder closure during weekday and weekend overnight hours, maintaining two (2) eastbound lanes and one (1) westbound lane
- Westbound roadway closure during limited weekday and weekend overnight hours, maintaining two (2) eastbound lanes and diverting westbound traffic via the Portland-Columbia Bridge to PA Route 611
- Westbound shoulder closure during off-peak, overnight, and weekend hours, maintaining two (2) lanes of traffic in each direction at limited locations as described below

Most of the rockfall mitigation work will require a westbound right lane and shoulder closure. On certain occasions, such as scaling operations, a closure of the entire westbound roadway may be required, and, in limited occasions, a westbound shoulder closure only may be permissible. There are no eastbound closures anticipated; any work that may impact the eastbound lanes would be accomplished using police slowdowns. Note that during high-traffic weekends such as Pocono Raceway event weekends, westbound shoulder and lane closures may be suspended due to traffic volumes. Regional events should be identified during the Preliminary Engineering and Final Design phases and included in the table of weekends on the Maintenance and Protection of Traffic plans indicating when these closures will not be permitted.

To account for an instance when an unforeseen event requires a complete shut-down of Route I-80, a detour route through PA Route 611 may be implemented with appropriate traffic management steps to maximize the capacity of the detour. As indicated in the Traffic Analysis section, there is an approved detour route, officially designated as Diversion Route 80W-7 in the Warren County Diversion Book. Also, DRJBTC has recently diverted traffic using this detour route when four toll lanes were closed due to the ORT project. NJDOT may consider pre-setting the detour signs and keeping them covered so that the detour is ready for use at any time. This detour route is not a desirable alternate for Route I-80 without the appropriate traffic management steps due its local characteristics; therefore, the detour route is recommended for emergency use only. See the previous Traffic Analysis section for a detailed discussion.

The westbound shoulder of Route I-80 within the project area is predominantly 4 feet wide as shown in the as-built plans in Appendix B. This width would not be appropriate to store or temporarily stop vehicles, discharge personnel or equipment, or perform any work without a simultaneous closure of the adjacent right travel lane. The implementation of shoulder only closures would be limited to locations immediately adjacent to the rock slope where the shoulder is 12 feet wide; just beyond the eastern and western limits of the project. However, this would require workers to walk along the 4-foot wide shoulder in order to access locations along all parts of the work areas. Considering the traffic volumes, roadway geometry and potential for nighttime work activities, it is not recommended that shoulder only closures be incorporated into the project.

The standard winter shutdown, as designated by the Department, is expected during the construction phase due to snow and ice events typically experienced in this part of the state.

F. Controlling Substandard Design Elements and Reasonable Assurance

Although there are several controlling substandard design elements in the project area as discussed in Section III, it was determined that any improvements to correct the substandard roadway features would involve extensive effort and time during the Preliminary Engineering phase. This effort would include the following:

- To remove the substandard inner and outer shoulders, the westbound roadway needs to be widened a total of 8 feet. This would require obtaining a Stormwater Management permit, construction of retaining walls, incorporating stormwater best management practice devices, and reconstruction of the existing drainage system and lighting system.
- To remove the substandard horizontal sight distance and substandard minimum radii, the roadways would need to be re-aligned and reconstructed. This would require construction of retaining walls, cutting back the rock slope, obtaining a Stormwater Management permit, incorporating stormwater best management practice devices, reconstruction of the existing drainage system and the existing highway lighting system. These improvements would extend beyond the limits of this project and potentially involve the auxiliary lanes at Exit 2.

One goal of this project, as noted in Section II, is to implement cost effective roadway improvements that are related to the recommended rockfall mitigation measures which would reduce or eliminate CSDEs. None of the recommended rockfall mitigation measures will present the opportunity to also reduce or eliminate CSDEs. Therefore, this secondary benefit cannot be obtained as part of this project.

G. Construction Cost Estimate

Preliminary cost estimates were prepared for the proposed alternatives previously described in this section. The following tables show the alternative cost comparisons for each designated area. Cost estimate backup information for Areas A, B, and C can be found in Appendix M. Cost estimate backup information for Area D can be found in Appendix N.

Table 10 – Cost Comparison for Areas A & B

ITEM	*COST*
Areas A & B Improvements	
Alternative I – No Action	***$0***
Alternative II – Rock Catch Fence	***$327,200***
Alternative III – Heightened Barrier	***$463,346***

Table 11 – Cost Comparison for Area C

ITEM	*COST*
Areas C Improvements	
Alternative I – No Action	***$0***
Alternative II – Mesh on Lower Slope	***$424,280***
Alternative III- Mesh on Both Slopes	***$1,336,200***
Alternative IV – Rock Catch Fence	***$132,000***
Alternative V – Hybrid System	***$2,156,127***

Table 12 – Cost Comparison for Area D

ITEM	*COST*
Areas D Improvements	
Alternative I – No Action	***$0***
Alternative II – Reinforce Source of Rockfall	***$680,000***
Alternative III – Modify Catchment Area	***$926,333***
Alternative IV – Rock Control Fence	***$875,000***
Alternative V – Modify Catchment Area and Rock Control Fence	***$870,111***

H. Value Engineering Study and Report

Value Engineering was not part of the scope of this project. A value engineering review is not necessary for this type of project.

I. Life Cycle Cost Analysis

Life Cycle Cost Analysis was not part of the scope of this project. Life Cycle Cost Analyses are typically performed for pavement design and are not applicable to this project.

J. Alternative Matrix

A comparison of the alternatives in each area is shown on the following pages.

Table 13 – Comparison Matrix for Area A & B Mitigation Alternatives

Option	Description	Risk Reduction	Outside Right-of-Way	Required Ongoing Maintenance	Construction Impact	Construction Difficulty	Construction Duration (days)		Cost ($1,000)		Aesthetic Impact
							Low	High	Low	High	
I	No Action	None	No	Status Quo	None	None	0	0	$0	$0	Low
II	Rock Catch Fence	High	No	Moderate	Moderate	Moderate	35	60	$262	$393	Low
III	Heightened Concrete Barrier Curb with Energy Dissipation	High	No	Low	Moderate to High	Moderate	50	75	$371	$556	Moderate

Color Key:

Desirable	Neutral	Undesirable

Notes:

1. **Risk Reduction –** Subjectively compares the amount of risk that can be mitigated with each proposed mitigation.
2. **Right-of-Way –** Options I, II, and III will remain within the NJDOT Right-of-Way.
3. **Required Maintenance** is a subjective assessment of the degree to which the proposed mitigation requires ongoing periodic maintenance by highway operations personnel.
4. **Construction Impact** relates to the degree to which traffic will be impacted by the specific construction option.
5. **Construction Difficulty** relates to how difficult the proposed mitigation would be to construct, considering access, working conditions, and type of equipment and skills needed.
6. **Construction Duration** is an estimate of the days required for actual work assuming 10-hour days.
7. **Costs** were developed from recent unit prices modified for the site-specific conditions.
8. **Aesthetic Impact** is a subjective assessment of the degree to which the mitigation measures will be noticeable by park users and by the traveling public.

Table 14 – Comparison Matrix for Area C Mitigation Alternatives

Option	Description	Risk Reduction	Outside Right-of-Way	Required Ongoing Maintenance	Construction Impact	Construction Difficulty	Construction Duration (days)		Cost ($1,000)		Aesthetic Impact
							Low	High	Low	High	
I	No Action	None	No	Status Quo	None	None	0	0	$0	$0	None
II	Anchored or Draped Mesh on Lower Slope	Low	No	Moderate	Moderate	Moderate	25	40	$339	$509	Moderate
III	Rock Bolts and Anchored Mesh on Upper and Lower Slopes	Moderate	Yes	Moderate	Moderate	Moderate	40	60	$1,069	$1,603	High
IV	Rock Catch Fence	Low	No	High	Moderate	Low	15	25	$106	$158	Low
V	Hybrid System	High	No	Low	Moderate	Moderate	30	45	$1,567	$2,351	High

Color Key: Desirable | Neutral | Undesirable

Notes:

1. **Risk Reduction –** Subjectively compares the amount of risk that can be mitigated with each proposed mitigation.
2. **Right-of-Way –** Option III may be outside NJDOT Right-of-Way and may require access easements for construction.
3. **Required Maintenance** is a subjective assessment of the degree to which the proposed mitigation requires ongoing periodic maintenance by highway operations personnel.
4. **Construction Impact** relates to the degree to which traffic will be impacted by the specific construction option.
5. **Construction Difficulty** relates to how difficult the proposed mitigation would be to construct, considering access, working conditions, and type of equipment and skills needed.
6. **Construction Duration** is an estimate of the days required for actual work assuming 10-hour days.
7. **Costs** were developed from recent unit prices modified for the site-specific conditions.
8. **Aesthetic Impact** is a subjective assessment of the degree to which the mitigation measures will be noticeable by park users and by the traveling public.

Table 15 – Comparison Matrix Area D Mitigation Alternatives

Option	Description	Risk Reduction	Outside Right-of-Way	Required Ongoing Maintenance	Construction Impact	Construction Difficulty	Construction Duration (days)		Cost ($1,000)		Aesthetic Impact
							Low	High	Low	High	
I	No Action	None	No	Status Quo	None	None	0	0	$0	$0	None
II	Removal / Reinforce	Low	Yes	Low	Moderate	Moderate	67	87	$562	$966	Low
III	Modify Catchment	Moderate	No	Moderate	Moderate	Moderate	90	120	$705	$1,267	Moderate
IV	Fence(s)	High	Yes	High	Low	High	54	91	$649	$1,104	High
V	Catchment / Fence Hybrid	Highest	No	Moderate	Moderate	Moderate	120	150	$713	$1,260	High

Color Key:	Desirable	Neutral	Undesirable

Notes:

1. **Risk Reduction** refers to subjective comparison with current risk. Low = 10 to 30% reduction, Moderate = 20 to 40% reduction, High = 30 to 50% reduction.
2. **Right-of-Way –** Option II and IV are judged to be outside NJDOT Right-of-Way and would require access easements for construction.
3. **Required Maintenance** is a subjective assessment of the degree to which the proposed mitigation requires ongoing periodic maintenance by highway operations personnel.
4. **Construction Impact** relates to the degree to which traffic will be impacted by the specific construction option.
5. **Construction Difficulty** refers to site conditions that are unusual, for example the requirement to drill and grout anchors in the coarse talus for the fence option.
6. **Construction Duration** is an estimate of the days required for actual work assuming 10-hour days.
7. **Costs** were developed from recent unit prices modified for the site-specific conditions.
8. **Aesthetic Impact** is a subjective assessment of the degree to which the mitigation measures will be noticeable by park users and by the traveling public.

K. Discussions with Subject Matter Experts

Mr. John Jamerson from the NJDOT Geotechnical Engineering unit has been regularly consulted throughout the preparation of this report. Mr. Jamerson has also attended all the field investigations noted. Meeting minutes, telephone conversations, and e-mails recording major decisions have been documented in Appendix I.

L. Preliminary Preferred Alternative (PPA)

This section presents recommendations for rockfall mitigation for each area. A plan showing the Preliminary Preferred Alternative and conceptual sketches of the proposed rockfall mitigation can be found in Appendix L. Preliminary engineering, final design, and preparation of contract plans and specifications will be performed in the subsequent phases of the project.

A program of cost effective rockfall mitigation measures was developed which will meet the stated goal of removing this location from the listing of High Priority locations in the Rockfall Hazard Management System. The NJDOT has not provided an amount of reduction required in the Rockfall Hazard Rating following construction. The Rockfall Hazard Rating is the sum of nine categories: Slope Height, Ditch Effectiveness, Average Vehicle Risk, Sight Distance, Roadway Width, Geologic Character, Block Size, Climate, and Rockfall History. At the initiation of the project, the NJDOT Geotechnical Engineering Unit determined that large-scale rock removal would not be feasible given that the site is located in the Delaware Water Gap National Recreation Area, the roadway width is limited, and there is a lack of suitable long-term alternate parallel routes for Route I-80's traffic. This decision limits mitigation to alter only the "Ditch Effectiveness" category of the Rockfall Hazard Rating System. As per the NJDOT inventory, the Ditch Effectiveness was rated between 10 and 90 points at the four distinct areas of concern, which leaves a range of impact the proposed mitigation will have on the rating values.

The Rockfall Hazard Rating System is a generic and subjective system intended for relative risk ranking of sites, which does not have a means to account for the improvement provided by the proposed protection. Thus, while the proposed mitigation measures will result in an appreciable safety increase, this increase may not be reflected by a corresponding improvement in the Rockfall Hazard Rating score, due to the realities of the site geometry and the minimal impact that these measures will have on said geometry. Site-specific engineering studies override the ranking system as outlined in Section 8.1 of the FHWA's Rockfall Hazard Rating System User Manual, wherein slopes that have been modified by construction may be removed from the RHRS inventory. The NJDOT should consider removing this site from their inventory following construction because the proposed protection will be constructed to resist a design rockfall event, which will be determined by geologic studies and rockfall simulation modeling in a later phase of this project.

The factors considered for the recommended rockfall mitigation in each designated area include the rockfall history, slope geometry, geology, height of the rock slope, steepness of slope, past impacts to traffic, and the width of the existing catchment areas.

NJDOT maintenance had indicated that the existing stacked stone wall currently appears to be leaning and has crushed or blocked the drainage pipes. Refer to the NJDOT communication in Appendix I. Furthermore, a rockfall event could gain enough momentum to break the stacked stone wall and the stone from the wall could fall onto the highway. Therefore, it is recommended that the stacked stone wall be removed.

Throughout the entire project area, the recommended improvements include the removal of accumulated rockfall at the toe of slope. Specific alternative comparison and recommendations for each area are provided below.

1. Areas A and B

Risk Reduction

Alternative I will accept the current risk. Alternatives II and III would both be capable of preventing an assumed design rockfall event determined from rockfall simulation modeling performed in a subsequent phase. As part of this future analysis, the rock catch fence alternate (Alternative II) would be checked for deflection to ensure secondary impact to the stacked stone wall would not occur, which would remain in place for this alternative.

Outside Right-of-Way

Alternatives I, II, and III will remain within the NJDOT Right-of-Way.

Required Ongoing Maintenance

Alternative I will result in no change in maintenance efforts as they exist today. Both Alternatives II and III will require rockfall to be collected from behind the barrier or fence. Alternative II will be more difficult since access behind the fence will be even more limited than currently exists, and long reach equipment may need to be utilized to reach over the existing stacked stone wall and fence to remove rockfall collected behind the fence. The use of this equipment will require a lane closing and greater impact to traffic. In addition, Alternative II leaves the stacked stone wall in place, which may require additional maintenance if stones become dislodged. Alternative III would include improved access behind the barrier, minimizing the difficulty of maintenance and impact to traffic.

Construction Impact

Alternative I will have no impact to traffic. Alternative II can be constructed primarily from behind the existing stacked stone wall but will require lane closings to deliver equipment and materials to the work area. Alternative III will require lane closings for the majority of the construction duration, resulting in a greater impact to traffic during construction.

Construction Difficulty

Getting equipment behind the stacked stone wall to drill post holes for Alternative II is considered moderately difficult to construct. Removal of the stacked stone wall and existing barrier are tedious tasks, which make Alternative III the most difficult to construct.

Construction Duration

The construction duration was estimated assuming 10-hour days. Low and high values were provided. See Table 13 for Construction Durations and Appendix P for the Construction Timeline and Assumptions.

Cost

Costs were developed from recent unit prices modified for site specific conditions. Details of the assumptions are provided in Appendix M. See the Construction Cost Estimate section for the costs.

Aesthetic Impact

Alternative I will have no aesthetic impact. Alternative II will be located behind the existing stacked stone wall, and will not be visible by park users and by the traveling public. Alternative III will be visible by park users and by the traveling public; however, a concrete casting form liner and colorizing additive in the concrete are proposed to provide similar texture and color of the existing stacked stone wall.

Preliminary Preferred Alternative

The trees and existing barrier curb with stone wall provide some rockfall mitigation; however, it is recommended that additional measures are necessary to adequately mitigate the potential rockfall events, and prevent secondary impact from the stacked stone wall and existing barrier. **Alternative III - the**

installation of a concrete barrier curb with 42 to 72 inch height and sacrificial timber lagging attached to the back for energy dissipation is recommended. This concrete barrier curb will replace the existing barrier curb and stone wall. To allow maintenance access behind the barrier to remove rockfall, the existing concrete drainage ditch in Area B will be removed and both Area A and B will be re-graded to accommodate access and adequate drainage. It should be reiterated that the most recent rockfall event occurred in Area B, reinforcing the need for mitigation and the higher concrete barrier curb. Also of note, one area of rock extremely close to the roadway at the eastern reach of area B may need to be cut back to allow for the proposed barrier. See Appendix L for a cross section view.

Rock cleaning will be event-driven as the rockfall events do not happen at a steady frequency. According to a telephone conversation with Scott Sheldon of NJDOT, the maintenance crew removes rock from the site approximately once every eighteen months.

In addition, some clearing of trees will likely be required. Seasonal restrictions and permitting for tree clearing will be addressed in the Preliminary Engineering phase.

2. Area C

Risk Reduction
Alternative I provides no reduction to current risk. Alternative II will reduce the risk of rockfall generated from the lower slope from reaching the roadway, but will provide no reduction of risk of rockfall generated from the upper slope. Alternative III will reduce the risk of rockfall generated from both the upper and lower slopes. Alternative IV will reduce risk of rockfall generated from the lower slope, but may not be capable of mitigating the risk from the upper slope; therefore, a shorter fence was assumed for cost purposes. Alternative V will provide the greatest mitigation of rockfall by addressing the potential sources of both the upper and lower slopes.

Outside Right-of-Way
The only alternative which may extend beyond the NJDOT Right-of-Way is Alternative III.

Required Ongoing Maintenance
Alternative I maintains the current level of maintenance efforts associated with removing rock from the roadway and maintaining the existing catchment area. Alternative V is anticipated to require the least maintenance, which would include the removal of rockfall from toe of slope. Alternatives II and III will require moderate maintenance as rockfall may need to be removed from behind the mesh at the toe of slope and components of the mesh systems will need to be maintained and periodically replaced. Alternative IV will require the most maintenance given rockfall will accumulate at the toe of slope and the fence will make it more difficult to access.

Construction Impact
Alternative I presents no impact to traffic. Alternatives II, III, IV, and V will all have similar impacts to traffic as their construction will be equally visible, of similar duration, and require intermittent to long-term shoulder and lane closures.

Construction Difficulty
Alternative IV will be the least difficult to construct. Alternatives II, III, and V are all considered to be of moderate construction difficulty given they will all require working on the slope.

Construction Duration
Alternative IV will require the shortest construction duration. Alternatives II, III, and V will require similar moderate construction durations. The construction duration was estimated assuming 10-hour days. Low

and high values were provided. See Table 14 for Construction Durations and Appendix P for the Construction Timeline and Assumptions.

Cost

Alternative IV is the lowest cost alternative. Alternative II is a moderate cost alternative, and Alternatives III and V are the highest cost alternatives. Cost analysis assumptions are included in Appendix M.

Aesthetic Impact

Alternative I will have no aesthetic impact and Alternative IV will have a low aesthetic impact as it will only block the toe of slope. Alternative II will have a moderate aesthetic impact because it will cover the lower slope. Alternatives III and V will have a high aesthetic impact because they will cover or block both the lower and upper slopes.

Preliminary Preferred Alternative

A hybrid system (Alternative V) is recommended for Area C, as it provides the best rockfall risk reduction. In conjunction with this proposed mitigation, it is assumed for the purposes of this document that the replacement of the existing barrier is part of the PPA in sections A, B, and D, so the barrier will also be reconstructed through Section C.

Minor surface scaling is also recommended to remove any loose rocks from the vertical face. This scaling will provide the following benefits:

- It will minimize the amount of future rockfall
- It will help protect workers while installing the hybrid system

The scaling work is anticipated to be dental type work and will be performed by hand with a rock bar. Any significant mechanical scaling performed would be at the direction of the resident engineer. Rock bolts and shotcrete should be placed as contingency items in the contract for further reinforcement.

The eastern edge of Area C (approximately M.P. 1.32 to M.P. 1.35) initially appears to be effectively protected by the existing gabion wall. However, the top of the gabion retains a vegetated soil slope. The depth to rock under the soil could not be determined. Fallen rock was observed on the slope and top of the gabion wall. Therefore, the hybrid system is recommended to extend through this portion of Area C as well.

3. Area D

As discussed in the risk assessment report, Alternative V – Combination of rock control fence and excavating with reinforcement to the existing talus slope to create an enlarged catchment area is recommended. This Alternative yields the highest rockfall mitigation with no right-of-way impact, and moderate construction impact and difficulty. See the risk assessment report in Appendix N for a detailed description of the alternative.

To perform final design, it is recommended that detailed survey of the rock slope be obtained. In addition, borings spaced at 50 feet along Area D should be taken at the toe of slope in the talus area to determine the depth of rock and obtain rock cores for unconfined compressive strength testing.

4. Lighting

Street lighting will be replaced as part of the proposed improvements because the existing lighting is integrated into the existing concrete barriers that will be removed. Field reconnaissance revealed that the concrete barrier segments may be specially formed to integrate with the lighting. Field inspection shows that a separate segment (approximately 1' long) is integrated with the light poles while another separate segment (approximately 4'-5' long) is integrated with the accompanying junction boxes. Despite the separation of the barrier with lighting and the regular barrier, it is expected that the lighting and the wiring would be impacted and require replacement as a result of the proposed rockfall mitigation work.

5. Maintenance and Access

The rockfall mitigation equipment, including the extended concrete barrier and the hybrid system, generally do not require scheduled maintenance or repair unless a large-scale rockfall occurs. Therefore, the maintenance work in the project site is limited to the occasional removal of the accumulated rocks from the rock catch fence and the hybrid system in Area C. This can be performed in several different ways including:

1. Using a long reach excavator situated on the Route I-80 westbound roadway to reach over the concrete barrier.
2. Accessing the back of the rock catch fence with a backhoe going around the ends of the fence.
3. A combination of 1 and 2.

Currently, NJDOT maintenance crews access the catchment area in Area A from the rest area near M.P. 0.95. It is expected that the crews will be able to do the same in the proposed condition. Areas C and D may be accessed from the beginning of the concrete barrier near M.P. 1.48. Minor tree clearing will be required to create a path for a backhoe to travel behind the barrier toward Area D. See the Design Influence Plan in Appendix E for an illustration of the access points.

The rock removal can be performed on an event-driven basis or on a fixed-time cycle. Since the rate of rockfall varies, there is no optimum rock removal frequency. NJDOT maintenance crews currently clean up the site once every 18 months. It is recommended that NJDOT maintain the current frequency initially after the construction of the mitigation and make future adjustments as necessary.

6. Drainage

It is recommended that an underdrain be installed behind the proposed concrete barrier as necessary to intercept water seeping through the concrete barrier. A proposed underdrain should resolve the puddling problem in the right shoulder near M.P. 1.15 and prevent the same problem from happening elsewhere.

7. Maintenance of Traffic during Construction

Maintaining traffic is a critical issue on this project due to the fact that it is an interstate highway with high traffic volumes. To minimize the potential for queuing, it is recommended to apply the lane closure hours listed in Table 9, subject to approval by NJDOT Division of Traffic Operations. The recommended hours for intermittent roadway shut-downs are 12:00 am to 6:00 am Monday-Friday and 12:00 am to 7:00 am Saturday-Sunday.

Although the recommended lane closure hours are calculated to maintain a low potential for queuing while maximizing available closure hours, it is still possible that queues may form. The use of ITS technology to communicate construction and delay information to drivers or to collect work zone volume and speed data should be considered during the Preliminary Engineering and Final Design phases of the project.

Note that additional restrictions for holidays and special events may be imposed for certain hours or days depending on the nature of the traffic expected. Special events would include, but are not limited to, NASCAR/ARCA races held three times per year at the Pocono Raceway that may draw approximately 100,000 patrons.

8. Cost Estimate

The following table summarizes the preliminary cost estimate for the PPA.

Table 16 – Cost Estimate for Preliminary Preferred Alternative

ITEM	*QUANTITY*	*UNIT*	*UNIT COST*	*COST*
Mobilization	*1*	*LS*	*$150,000.00*	*$150,000*
Performance & Payment Bonds	*1*	*LS*	*$15,000.00*	*$15,000*
Liability Insurance	*1*	*LS*	*$10,000.00*	*$10,000*
Progress Schedule	*1*	*LS*	*$6,000.00*	*$6,000*
Field Office	*1*	*Unit*	*$40,000.00*	*$40,000*
Construction Layout	*1*	*LS*	*$25,000.00*	*$25,000*
Final Cleanup	*1*	*LS*	*$7,500.00*	*$7,500*
Clearing Site	*1*	*LS*	*$15,000.00*	*$15,000*
Areas A & B Improvements				*$463,346*
Area C Improvements				*$2,156,127*
Area D Improvements				*$870,111*
Light Poles and Junction Boxes	*15*	*Unit*	*$6,000.00*	*$90,000*
Traffic Control and Staging				*$270,000*
Underdrain	*2200*	*LF*	*$40.00*	*$88,000*
Contingency Items (5% of subtotal)				*$208,415*
			Total	*$4,414,499*
			Say	***$4,415,000***

To perform Preliminary Engineering, it is recommended that:

- Probe drilling is performed to determine thickness of talus deposits for entire length of Area D. Assume two holes on sections every 50 feet in Area D.
- Core drilling is performed to obtain samples for laboratory testing for intact compressive strength of rock beneath the talus and for talus fragments in Area D.
- Detailed rockfall simulation analyses to optimize size, location, height, and impact capacity of catchment area and barrier, in all areas.
- Helicopter reconnaissance and ground reconnaissance of the cliff to confirm that no major potential instabilities are present.
- Slope stability analyses to evaluate interim and final stability factors.
- Development of specifications for grout and shotcrete that are matched to site conditions for Area D.
- A digital terrain model (DTM) with maximum 2-foot contour interval is developed through LiDAR methods.

M. Preliminary Engineering Scope Statement Form

The Preliminary Engineering Scope Statement Form is located in Appendix O.

SECTION VII - CONCEPT DEVELOPMENT RECOMMENDATION

The project need is confirmed and it is recommended that this project be presented to the CPC Screening Committee to obtain approval to advance this study to Preliminary Engineering.

It is recommended that the following rockfall mitigation measures are implemented ($4.38M construction cost):

- <u>Area A:</u> **Alternative III –** the installation of a concrete barrier curb with 42 to 72 inch height and sacrificial timber lagging attached to the back for energy dissipation is recommended.
- <u>Area B:</u> **Alternative III –** the installation of a concrete barrier curb with 42 to 72 inch height and sacrificial timber lagging attached to the back for energy dissipation is recommended.
- <u>Area C:</u> **Alternative V –** a hybrid system is recommended, as it provides the best rockfall risk reduction.
- <u>Area D:</u> **Alternative V –** combination of rock control fence and excavating with reinforcement to the existing talus slope to create an enlarged catchment area is recommended.

The following project costs are estimated:

Approximate Preliminary Engineering Cost	$460,000
Approximate Final Design Cost	$225,000
Right-of-Way Cost	$0
CE Support during Construction	$40,000
Construction Cost	$4.415M

This project is included in the FY2012-2021 Draft State Transportation Improvement Program (STIP), page 31 of 34. PE funding will be addressed through the ERC line item (DB #X152); PE in FY 2012, FD in FY 2013, and Construction funding is provided in FY2015 (DB #09545).

A. Federal Highway Administration (FHWA) Approval of Report

FHWA reviewed the preliminary Concept Development Report and the associated Comment Resolution Summary (CRS). In an e-mail dated 8/12/2011, FHWA requested incorporation of the items discussed in the CRS into the final report and a copy provided for their files, thus providing concurrence on the CRS and approval of the report.

B. Capital Program Screening Committee (CPSC) Recommendation

To be provided once completed

C. Capital Program Committee (CPC) Approval

To be provided once completed

APPENDIX A

PROBLEM STATEMENT /
PURPOSE AND NEED STATEMENT

NEW JERSEY DEPARTMENT OF TRANSPORTATION
MEMORANDUM

TO: Kuang-Yu Yang
Geotechnical Engineering

FROM: Thomas A. Wospil, Director
Capital Investment Planning and Development

DATE: February 24, 2009

SUBJECT: Route 80 WB, MP 1.04- MP 1.35 – DB Number 09545
Townships of Hardwick & Knowlton, Warren County
Problem Statement - Rockfall Mitigation

We received the Problem Statement submitted by your office covering the above referenced location. We recognize that the referenced location is ranked the highest priority within the System, therefore, would you please present this to the CPC to be assigned to the appropriate pipeline.

Attachment
C: Brian Strizki
John Jamerson
Bob Harris
Howard Immordino
Karen Stalcup-Finch

New Jersey Department of Transportation

Transportation Problem Statement

PLEASE SEND THIS COMPLETED FORM TO:
THOMAS WOSPIL, CAPITAL INVESTMENT PLANNING & DEVELOPMENT
NJ Department of Transportation, P.O.Box 600, Trenton, NJ 08625-0600

The following information is to be completed by the Division of Capital Investment Planning & Development:

DB Number:

Legislative District:

Congressional District:

Program Category:

Information contained on this form has been verified by ______________________________

LOCATION (To be completed by initiator)

Route (if applicable): I-80 WB

Mileposts (if applicable): 1.04 – 1.35

Structure number (if applicable): NA

Limits: Four (4) Sites from MP 1.04 to MP 1.35

County(s): Warren

Municipality(s): Hardwick Township & Knowlton Township

DESCRIPTION OF PROBLEM (to be completed by initiator)

NOTE: Please attach related correspondence, map of the area, and other appropriate support material.

Check those items that best describe the problem:

Existing Highway

_____ Capacity problem

_____ Operational problem

__X__ Physical condition problem

__X__ Safety problem

_____ Other (specify)

Existing Bridge

_____ Capacity problem

_____ Physical condition problem

_____ Safety problem

Corridor/area Capacity Problem

_____ Need for corridor study

_____ Possible highway on new alignment

_____ Possible new transit line

_____ Need for park and ride development

DESCRIBE THE PROBLEM:

THE EXISTING ROCK CUTS ALONG THIS STRETCH OF ROUTE I-80, WHICH RANGE IN HEIGHT FROM 80' TO OVER 100', HAVE MANY LARGE OVERHANGS, LOOSE BOULDERS & ROCK BLOCKS WHICH HAVE THE POTENTIAL OF TOPPLING DOWN ONTO THE SHOULDER AND/OR TRAVEL LANES, THUS CREATING A SERIOUS SAFETY THREAT TO MOTORISTS. THIS PROBLEM IS CAUSED BY SUBSTANDARD ROCK CATCHMENT ZONES AT THE SITES (SEE ATTACHED PHOTOS).
IN THE PAST, THERE HAVE BEEN NUMEROUS REPORTS OF ROCKFALLS, SEVERAL OF WHICH HAVE RESULTED IN ROCK REACHING THE ROADWAY, AS WELL AS DAMAGING THE EXISTING BARRIER CURB.
RECOMMENDED REMEDIAL ACTION WOULD CONSIST OF ANALYSIS, DESIGN & INPLEMENTATION OF ROCKFALL MITIGATION MEASURES. THESE MEASURES MAY INCLUDE, BUT MAY NOT BE LIMITED TO: SCALING, ROCK BOLTING, WIRE MESH, AND ROCK CATCH FENCES.

THESE ROCK CUTS ARE CURRENTLY RANKED THE HIGHEST PRIORITY WITHIN THE DEPARTMENT'S ROCKFALL HAZARD MANAGEMENT SYSTEM.

If an outside group actively supports this problem, please identify:

Other comments (if any) by initiator:

Initiator (Please print or type): John Jamerson Project Engineer, Geology

Division: Design Services/Structural Engineering/Geotechnical Engineering

Date of Initiation: 2/3/09

Signature 2/3/09 2/4/2009

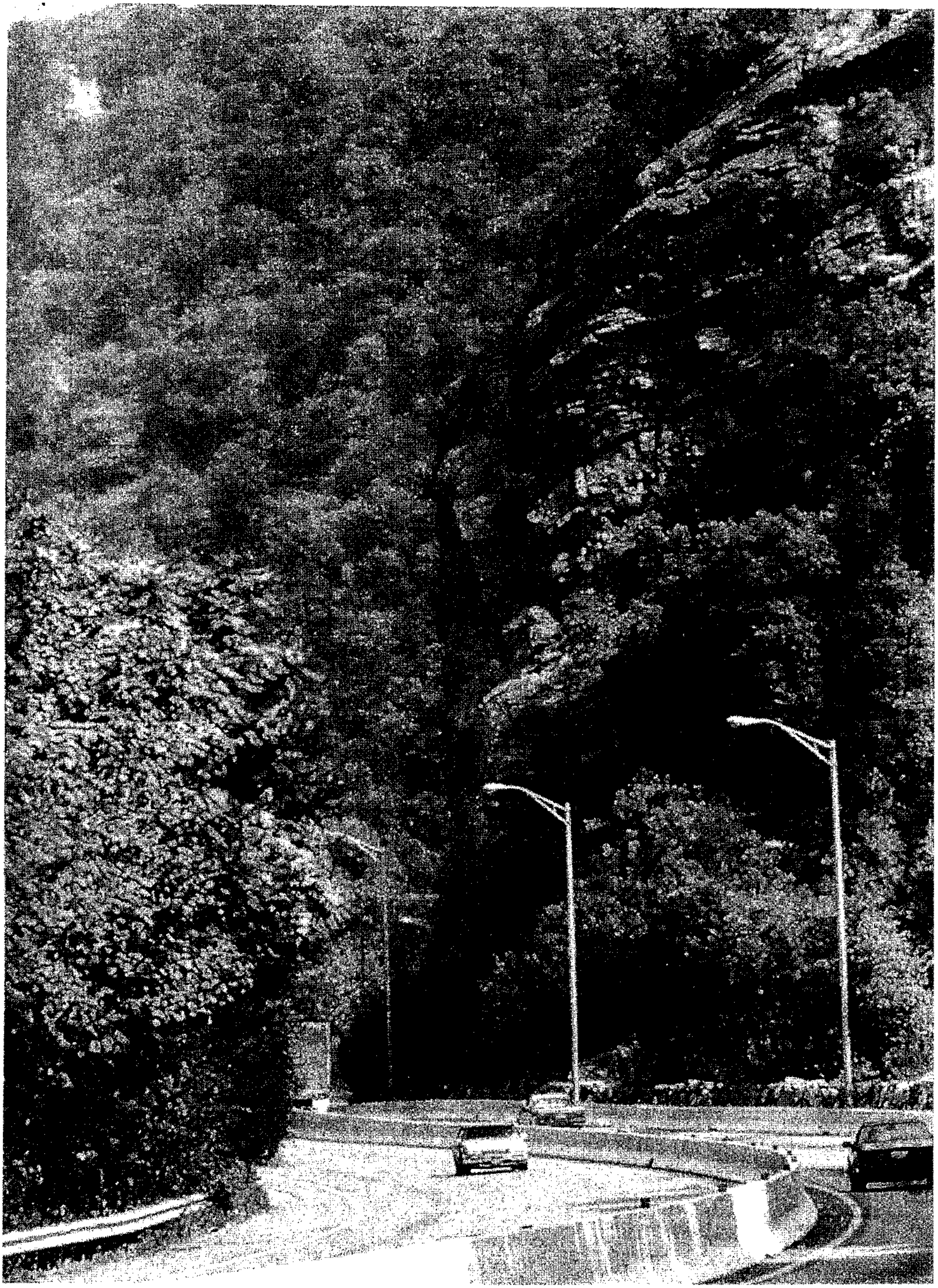
Concurrence by Division Director (Signature)

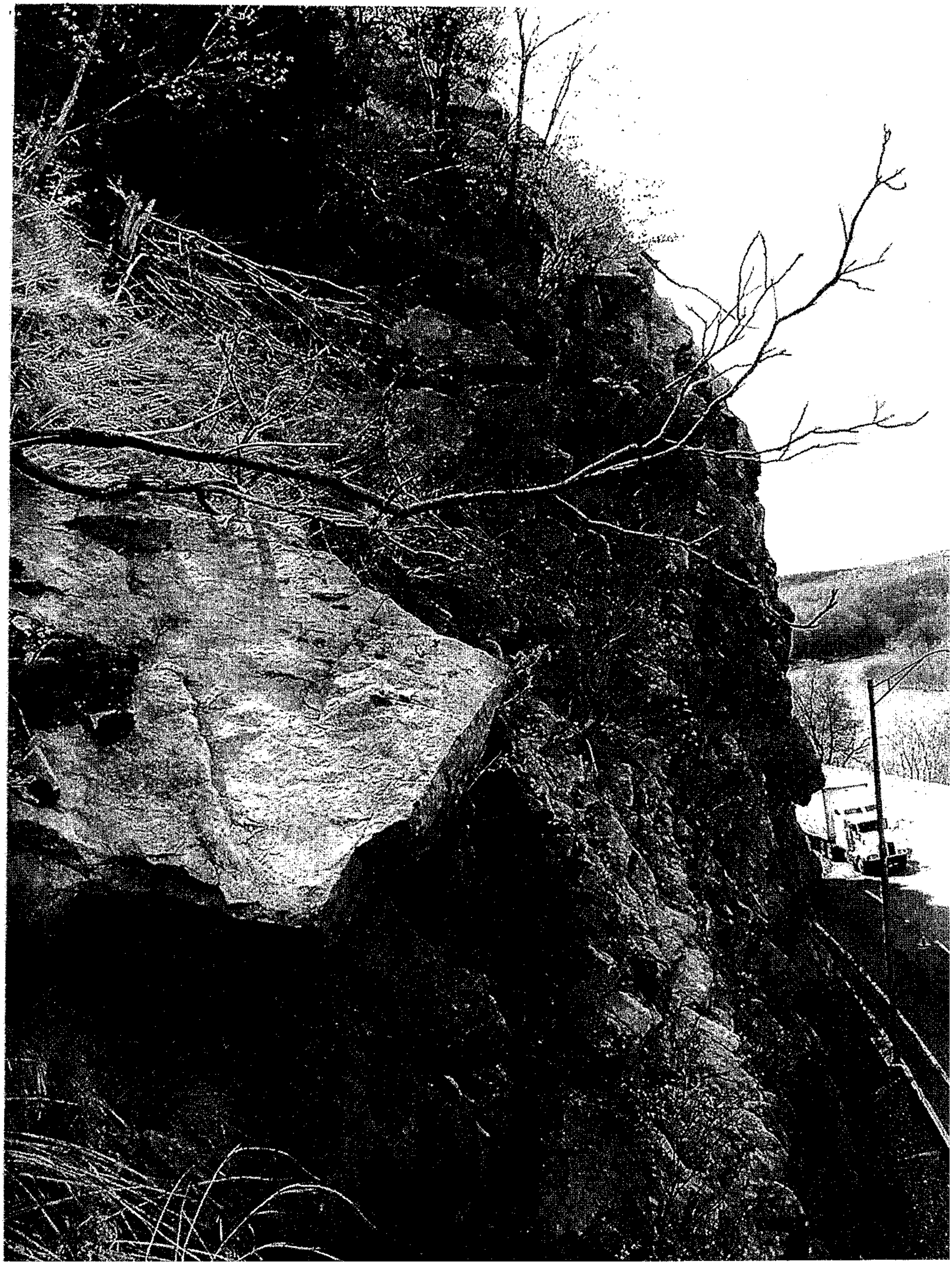
Date of Concurrence 2/17/09

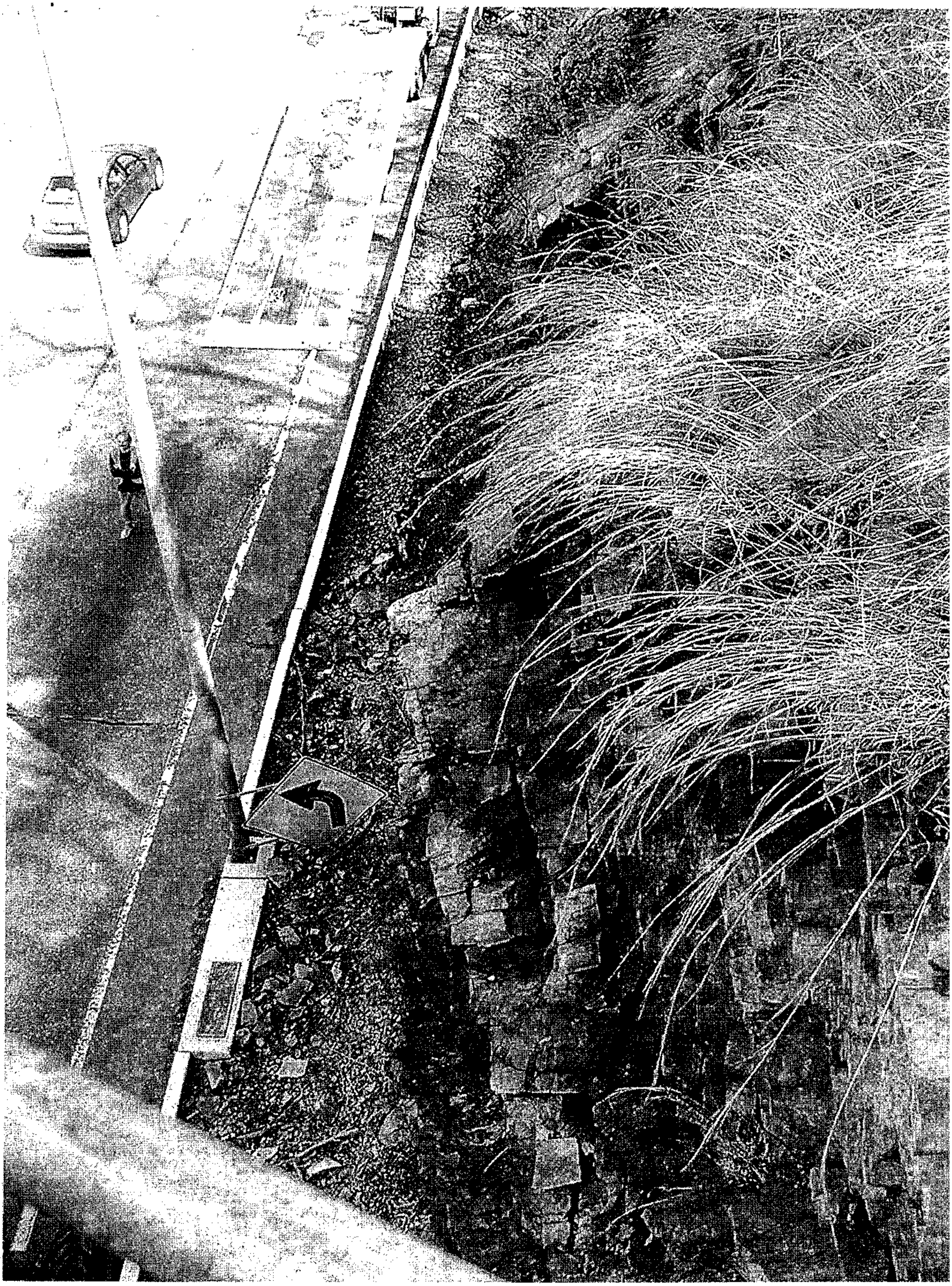
Attachment I

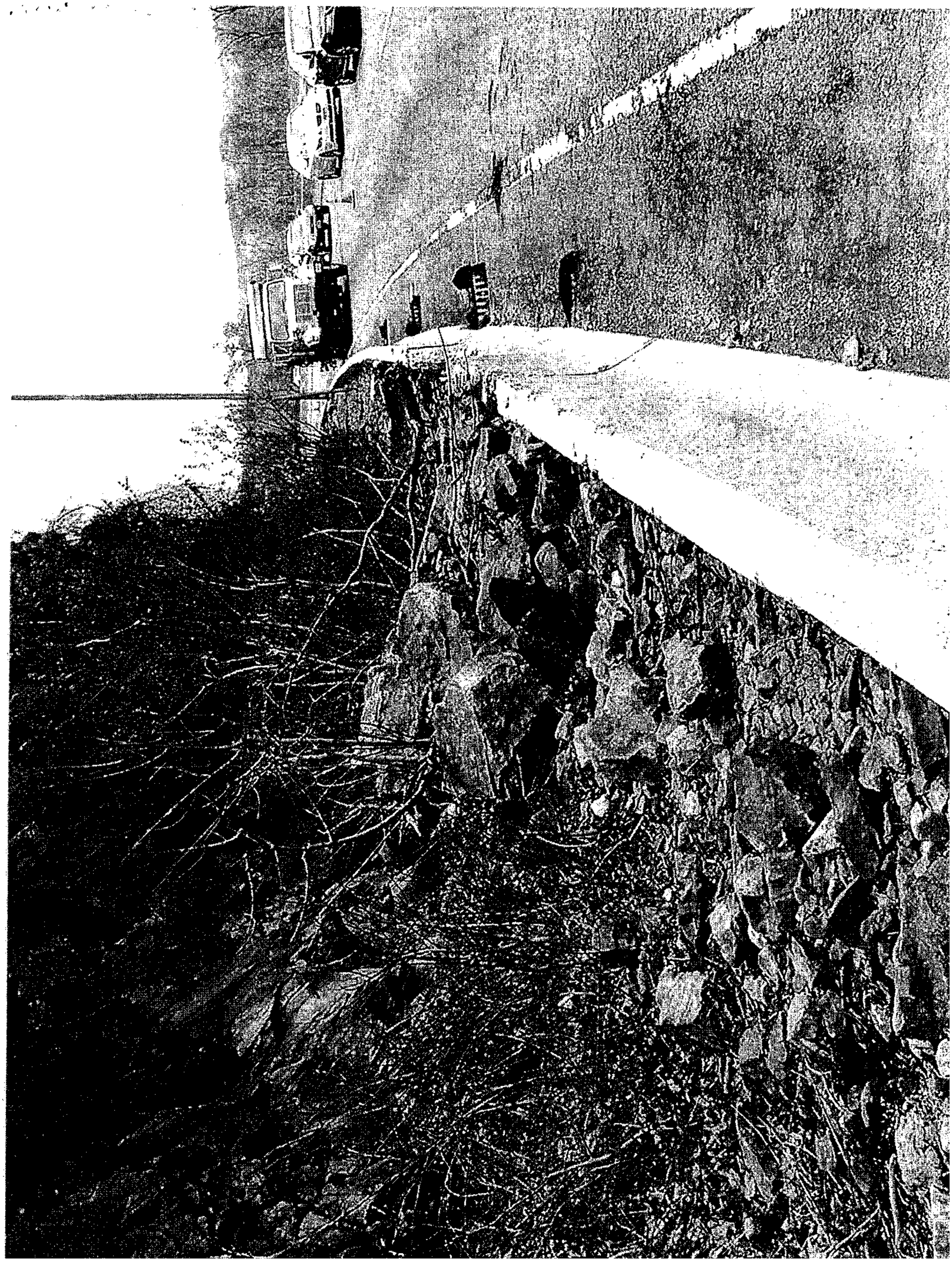
Information required on Transportation Problem Statements

- Concise statement of need
- Proposed concept and/or scope of work of a capital improvement project to address the identified need where appropriate
- Statement of the extent to which the proposed capital improvement project or removal of the identified deficiency would advance the Department's objectives as identified in the Capital Investment Strategy.
- Current traffic counts and accident rates, with respect to the following program categories: Bridge Rehabilitation and Replacement, Highway Rehabilitation and Reconstruction, Safety Intersection Improvements. (if available)
- Identification of individuals or groups who may be sponsoring or supporting the proposed project.
- Summary of identified environmental issues within the probable footprint of the proposed project, especially including the identification of any historic or potentially historic properties, historic or potentially historic structures, historic districts, and wetlands.









I-80 Rockfall Mitigation (Milepost 1.04 to 1.45)
Townships of Hardwick and Knowlton, Warren County

Purpose and Need Statement

Purpose

The purpose of the I-80 Rockfall Mitigation Milepost 1.04 to 1.45 project is to reduce the frequency and severity of rockfall events along Route I-80 within these milepost limits, such that this location can be removed from the NJDOT Rockfall Hazard Management System's listing of High Priority locations.

Need

The existing rock cut areas along the westbound direction of I-80 within the project limits exhibit large overhangs, steep vertical faces, loose boulders, and rock blocks, which have resulted in rock toppling down and landing on the shoulder and/or roadway lanes and washouts along the adjacent Route I-80 roadway. Documented instances of these occurrences have led to accidents caused by rock debris on the highway and have required lane closures and the deployment of NJDOT Maintenance forces to conduct cleanup activities. Traffic Operations North reported three (3) rockfall-related incidents between February 2003 and March 2008 within the project limits that resulted in lane closures:

- 8/13/04 5:18 AM to 6:06 AM: Two right lanes EB closed due to debris in roadway
- 4/15/07 5:59 PM to 7:42 PM: WB lanes closed due to wall collapse/mud slide. State Police were on site with a detour. Two (2) crashes (one EB and one WB) also occurred in this area at the time of this incident.
- 4/15/07 10:04 PM to 4/16/07 11:04 AM: Right lane WB closed due to washout.

NJDOT Bureau of Safety Programs crash data for January 2007 to December 2009 also shows that there are 81 crashes within the project limits for that period. This section of I-80 has a crash rate of 4.52 crashes/mvm, which is 58% greater than the statewide crash rate for the year 2009 of 2.86 crashes/mvm. There are substandard rock catchment zones along this section of I-80 that are believed to be a contributing factor in the problems. The rock catchment zones are too narrow because the rock slope is too close to the roadway. The catchment area widths vary in each rock cut area, ranging from no catchment area to approximately 40 feet wide.

Goals and Objectives

Goals and objectives for this project include:

- Implement cost effective rockfall mitigation measures that will address the stated purpose;
- Avoid, minimize and/or mitigate impacts to environmentally sensitive areas, including Federal and State parklands, wetlands, water resources, etc.;
- Minimize impacts to traffic during the construction phase;
- Implement where feasible, cost effective geometric roadway and drainage improvements, as related to the rockfall mitigation measures that will reduce or eliminate controlling substandard design elements.

APPENDIX B

AS-BUILT PLANS AND ROW PLANS

As-Built Plans used in this project include the following:

- Route 46 (1953) Section 1 Dunnfield to Columbia, Grading (May 1952). Layout and Key Map, Typical Sections, and Plan and Profile. Sheets 1, 4, and 6-7 of 131.
- Route 46 (1953) Section 1B Dunnfield to Columbia, Paving (February 1953). Layout and Key Map, Typical Sections, and Plan and Profile. Sheets 1, 4, and 6-7 of 84.
- Route 80 Section 1AB From Delaware River Toll Bridge to Vicinity of Route 94, Widening, Resurfacing and Safety Improvements (October 1976). Key Sheet, Typical Sections, Construction Plans, Profiles, and Tie and Grade Sheets. Sheets 1, 12, 22-23, 49-51, and 64-65 of 212.
- Route 80 Section 1AR From Vicinity of River Road Interchange to West of Knowlton Road (Co. Rt. 616), Concrete Slab Removal, Resurfacing and Related Safety Improvements (February 1993). Key Sheet, Typical Sections, and Construction Plans. Sheets 1, 11, and 19-20 of 79.
- Route I-80 From East of Delaware River to West of Knowlton Road, Contract No. 000053960, Resurfacing (October 2006). Key Sheet, Typical Sections, Construction Plans, and Traffic Striping Plans. Sheets 1, 13-14, 41-42, and 96-97 of 156.

Right-of-Way Plans used in this project include the following:

- Route 46 (1953) Section 1 (FREEWAY) Dunnfield to Columbia (May 1952). General Property Parcel Maps. Sheets 2-3 of 13.

These plans have been included on the attached disc as part of the report.

HNTB

Rockfall Mitigation of
Route I 80 Westbound
MP 1.04 to MP 1.45
Township of Hardwick
Warren County
Concept Development Report

Appendix B
As-Built Plans and ROW Plans

September 2011

APPENDIX C

CRASH DATA AND COLLISION DIAGRAM

State of New Jersey
Department of Transportation
1035 Parkway Avenue
CN 600
Trenton, New Jersey 08625-0600

CHRIS CHRISTIE
GOVERNOR

JAMES S. SIMPSON
COMMISSIONER

November 8, 2010

Laura Wolfe, Engineer
HNTB Corporation
Wayne Plaza I, Suite 400
145 Route 46 West
Wayne, NJ 07470-6830

RE: Crash Analysis
Route I-80 MP 1.04 – 1.45
Hardwick Township, Warren County

This is in reference to your request dated October 5, 2010, requesting this office to furnish the crash data for the above referenced location for the most recent three years.

CRASH DATA RELATIVE TO OVERREPRESENTATIONS:

The crash summary relative to overrepresentations for this section of Route I-80 for the period January 1, 2007, to December 31, 2009, is herewith attached. The percentages of those crash types and conditions that exceed 2009 statewide average values are indicated.

CRASH RATE:

Route	Mile Post	Cross-Section	Actual Crash Rate (Crashes/mvm.)	Statewide Crash Rate for Year 2009 (Crashes/mvm.)
80	1.04 – 1.45	4 or more lanes, barrier median without shoulder	4.52	2.86

The crash rate for this section of Route I-80 is above the statewide average crash rate for roadways with similar cross–section. Hence, a further review of the crash summary and details may be necessary. A review of the crash overrepresentations may provide an insight into any additional crash countermeasures that could be implemented to bring the crash rate more in line with the statewide average.

Also, enclosed are the Details of Motor Vehicle Accident Reports for the years 2007 through 2009 for the subject location.

If there are any further questions, please contact Mr. Geoffrey Gayanilo of this office at 530-4288.

Very truly yours,

Kevin M. Conover
Section Chief, Bureau of Safety Programs

KC:TZ:GG
Mail Log No. 192-10

Cc: Bhavesh Shah – Division of Project Development

CRASH SUMMARY

Route I-80 MP 1.04 - 1.45
Hardwick Township, Warren County
01/01/2007 THRU 12/31/2009

TOTAL CRASHES: 81

SEVERITY	COUNT	% OF TOTAL	2009 Average
Fatal	0	0.00%	
Injury	23	28.40%	22.43%
Property Damage	58	71.60%	
Total	81		

INTERSECTION	COUNT	% OF TOTAL	2009 Average	**
At Signalized Intersection	0	0.00%		
At Unsignalized Intersection	0	0.00%		
Between Intersections	81	100.00%	100.00%	
Railroad Crossing	0	0.00%		
Total	81			

COLLISION TYPE	COUNT	% OF TOTAL	2009 Average	**
Same Dir.-Rear End	13	16.05%		
Same Dir.-Sideswipe	11	13.58%		
Angle	0	0.00%		
Head On	0	0.00%		
Parked Vehicle	1	1.23%	0.55%	
Left Turn / U Turn	0	0.00%		
Backing	0	0.00%		
Encroachment	0	0.00%		
Overturned	1	1.23%		
Fixed Object	50	61.73%	30.01%	
Animal	0	0.00%		
Pedestrian	0	0.00%		
Pedalcycle	0	0.00%		
Non-Fixed Object	4	4.94%		
Unknown	0	0.00%		
Other	1	1.23%		
Total	81			

SURFACE CONDITION	COUNT	% OF TOTAL	2009 Average	**
Dry	24	29.63%		
Wet Surface	47	58.02%	27.15%	
Snow	5	6.17%	4.75%	
Ice	4	4.94%	2.46%	
Unknown	0	0.00%		
Other	1	1.23%		
Total	81			

LIGHT	COUNT	% OF TOTAL	2009 Average	**
Day	43	53.09%		
Dusk	1	1.23%		
Night	37	45.68%	28.97%	
Dawn	0	0.00%		
Unknown	0	0.00%		
Total	81			

Note:
** These columns indicate the number of fatal crashes in each accident category.

Length of Segment 0.41
Number of Years 3
AADT 39926

Crash Rate/MVM 4.52

2009 Statewide Crash Rate/MVM 2.86

NEW JERSEY DEPARTMENT OF TRANSPORTATION
BUREAU OF SAFETY PROGRAMS
DETAIL OF MOTOR VEHICLE ACCIDENTS
ON ROUTE 80
MILEPOST 1.040 TO 1.450
01/01/2007 TO 12/31/2009

ROAD SYS / D L N	COLLISION TYPE	VEHICLE 1 DIR TRAV / VEH TYPE, VEH ACTN	VEHICLE 2 DIR TRAV / VEH TYPE, VEH ACTN	WEA SUR	LITE	DATE	DOW	TIME	VEH 1 CONTRIB CIRCUMSTANCES	VEH 2 CONTRIB CIRCUMSTANCES	NO. KIL	NO. MAJ	INJURED MOD	INJURED MIN	N A
INTERSTATE	*RT 80*	*MP 001.04*	*NEAR FOREST AVE*				*HARDWICK TWP*			*WARREN*	*0*	*0*	*0*	*0*	
09004518	SAME DIR-SIDE	E- SUV-GOING STRT	E- SUV-CHNG LANES	CL/DR	DAY	11/27/08	THR	14:46	NONE-DRIVER/CYC	IMP LANE CHANGE	0	0	0	0	
INTERSTATE	*RT 80*	*MP 001.10*	*NOT AT INTERSECTION*				*HARDWICK TWP*			*WARREN*	*0*	*0*	*1*	*13*	3
07069143	NON-FIXED OBJ	W- SUV-GOING STRT	- -	CL/DR	DAY	03/03/07	SAT	09:20	OTH RDWAY FACTS	Debris	0	0	0	0	
07062765	SAME DIR-REAR	W- PASS-GOING STRT	W- PASS-GOING STRT	CL/DR	DAY	04/09/07	MON	16:15	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
07062764	SAME DIR-REAR	W- PASS-GOING STRT	W- PASS-GOING STRT	CL/DR	DAY	04/09/07	MON	16:20	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
07229343	SAME DIR-SIDE	E- PASS-NEG CURVE	E- PASS-NEG CURVE	RN/WT	DAY	10/09/07	TUE	15:55	DRI INATTENTION	NONE-DRIVER/CYC	0	0	0	0	
08067437	SAME DIR-REAR	W- PASS-GOING STRT	W-S2AXL-GOING STRT	SL/IC	DARK	03/09/08	SUN	01:20	RD SURF CNDTION		0	0	0	0	
08053755	FIXED OBJECT	W- SUV-NEG CURVE	- -	CL/IC	DARK	03/10/08	MON	02:55	RD SURF CNDTION		0	0	0	0	
08065366	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DARK	04/12/08	SAT	03:09	DRI INATTENTION		0	0	0	0	
08103689	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DARK	05/27/08	TUE	02:52	DRI INATTENTION		0	0	0	0	
08155210	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	06/04/08	WED	04:58	DRI INATTENTION		0	0	0	0	
08217540	FIXED OBJECT	W- PASS-NEG CURVE	- -	RN/WT	DARK	09/27/08	SAT	23:01	UNSAFE SPEED		0	0	0	0	
08233879	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	10/09/08	THR	05:55	DRI INATTENTION		0	0	0	2	
08233878	SAME DIR-REAR	E- PASS-GOING STRT	E- PKUP-GOING STRT	RN/WT	DAY	10/09/08	THR	07:16	DRI INATTENTION	NONE-DRIVER/CYC	0	0	0	1	
08242541	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DAY	10/27/08	MON	17:22	DRI INATTENTION		0	0	0	0	
08249992	FIXED OBJECT	E- SUV-GOING STRT	- -	CL/WT	DARK	11/06/08	THR	04:15	DRI INATTENTION		0	0	0	0	
08251169	FIXED OBJECT	E- PASS-NEG CURVE	- -	OC/WT	DAY	11/08/08	SAT	11:47	DRI INATTENTION		0	0	0	0	
08254748	SAME DIR-SIDE	E- PASS-NEG CURVE	E- PKUP-NEG CURVE	FG/WT	DARK	11/14/08	FRI	23:35	DRI INATTENTION		0	0	0	2	
08291859	FIXED OBJECT	E- PASS-GOING STRT	E-SEMIT-GOING STRT	CL/WT	DARK	11/15/08	SAT	20:23	DRI INATTENTION	UNKNOWN	0	0	0	0	
08265153	FIXED OBJECT	E- PASS-SLOW-STOP	- -	CL/WT	DARK	12/01/08	MON	18:06	DRI INATTENTION		0	0	0	0	
09118157	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DARK	06/03/09	WED	19:24	UNSAFE SPEED		0	0	0	0	
09148365	FIXED OBJECT	E- SUV-NEG CURVE	E- PASS-NEG CURVE	RN/WT	DAY	07/02/09	THR	07:41	DRI INATTENTION	NONE-DRIVER/CYC	0	0	0	2	
09192820	FIXED OBJECT	E- SUV-NEG CURVE	- -	RN/WT	DAY	08/28/09	FRI	08:42	UNSAFE SPEED		0	0	0	0	
09192825	FIXED OBJECT	E- PASS-GOING STRT	- -	CL/WT	DAY	08/29/09	SAT	09:07	UNSAFE SPEED		0	0	0	0	
09209279	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DAY	09/12/09	SAT	11:54	DRI INATTENTION		0	0	0	0	
09210370	FIXED OBJECT	E- SUV-GOING STRT	E- PASS-GOING STRT	RN/WT	DARK	09/16/09	WED	20:04	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	1	
09225479	FIXED OBJECT	E- SUV-NEG CURVE	- -	RN/WT	DARK	10/03/09	SAT	04:21	DRI INATTENTION		0	0	0	0	
09237517	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	10/15/09	THR	20:09	UNSAFE SPEED		0	0	0	0	
09248542	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DAY	10/18/09	SUN	11:19	DRI INATTENTION		0	0	0	1	
09248541	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DAY	10/18/09	SUN	07:48	DRI INATTENTION		0	0	0	2	
09248526	STR PK VEH	E- PASS-PARKED	E- SUV-GOING STRT	CL/DR	DAY	10/25/09	SUN	13:34	NONE-DRIVER/CYC	IMP LANE CHANGE	0	0	0	0	
09261814	SAME DIR-REAR	W-CV10K-SLOW-STOP	W- PASS-SLOW-STOP	CL/DR	DAY	10/30/09	FRI	15:45	DRI INATTENTION	NONE-DRIVER/CYC	0	0	0	0	
09249543	FIXED OBJECT	E- PASS-NEG CURVE	- -	OC/WT	DAY	10/31/09	SAT	11:48	DRI INATTENTION		0	0	0	0	
09261826	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	11/14/09	SAT	05:19	DRI INATTENTION		0	0	0	0	
09271914	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DAY	11/25/09	WED	12:01	FAIL TO KEEP RT		0	0	0	0	
09271913	SAME DIR-SIDE	E-SEMIT-PED OFF RD	E- PKUP-GOING STRT	RN/WT	DAY	11/25/09	WED	12:05	OTH DR/PED ACT	NONE-DRIVER/CYC	0	0	0	1	
09286760	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DAY	11/30/09	MON	12:45	UNSAFE SPEED		0	0	0	1	
09307589	FIXED OBJECT	E- PASS-GOING STRT	- -	CL/DR	DARK	12/23/09	WED	19:36	UNSAFE SPEED		0	0	0	0	

County-Municipality Restrictions: 1:

2:

Nov 12 2010 11:17 P.05

NEW JERSEY DEPARTMENT OF TRANSPORTATION
BUREAU OF SAFETY PROGRAMS
DETAIL OF MOTOR VEHICLE ACCIDENTS
ON ROUTE 80
MILEPOST 1.040 TO 1.450
01/01/2007 TO 12/31/2009

ROAD SYS D L N	COLLISION TYPE	VEHICLE 1 DIR TRAV VEH TYPE, VEH ACTN	VEHICLE 2 DIR TRAV VEH TYPE, VEH ACTN	WEA SUR	LITE	DATE	DOW	TIME	VEH 1 CONTRIB CIRCUMSTANCES	VEH 2 CONTRIB CIRCUMSTANCES	NO. KIL	NO. MAJ	INJURED MOD	MIN	N A
INTERSTATE	RT 80	MP 001.10	NOT AT INTERSECTION				HARDWICK TWP			WARREN	0	0	1	13	3
09306820	SAME DIR-SIDE	W-S2AXL-NEG CURVE	W- PKUP-NEG CURVE	CL/DR	DARK	12/27/09	SUN	22:50	NONE-DRIVER/CYC	DRI INATTENTION	0	0	1	0	
INTERSTATE	RT 80	MP 001.20	NOT AT INTERSECTION				HARDWICK TWP			WARREN	0	0	1	5	1
07069144	SAME DIR-REAR	W- PASS-STOP-TRAF	W- SUV-GOING STRT	CL/DR	DAY	03/03/07	SAT	09:27	DRI INATTENTION	NONE-DRIVER/CYC	0	0	0	0	
07299127	FIXED OBJECT	W- PASS-NEG CURVE	- -	RN/WT	DARK	12/29/07	SAT	02:22	DRI INATTENTION		0	0	0	0	
08026941	SAME DIR-REAR	W- PASS-GOING STRT	W- PASS-GOING STRT	RN/WT	DARK	02/06/08	WED	19:18	FOLLOW TO CLOSE	NONE-DRIVER/CYC	0	0	0	0	
08162006	FIXED OBJECT	E- PASS-GOING STRT	- -	CL/DR	DAY	08/02/08	SAT	20:30	DRI INATTENTION		0	0	0	0	
08180804	FIXED OBJECT	W- PASS-GOING STRT	- -	CL/DR	DAY	08/23/08	SAT	19:25	DRI INATTENTION		0	0	0	0	
08188875	SAME DIR-SIDE	E-SEMIT-CHNG LANES	E- PASS-GOING STRT	CL/DR	DARK	08/26/08	TUE	03:52	IMP LANE CHANGE	NONE-DRIVER/CYC	0	0	0	0	
08283902	FIXED OBJECT	W- SUV-GOING STRT	- -	OC/WT	DAY	12/15/08	MON	08:36	DRI INATTENTION		0	0	0	0	
08297587	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	12/16/08	TUE	23:53	DRI INATTENTION		0	0	1	0	
09003124	SAME DIR-SIDE	W- SUV-GOING STRT	W-SEMIT-GOING STRT	SN/SL	DAY	01/10/09	SAT	09:40	UNSAFE SPEED	NONE-DRIVER/CYC	0	0	0	0	
09199892	FIXED OBJECT	W- PASS-NEG CURVE	- -	RN/WT	DARK	08/29/09	SAT	01:58	UNSAFE SPEED		0	0	0	4	
09225486	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DAY	09/28/09	MON	15:57	DRI INATTENTION		0	0	0	0	
09225477	FIXED OBJECT	E- PASS-NEG CURVE	- -	OC/WT	DARK	10/03/09	SAT	03:36	DRI INATTENTION		0	0	0	0	
09306818	FIXED OBJECT	W- SUV-NEG CURVE	- -	RN/IC	DARK	12/25/09	FRI	04:25	DRI INATTENTION		0	0	0	1	
INTERSTATE	RT 80	MP 001.25	NOT AT INTERSECTION				HARDWICK TWP			WARREN	0	0	1	0	
08052437	FIXED OBJECT	W- PASS-GOING STRT	- -	CL/IC	DARK	03/06/08	THR	04:01	RD SURF CNDTION		0	0	1	0	
INTERSTATE	RT 80	MP 001.30	NOT AT INTERSECTION				HARDWICK TWP			WARREN	0	0	1	14	2
07125949	NON-FIXED OBJ	B- PASS-GOING STRT	- -	RN/WT	DAY	04/15/07	SUN	18:08	DEBRIS ON ROAD		0	0	0	0	
07068498	~~OTHER~~ NON-FIXED	W- PKUP-GOING STRT	- -	RN/WT	DAY	04/15/07	SUN	17:40	DEBRIS ON ROAD		0	0	0	0	
07220111	FIXED OBJECT	E- PASS-GOING STRT	- -	CL/DR	DARK	09/30/07	SUN	21:25	FAIL TO KEEP RT		0	0	0	0	
07234322	FIXED OBJECT	W-SEMIT-NEG CURVE	- -	CL/DR	DARK	10/14/07	SUN	05:14	UNSAFE SPEED		0	0	0	0	
07292943	FIXED OBJECT	E- PASS-GOING STRT	- -	SN/SN	DAY	12/04/07	TUE	09:10	DRI INATTENTION		0	0	0	1	
08019443	SAME DIR-REAR	W- PASS-SLOW-STOP	W- SUV-GOING STRT	CL/DR	DUSK	01/25/08	FRI	17:38	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
08049383	SAME DIR-REAR	W-PVLT9-GOING STRT	W- SUV-GOING STRT	CL/DR	DAY	02/21/08	THR	15:18	FOLLOW TO CLOSE	NONE-DRIVER/CYC	0	0	0	2	
08032527	SAME DIR-REAR	E- PASS-NEG CURVE	E- PASS-NEG CURVE	SN/SN	DARK	02/22/08	FRI	02:18	RD SURF CNDTION	NONE-DRIVER/CYC	0	0	0	0	
08183219	SAME DIR-SIDE	E- PASS-NEG CURVE	E- PASS-NEG CURVE	OC/WT	DAY	07/27/08	SUN	14:02	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
08193821	FIXED OBJECT	E-BOBTL-SLOW-STOP	- -	RN/WT	DAY	09/06/08	SAT	12:03	DRI INATTENTION		0	0	0	0	
08195860	FIXED OBJECT	E- PASS-GOING STRT	- -	OC/WT	DARK	09/13/08	SAT	00:11	DRI INATTENTION		0	0	0	1	
08206566	OVERTURNED	E- PASS-GOING STRT	- -	CL/DR	DARK	09/19/08	FRI	20:46	DRI INATTENTION		0	0	0	1	
08254747	FIXED OBJECT	W- PASS-NEG CURVE	- -	CL/WT	DAY	11/15/08	SAT	15:58	DRI INATTENTION		0	0	0	0	
08271452	~~OTHER~~ NON-FIXED	E- PASS-GOING STRT	W- PKUP-GOING STRT	CL/DR	DARK	12/02/08	TUE	16:34	NONE-DRIVER/CYC	WHEELS	0	0	0	0	
09003125	SAME DIR-REAR	W- SUV-SLOW-STOP	W- SUV-SLOW-STOP	SN/SN	DAY	01/10/09	SAT	09:45	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	5	
09003127	FIXED OBJECT	W- PASS-NEG CURVE	- -	SN/SN	DAY	01/10/09	SAT	08:25	DRI INATTENTION		0	0	1	0	
09017176	FIXED OBJECT	E- PASS-NEG CURVE	- -	CL/DR	DAY	01/22/09	THR	14:27	DRI INATTENTION		0	0	0	1	
09048665	FIXED OBJECT	E- PASS-NEG CURVE	- -	CL/DR	DAY	02/20/09	FRI	08:09	UNSAFE SPEED		0	0	0	1	

County-Municipality Restrictions: 1: 2:

NEW JERSEY DEPARTMENT OF TRANSPORTATION
BUREAU OF SAFETY PROGRAMS
DETAIL OF MOTOR VEHICLE ACCIDENTS
ON ROUTE 80
MILEPOST 1.040 TO 1.450
01/01/2007 TO 12/31/2009

ROAD SYS D L N	COLLISION TYPE	VEHICLE 1 DIR TRAV VEH TYPE, VEH ACTN	VEHICLE 2 DIR TRAV VEH TYPE, VEH ACTN	WEA SUR	LITE	DATE	DOW	TIME	VEH 1 CONTRIB CIRCUMSTANCES	VEH 2 CONTRIB CIRCUMSTANCES	NO. KIL	NO. MAJ	INJURED MOD	MIN	N A
INTERSTATE	*RT 80*	*MP 001.30*	*NOT AT INTERSECTION*				*HARDWICK*	*TWP*		*WARREN*	*0*	*0*	*1*	*14*	:
09167864	SAME DIR-SIDE	E- PASS-GOING STRT	E-SEMIT-GOING STRT	CL/DR	DAY	07/26/09	SUN	16:02	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
09167871	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DAY	07/31/09	FRI	14:12	DRI INATTENTION		0	0	0	2	
09225480	SAME DIR-REAR	W- PASS-SLOW-STOP	W- PASS-GOING STRT	CL/WT	DARK	10/02/09	FRI	19:53	NONE-DRIVER/CYC	DRI INATTENTION	0	0	0	0	
09271912	FIXED OBJECT	E- PASS-NEG CURVE	- -	RN/WT	DARK	11/25/09	WED	20:10	UNSAFE SPEED		0	0	0	0	
09286753	SAME DIR-REAR	E- PASS-NEG CURVE	E- PASS-NEG CURVE	RN/WT	DARK	11/25/09	WED	20:10	OTH RDWAY FACTS	FOLLOW TO CLOSE	0	0	0	0	
INTERSTATE	*RT 80*	*MP 001.40*	*NOT AT INTERSECTION*				*HARDWICK*	*TWP*		*WARREN*	*0*	*0*	*0*	*0*	
07255212	FIXED OBJECT	E- PASS-GOING STRT	- -	RN/WT	DARK	11/10/07	SAT	03:55	DRI INATTENTION		0	0	0	0	
07275681	FIXED OBJECT	E- PASS-GOING STRT	- -	OC/WT	DAY	11/20/07	TUE	15:11	DRI INATTENTION		0	0	0	0	
09011002	SAME DIR-SIDE	E- PASS-GOING STRT	E-SEMIT-CHNG LANES	CL/DR	DAY	01/17/09	SAT	11:23	NONE-DRIVER/CYC	IMP LANE CHANGE	0	0	0	0	
09011003	FIXED OBJECT	E- PASS-NEG CURVE	- -	SN/SN	DARK	01/19/09	MON	05:37	DRI INATTENTION		0	0	0	0	
09018784	OTHER	W-APWTR-GOING STRT	- -	CL/DR	DAY	01/25/09	SUN	07:50	VEH HITCH ETC		0	0	0	0	
09192811	SAME DIR-SIDE	W- PASS-SLOW-STOP	W- PASS-SLOW-STOP	CL/DR	DAY	08/19/09	WED	13:11	NONE-DRIVER/CYC	UNSAFE SPEED	0	0	0	0	

TOTAL 81

County-Municipality Restrictions: 1:

2:

Page 1 of 1 ☐ Fatal

New Jersey Police Crash Investigation Report

☒ Reportable ☐ Non-Reportable ☐ Change Report

1 Case Number	B020 2010 00648A
2 Police Dept of	STATE POLICE
Code	2
3 Station/Precinct	HOPE
4 Date of Crash (mm dd yy)	10 07 10
5 Day of Week (Su M Tu W Th F Sa)	Th
6 Time (use 2400 hrs)	2254
7 Municipality Code	2109
8 Total Killed	- -
9 Total Injured	- -
10 Crash Occurred On: Road Name	I80 WB
Dir	W
11 Speed Limit	50
12 Route No.	80
Suffix	
13 Milepost	1.2
14 / 15 / 16	☐ At Intersection with ☐ Feet ☐ Miles ☐ N ☐ S ☐ E ☐ W of:
17 Cross Road Name	
18 Speed Limit	
19 Ramp ☐ To: ☐ From:	
20 Route/Name	☐ NB ☐ SB ☐ EB ☐ WB
21 Latitude	40.97106
22 Longitude	75.12145

96	01
97	01
98	05
99	01
100	04
101	02
102	01
103	01
104	1
105	15
106	-
107	-
108	25
109	-
110	02
111	-
112	-
113	-
114	03
115	-
116	04
117	-
118a	52
118b	-
119a	-
119b	-
120	01
121	-
122	-
123	-
124	01
125	-
126	04
127	-
128a	39
128b	-
128c	-
128d	-
129a	-
129b	-
129c	-
129d	-
130	12
131	12
132	-
133	-

Vehicle 1

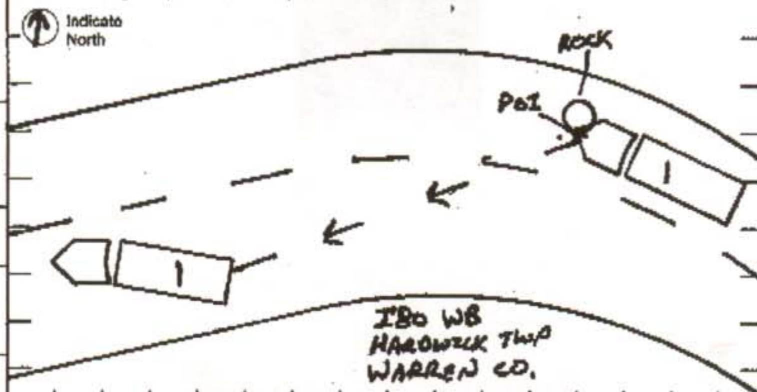
23 Veh No	1
24 Policy No.	-
25 Ins Code	-
	☐ Parked ☐ Ped ☐ Pedalcyclist ☐ Resp to Emergency ☐ Hit & Run
26 Driver's First Name	MILJAN
Initial	
Last Name	BULIC
29 Sex	M
27 Number and Street	4009 N. ST. LOUIS
30 Eyes	2
28 City	CHICAGO
State	IL
Zip	60618
31 State	IL
32 Drivers License No	B420 5408 3183
33 DOB (mm dd yy)	06 28 83
34 Expires (mm yy)	06 13
35 Owner's First Name (☐ Same As Driver)	WINDY CITY CARRIERS INC.
36 Number and Street	7400 N WAUKEGAN RD
37 City	NILES
State	IL
Zip	60714
38 Make	FRHT
39 Model	TT
40 Color	WHT
41 Year	06
42 Plate No.	PL92217
43 State	IL
44 VIN	1FUJA6CK36LU65972
45 Expires	03 11
46 Vehicle Removed To ☐ Driven ☐ Left at Scene ☒ Towed ☐ Impound ☐ Disabled	H+K WASHINGTON, NJ
47 Authority ☐ Owner ☐ Driver ☒ Police	
48 Alcohol/Drug Test	Given: ☒ No ☐ Yes ☐ Refused; Type: ☐ Breath ☐ Blood ☐ Urine; Results: 0.___% ☐ Pending
49 Hazardous Material	On Board ☐ Spill ☐ Name or Placard No.
50 Carrier No. ☒ USDOT ☐ Other*	1194419
51 Commercial Vehicle Weight	☐ ≤ 10,000 lbs ☐ 10,001 - 26,000 lbs ☒ ≥ 26,001 lbs
52 Carrier name	WINDY CITY

Vehicle 2

53 Veh No	
54 Policy No.	
55 Ins Code	
	☐ Parked ☐ Ped ☐ Pedalcyclist ☐ Resp to Emergency ☐ Hit & Run
56 Driver's First Name / Initial / Last Name	
59 Sex	
57 Number and Street	
60 Eyes	
58 City / State / Zip	
61 State	
62 Drivers License No	
63 DOB (mm dd yy)	
64 Expires (mm yy)	
65 Owner's First Name (☐ Same As Driver) / Initial / Last Name	
66 Number and Street	
67 City / State / Zip	
68 Make	
69 Model	
70 Color	
71 Year	
72 Plate No.	
73 State	
74 VIN	
75 Expires	
76 Vehicle Removed To ☐ Driven ☐ Left at Scene ☐ Towed ☐ Impound ☐ Disabled	
77 Authority ☐ Owner ☐ Driver ☐ Police	
78 Alcohol/Drug Test	Given: ☐ No ☐ Yes ☐ Refused; Type: ☐ Breath ☐ Blood ☐ Urine; Results: 0.___% ☐ Pending
79 Hazardous Material	On Board ☐ Spill ☐ Name or Placard No.
80 Carrier No. ☐ USDOT ☐ Other*	
81 Commercial Vehicle Weight	☐ ≤ 10,000 lbs ☐ 10,001 - 26,000 lbs ☐ ≥ 26,001 lbs
82 Carrier name	

134 Crash Diagram (NOT TO SCALE)

Indicate North



135 Crash Description DRIVER #1 STATED HE DID NOT SEE THE ROCK UNTIL IT WAS TOO LATE AND HIT IT. INVESTIGATION REVEALED V#1 WAS TRAVELLING IN THE RIGHT LANE AND STRUCK A LARGE ROCK.
BLK# 11Ba · LARGE ROCK IN ROADWAY.
TRAILER REG 139356 MAINE

136 Damage To Other Property

Oper.	137 Charge ☐ Multiple Charges	138 Summons No.	Oper.	139 Charge ☐ Multiple Charges	140 Summons No.

141 Officer's Signature	142 Badge No.	143 Reviewed By	Badge No.	144 Case Status
[signature]	5414	[signature]	7413	☐ Pending ☒ Complete

	83	84	85	86	87	88	89	90	91	92	93	94	95	Names & Addresses of Occupants - If Deceased, Date & Time of Death
A	1	1	01	-	27	M	-	-	-	04	04	-	-	MILJAN BULIC CHICAGO IL
B														
C														
D														
E														

Page 1 of 1 ☐ Fatal

New Jersey Police Crash Investigation Report

☒ Reportable ☐ Non-Reportable ☐ Change Report

96	01
97	01
98	96
99	01
100	04
101	02
102	01
103	01
104	01
105	15
1 Case Number	BC0201000650A
2 Police Dept of	STATE POLICE — Code 02
3 Station/Precinct	HOPE STATION
4 Date of Crash (mm dd yy)	10 07 10
5 Day of Week	Th
6 Time (use 2400 hrs)	2305
7 Municipality Code	2109
8 Total Killed	--
9 Total Injured	--
10 Crash Occurred On	INTERSTATE 80
Dir	W
11 Speed Limit	50
12 Route No.	80
13 Milepost	1.0
21 Latitude	40.16528
22 Longitude	74.18392
118a	52

Vehicle 1

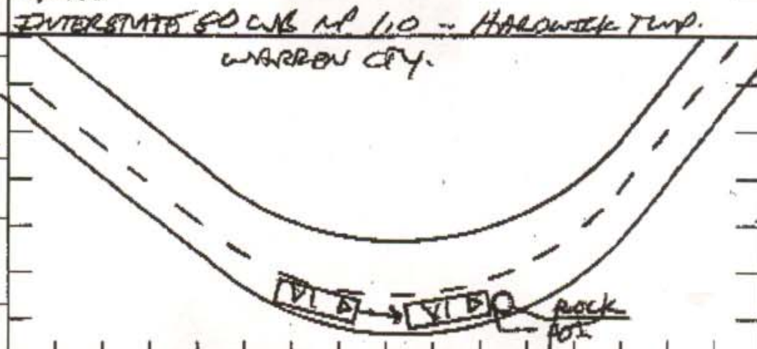
23 Veh No	1
24 Policy No	010 1206020A
25 Ins Code	X
26 Driver's First Name / Initial / Last Name	DIANE M SNYDER
29 Sex	F
30 Eyes	6
27 Number and Street	298 MUTTON HOLLOW RD
28 City / State / Zip	STROUDSBURG PA 18360
31 State	PA
32 Drivers License No	24 927 334
33 DOB	1 12 9 55
34 Expires	11 10
35 Owner's First Name	☒ Same As Driver
38 Make	SATURN
39 Model	SL
40 Color	SL
41 Year	200
42 Plate No.	DHV5713
43 State	PA
44 VIN	1G8ZR52F4YY672448
45 Expires	10 11
46 Vehicle Removed To	☒ Towed — STECKER'S TOWING BELVIDERE, NJ
	☒ Disabled
47 Authority	☒ Police
48 Alcohol/Drug Test	Given: ☒ No
108	01
110	01
116	04

Vehicle 2

53 Veh No	
120	9
124	16
126	04
128a	39

134 Crash Diagram (NOT TO SCALE)

Indicate North



135 Crash Description

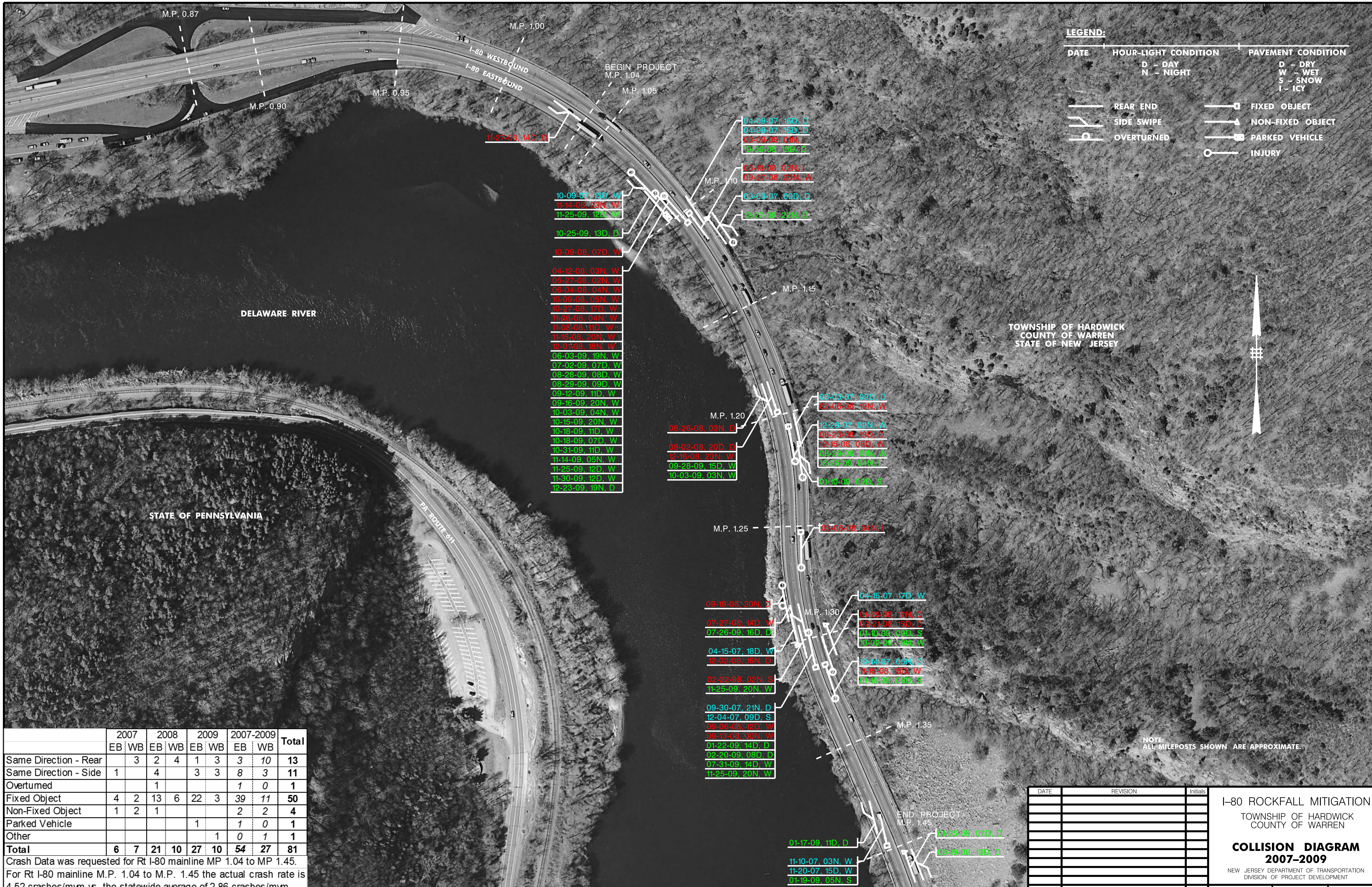
DRIVER #1 STATED: A ROCK WAS IN THE ROAD AND I HIT IT. INVESTIGATION REVEALED: VEHICLE #1 (V1) WAS TRAVELING WEST ON I-80 IN THE RIGHT LANE AT APPROXIMATELY MP 1.0, V1 COLLIDED WITH A ROCK THAT FELL FROM THE ADJACENT MOUNTAIN AND ONTO THE ROADWAY. BOX #25: ERIE INS. EXCHANGE COMPANY, EXP. 10/10. BOX #118A: ROCK/BOULDER IN ROADWAY. NO INJURIES REPORTED.

130: 01 — 131: 02

136 Damage To Other Property: NONE

141 Officer's Signature: TPR. [signature] /AGENS — 142 Badge No: 6936 — 143 Reviewed By: [signature] — Badge No. 5414 — 144 Case Status: ☒ Complete

	83	84	85	86	87	88	89	90	91	92	93	94	95	Names & Addresses of Occupants - If Deceased, Date & Time of Death
A	01	01	01	-	57	F	-	-	-	09	04	-	-	DIANE SNYDER - STROUDSBURG, PA
B	01	03	01	-	55	M	-	-	-	09	04	-	-	WILLIAM SNYDER - STROUDSBURG, PA
C														
D														
E														



	2007		2008		2009		2007-2009		Total
	EB	WB	EB	WB	EB	WB	EB	WB	
Same Direction - Rear		3	2	4	1	3	*3*	*10*	**13**
Same Direction - Side	1		4		3	3	*8*	*3*	**11**
Overturned			1				*1*	*0*	**1**
Fixed Object	4	2	13	6	22	3	*39*	*11*	**50**
Non-Fixed Object	1	2	1				*2*	*2*	**4**
Parked Vehicle					1		*1*	*0*	**1**
Other						1	*0*	*1*	**1**
Total	**6**	**7**	**21**	**10**	**27**	**10**	***54***	***27***	**81**

Crash Data was requested for Rt I-80 mainline MP 1.04 to MP 1.45.
For Rt I-80 mainline M.P. 1.04 to M.P. 1.45 the actual crash rate is 4.52 crashes/mvm vs. the statewide average of 2.86 crashes/mvm.

DATE	REVISION	Initials

I–80 ROCKFALL MITIGATION

TOWNSHIP OF HARDWICK
COUNTY OF WARREN

COLLISION DIAGRAM 2007–2009

NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF PROJECT DEVELOPMENT

SCALE: 1" = 200' | NOVEMBER 2010 | SHEET 1 OF 1

APPENDIX D

TRAFFIC COUNTS AND VOLUMES

Site Names:	092110, , I-80-1.5, 00000080__, Knowlton Twp	Seasonal Factor Type:	1 Urban Interstates
County:	WARREN	Daily Factor Type:	1 Urban Interstates
Funct. Class:	Urban Principal Arterial - Interstate	Axle Factor Type:	1
Location:	Bet Interchange 2 and Interchange 3	Growth Factor Type:	1 Urban Interstates

	01/17/2010			**01/18/2010**			**01/19/2010**			**01/20/2010**			**01/21/2010**			**01/22/2010**		
	ROAD	**W**	**E**	**ROAD**	**W**	**E**	**ROAD**	**W**	**E**	**ROAD**	**W**	**E**	**ROAD**	**W**	**E**	**ROAD**	**W**	**E**
00:00							1,498	845	653	1,342	793	549	1,527	879	648			
01:00							1,319	642	677	1,192	658	534	1,313	697	616			
02:00							1,216	491	725	1,139	466	673	1,199	538	661			
03:00							1,526	471	1,055	1,446	503	943	1,496	493	1,003			
04:00							2,427	484	1,943	2,466	603	1,863	2,173	412	1,761			
05:00							3,873	637	3,236	3,707	765	2,942	3,168	238	2,930			
06:00							4,284	974	3,310	4,147	987	3,160	4,187	1,055	3,132			
07:00							3,940	1,296	2,644	3,767	1,196	2,571	3,954	1,346	2,608			
08:00							3,647	1,432	2,215	3,618	1,445	2,173	3,920	1,725	2,195			
09:00							3,570	1,587	1,983	3,497	1,558	1,939	3,484	1,521	1,963			
10:00							3,501	1,805	1,696	3,538	1,784	1,754	3,715	1,932	1,783			
11:00							3,664	1,908	1,756	3,557	1,855	1,702	3,728	1,999	1,729			
12:00							3,749	2,090	1,659	3,707	1,997	1,710	3,794	2,066	1,728			
13:00							3,891	2,093	1,798	3,713	2,027	1,686						
14:00							3,979	2,213	1,766	4,008	2,164	1,844						
15:00							4,486	2,773	1,713	4,496	2,802	1,694						
16:00				6,561	3,267	3,294	5,170	3,473	1,697	5,254	3,575	1,679						
17:00				6,062	3,063	2,999	4,935	3,326	1,609	4,843	3,224	1,619						
18:00				5,386	2,608	2,778	4,190	2,752	1,438	4,153	2,703	1,450						
19:00				4,115	1,978	2,137	3,370	2,163	1,207	3,431	2,171	1,260						
20:00				3,479	1,611	1,868	2,801	1,649	1,152	3,156	1,872	1,284						
21:00				2,929	1,448	1,481	2,485	1,290	1,195	2,604	1,474	1,130						
22:00				2,432	1,161	1,271	2,128	1,103	1,025	2,179	1,111	1,068						
23:00				1,782	952	830	1,685	980	705	1,850	1,026	824						
Volume				32,746	16,088	16,658	77,334	38,477	38,857	76,810	38,759	38,051	37,658	14,901	22,757			
AM Peak Vol							4,370	1,908	3,535	4,147	1,865	3,241	4,312	2,000	3,283			
AM Peak Fct							0.97	0.93	0.97	0.95	0.89	0.93	0.88	0.94	0.97			
AM Peak Hr							5.45	11.00	5.30	6.00	10.15	5.30	7.30	10.30	5.45			
PM Peak Vol							5,170	3,489	1,811	5,259	3,575	1,844						
PM Peak Fct							0.96	0.93	0.92	0.95	0.97	0.89						
PM Peak Hr							16.00	16.15	13.15	16.15	16.00	14.00						
Seasonal Fct				1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107			
Daily Fct				0.897	0.897	0.897	0.878	0.878	0.878	0.968	0.968	0.968	0.961	0.961	0.961			
Axle Fct				0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432			
Pulse Fct				2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000			

Created 04/07/2010 10:56:10 AM **ROAD AADT** **69,869** **W AADT** **33,968** **E AADT** **35,901**

New Jersey Department of Transportation
Bureau of Transportation Data Development
Traffic and Technology Section

DAILY AVERAGE CLASSIFICATION DATA BY MONTH
(COMBINED WEEKDAYS AND WEEKENDS)

LOCATION: I-80 MP 8.3, Knowlton Twp., Warren(00080A) ~ EB/WB
F.C.=1

MONTH	DIR	Unclass	Motor-cycle	Auto	2-Axle 4-Tire	Bus	2-Axle 6-Tire	3-Axle 1-Unit	4-Axle 1-Unit	<=4-Axle 1-Trailer	5-Axle 1-Trailer	>=6-Axle 1-Trailer	<=6-Axle 2-Trailer	6-Axle 2-Trailer	>=7-Axle 2-Trailer	MONTHLY ADT EB WB	MONTHLY ADT COMBINE
		0	1	2	3	4	5	6	7	8	9	10	11	12	13		
JAN 2009	EB	111	2	15,754	3,259	126	178	84	4	93	2,232	37	82	12	1	21,976	
	WB	90	2	15,779	2,926	126	172	63	15	82	2,181	37	84	15	-	21,571	43,546
FEB 2009	EB	101	3	16,933	3,978	136	211	78	3	110	2,526	34	97	16	2	24,229	
	WB	101	2	17,152	3,359	136	208	69	13	101	2,486	34	93	19	1	23,775	48,004
MAR 2009	EB	111	3	16,802	3,863	147	241	85	6	105	2,700	38	99	18	1	24,218	
	WB	103	2	17,078	3,289	141	223	84	14	94	2,602	36	93	20	1	23,780	47,997
APR 2009	EB	134	5	17,642	4,685	165	276	96	7	110	2,848	40	104	20	1	26,133	
	WB	115	2	18,312	3,717	162	239	87	30	95	2,687	34	97	19	1	25,596	51,729
MAY 2009	EB	141	4	19,207	4,369	163	272	102	10	108	2,846	38	100	18	1	27,380	
	WB	112	2	19,427	3,626	161	235	84	37	99	2,712	36	96	19	1	26,647	54,026
JUN 2009	EB	177	4	18,954	4,238	164	278	100	16	114	2,919	39	104	18	1	27,126	
	WB	128	2	19,162	3,642	159	249	80	34	105	2,798	35	104	20	1	26,520	53,646
JUL 2009	EB	190	5	21,451	4,503	167	270	93	21	110	2,758	41	97	17	1	29,725	
	WB	127	1	22,034	4,003	167	242	83	28	100	2,656	35	99	21	1	29,596	59,321
AUG 2009	EB	196	4	21,870	4,562	178	284	87	7	108	2,846	41	105	14	4	30,307	
	WB	117	2	22,220	4,022	175	254	80	18	98	2,771	38	110	17	1	29,923	60,230
SEP 2009	EB	169	4	19,216	3,926	161	249	91	5	114	2,888	34	114	12	1	26,985	
	WB	116	1	19,306	3,400	155	227	78	18	100	2,769	35	114	16	1	26,336	53,321
OCT 2009	EB	156	3	18,057	3,715	157	241	93	7	121	2,880	37	120	15	3	25,606	
	WB	122	2	18,403	3,330	153	228	79	27	104	2,769	35	118	17	1	25,390	50,996
NOV 2009	EB	121	3	18,685	3,491	158	210	80	6	111	2,716	34	105	15	1	25,737	
	WB	103	2	18,709	3,281	156	197	74	19	97	2,619	34	102	15	1	25,409	51,146
DEC 2009	EB	127	2	16,975	3,541	156	201	72	6	110	2,513	35	102	16	1	23,858	
	WB	107	1	16,892	3,275	150	183	68	16	96	2,403	34	100	17	1	23,342	47,201
AVERAGE	EB	145	4	18,462	4,011	157	243	89	8	109	2,723	37	102	16	2	26,107	
	WB	112	2	18,706	3,489	153	221	77	22	98	2,621	35	101	18	1	25,657	51,764
TOTAL		256	5	37,168	7,500	310	464	166	31	207	5,344	73	203	34	2	51,764	
%DAILY	EB	0.6%	0.0%	70.7%	15.4%	0.6%	0.9%	0.3%	0.0%	0.4%	10.4%	0.1%	0.4%	0.1%	0.0%	100.0%	
	WB	0.4%	0.0%	72.9%	13.6%	0.6%	0.9%	0.3%	0.1%	0.4%	10.2%	0.1%	0.4%	0.1%	0.0%	100.0%	
%TOTAL		0.5%	0.0%	71.8%	14.5%	0.6%	0.9%	0.3%	0.1%	0.4%	10.3%	0.1%	0.4%	0.1%	0.0%	100.0%	

HNTB	Made by SMA	Date 11/3/10	Job Number 44829-PL-100
	Checked by RML	Date 11/8/10	Sheet Number 1 of 8
For: Route I-80 Rockfall	Backchecked by AL	Date 11/9/10	

Seasonal Factor Calculation

	WB Vol	EB Vol	Total Vol
Jan	22,985	23,160	22,985
Feb	24,733	25,391	24,733
Mar	24,189	24,962	24,189
Apr	26,571	27,148	26,571
May	27,592	28,556	27,592
Jun	27,504	28,126	27,504
Jul	30,546	30,798	30,546
Aug	31,011	31,752	31,011
Sep	27,370	28,119	27,370
Oct	26,468	26,779	26,468
Nov	26,208	26,051	26,208
Dec	24,246	26,634	24,246
Average	**26,631**	**27,305**	**26,631**

Volume source: DRJTBC Year 2009 monthly Average Daily Traffic (ADT)

Westbound seasonal factors:

Jan	1.159
Feb	1.077
Mar	1.101
Apr	1.002
May	0.965
Jun	0.968
Jul	0.872
Aug	0.859
Sep	0.973
Oct	1.006
Nov	1.016
Dec	1.098

Selected eastbound seasonal factors:

Apr	1.006
Jul	0.887

EB seasonal factors are calculated as monthly EB volume divided by yearly average EB volume.

WB seasonal factors are calculated as monthly WB volume divided by yearly average WB volume.

HNTB	Made by: SMA	Date: 11/3/10	Job Number: 44829-PL-100
	Checked by: RML	Date: 11/8/10	Sheet Number: 2 of 8
For: Route I-80 Rockfall	Backchecked by: AL	Date: 11/9/10	

Westbound Raw Volumes (Cars and Trucks)

CARS	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	463	276	319	326	315	374	574	604	413	390	430	498	594	721
1-2 am	268	155	198	178	197	210	333	387	245	212	279	261	388	459
2-3 am	169	83	110	95	104	110	187	284	119	163	159	186	193	303
3-4 am	119	68	73	83	89	79	145	178	115	107	120	117	180	209
4-5 am	90	78	69	78	73	101	125	144	131	104	132	143	161	185
5-6 am	109	140	139	130	142	135	121	199	257	196	174	191	275	269
6-7 am	172	267	263	265	246	259	235	354	457	363	406	463	519	528
7-8 am	444	511	502	507	371	533	649	693	684	647	693	764	945	1,105
8-9 am	820	575	616	674	575	744	1,148	1,045	826	782	823	900	886	1,859
9-10 am	976	574	641	626	413	769	1,350	1,751	831	777	822	904	1,247	2,292
10-11 am	1,118	590	649	634	493	753	1,586	2,122	1,095	982	940	1,300	1,365	2,537
11 am-12 pm	1,323	685	709	675	746	889	1,647	2,492	1,210	1,034	1,078	1,202	1,664	2,651
12-1 pm	1,507	716	724	751	693	1,071	1,649	2,485	1,301	961	1,115	1,257	1,765	2,194
1-2 pm	1,409	692	806	812	747	1,177	1,663	2,379	1,243	1,114	1,109	1,252	1,536	2,577
2-3 pm	1,373	870	904	944	915	1,469	1,578	2,098	1,282	1,106	1,226	1,319	1,811	2,310
3-4 pm	1,264	1,258	1,384	1,403	1,423	1,983	1,583	1,862	1,548	1,487	1,535	1,800	2,347	1,894
4-5 pm	1,160	1,734	1,950	1,956	1,962	2,331	1,496	1,742	2,062	1,993	2,140	2,228	2,560	1,772
5-6 pm	1,142	1,854	2,061	2,015	1,814	2,323	1,341	1,609	2,063	2,090	2,136	2,156	2,722	1,679
6-7 pm	952	1,526	1,623	1,795	1,601	2,438	1,192	1,386	1,728	1,703	1,832	1,912	2,418	1,442
7-8 pm	921	1,144	1,191	1,406	1,101	2,206	1,060	1,254	1,370	1,532	1,579	1,949	1,166	1,303
8-9 pm	781	818	885	929	876	1,873	843	1,103	978	1,046	1,173	1,428	1,976	1,155
9-10 pm	575	577	625	640	637	1,635	721	977	743	788	949	1,144	2,478	1,086
10-11 pm	438	400	484	479	498	1,139	675	756	665	610	628	1,071	2,152	886
11 pm-12 am	352	335	361	407	398	794	521	586	436	429	613	630	1,072	715
Totals:	17,945	15,926	17,286	17,808	16,429	25,395	22,422	28,490	21,802	20,616	22,091	25,075	32,420	32,131

TRUCKS	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	27	52	110	129	104	86	90	33	59	116	109	170	96	111
1-2 am	20	37	104	80	106	99	90	19	56	108	109	111	142	93
2-3 am	22	39	104	110	109	93	74	31	63	110	101	92	84	84
3-4 am	12	61	108	104	109	102	67	18	63	113	107	120	118	73
4-5 am	22	60	129	127	116	128	58	18	76	141	131	137	106	88
5-6 am	23	104	147	160	147	130	59	23	124	168	154	158	158	85
6-7 am	22	102	173	161	146	162	89	29	125	205	208	226	194	93
7-8 am	33	113	150	178	142	154	109	46	141	200	216	192	190	102
8-9 am	50	119	134	155	135	160	99	39	136	187	183	184	182	95
9-10 am	48	108	206	181	91	192	82	71	156	180	215	195	237	116
10-11 am	41	187	252	220	125	229	107	88	287	261	297	293	286	144
11 am-12 pm	57	207	289	241	321	226	97	88	256	280	281	287	292	122
12-1 pm	60	230	304	281	349	298	86	74	306	264	274	222	273	108
1-2 pm	62	207	295	295	294	256	76	56	270	359	307	287	251	107
2-3 pm	72	265	280	260	371	273	94	82	288	291	254	292	221	100
3-4 pm	44	272	278	281	353	257	67	70	299	290	282	262	251	93
4-5 pm	59	303	301	263	283	234	77	80	271	276	263	292	223	59
5-6 pm	43	259	259	255	248	217	59	59	262	236	259	216	208	77
6-7 pm	63	249	219	206	227	218	51	59	224	240	219	216	192	80
7-8 pm	54	173	166	207	147	187	51	72	198	216	253	262	119	56
8-9 pm	57	157	132	154	152	142	48	44	177	163	172	206	139	51
9-10 pm	50	160	124	157	119	122	37	53	155	157	160	152	199	49
10-11 pm	54	131	144	118	131	125	36	74	152	148	143	163	154	41
11 pm-12 am	52	125	103	108	101	95	26	75	116	119	138	136	152	45
Totals:	1,047	3,720	4,511	4,431	4,426	4,185	1,729	1,301	4,260	4,828	4,835	4,871	4,467	2,072

HNTB	Made by SMA	Date 11/3/10	Job Number 44829-PL-100
	Checked by RML	Date 11/8/10	Sheet Number 3 of 8
For: Route I-80 Rockfall	Backchecked by AL	Date 11/9/10	

Westbound Seasonal Factored Volumes (Cars and Trucks)

Seasonal factors from 2009 DRJTBC data: JAN 1.159 JUL 0.872

CARS	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	536	320	370	378	365	433	665	527	360	340	375	434	518	629
1-2 am	311	180	229	206	228	243	386	337	214	185	243	228	338	400
2-3 am	196	96	127	110	120	127	217	248	104	142	139	162	168	264
3-4 am	138	79	85	96	103	92	168	155	100	93	105	102	157	182
4-5 am	104	90	80	90	85	117	145	126	114	91	115	125	140	161
5-6 am	126	162	161	151	165	156	140	173	224	171	152	167	240	235
6-7 am	199	309	305	307	285	300	272	309	398	316	354	404	452	460
7-8 am	514	592	582	587	430	618	752	604	596	564	604	666	824	963
8-9 am	950	666	714	781	666	862	1,330	911	720	682	718	785	772	1,621
9-10 am	1,131	665	743	725	479	891	1,564	1,527	724	677	717	788	1,087	1,998
10-11 am	1,295	684	752	735	571	872	1,838	1,850	955	856	820	1,133	1,190	2,212
11 am-12 pm	1,533	794	821	782	864	1,030	1,908	2,173	1,055	901	940	1,048	1,451	2,311
12-1 pm	1,746	830	839	870	803	1,241	1,911	2,166	1,134	838	972	1,096	1,539	1,913
1-2 pm	1,632	802	934	941	865	1,364	1,927	2,074	1,084	971	967	1,092	1,339	2,247
2-3 pm	1,591	1,008	1,047	1,094	1,060	1,702	1,828	1,829	1,118	964	1,069	1,150	1,579	2,014
3-4 pm	1,464	1,458	1,604	1,626	1,649	2,298	1,834	1,623	1,350	1,296	1,338	1,569	2,046	1,651
4-5 pm	1,344	2,009	2,259	2,266	2,273	2,701	1,733	1,519	1,798	1,738	1,866	1,942	2,232	1,545
5-6 pm	1,323	2,148	2,388	2,335	2,102	2,691	1,554	1,403	1,799	1,822	1,862	1,880	2,373	1,464
6-7 pm	1,103	1,768	1,880	2,080	1,855	2,825	1,381	1,208	1,507	1,485	1,597	1,667	2,108	1,257
7-8 pm	1,067	1,325	1,380	1,629	1,276	2,556	1,228	1,093	1,194	1,336	1,377	1,699	1,017	1,136
8-9 pm	905	948	1,025	1,076	1,015	2,170	977	962	853	912	1,023	1,245	1,723	1,007
9-10 pm	666	669	724	742	738	1,894	835	852	648	687	827	997	2,160	947
10-11 pm	507	463	561	555	577	1,320	782	659	580	532	548	934	1,876	772
11 pm-12 am	408	388	418	472	461	920	604	511	380	374	534	549	935	623
Totals:	20,791	18,452	20,028	20,633	19,035	29,423	25,978	24,838	19,007	17,973	19,259	21,861	28,264	28,012

TRUCKS	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	31	60	127	149	120	100	104	29	51	101	95	148	84	97
1-2 am	23	43	120	93	123	115	104	17	49	94	95	97	124	81
2-3 am	25	45	120	127	126	108	86	27	55	96	88	80	73	73
3-4 am	14	71	125	120	126	118	78	16	55	99	93	105	103	64
4-5 am	25	70	149	147	134	148	67	16	66	123	114	119	92	77
5-6 am	27	120	170	185	170	151	68	20	108	146	134	138	138	74
6-7 am	25	118	200	187	169	188	103	25	109	179	181	197	169	81
7-8 am	38	131	174	206	165	178	126	40	123	174	188	167	166	89
8-9 am	58	138	155	180	156	185	115	34	119	163	160	160	159	83
9-10 am	56	125	239	210	105	222	95	62	136	157	187	170	207	101
10-11 am	48	217	292	255	145	265	124	77	250	228	259	255	249	126
11 am-12 pm	66	240	335	279	372	262	112	77	223	244	245	250	255	106
12-1 pm	70	266	352	326	404	345	100	65	267	230	239	194	238	94
1-2 pm	72	240	342	342	341	297	88	49	235	313	268	250	219	93
2-3 pm	83	307	324	301	430	316	109	71	251	254	221	255	193	87
3-4 pm	51	315	322	326	409	298	78	61	261	253	246	228	219	81
4-5 pm	68	351	349	305	328	271	89	70	236	241	229	255	194	51
5-6 pm	50	300	300	295	287	251	68	51	228	206	226	188	181	67
6-7 pm	73	288	254	239	263	253	59	51	195	209	191	188	167	70
7-8 pm	63	200	192	240	170	217	59	63	173	188	221	228	104	49
8-9 pm	66	182	153	178	176	165	56	38	154	142	150	180	121	44
9-10 pm	58	185	144	182	138	141	43	46	135	137	139	133	173	43
10-11 pm	63	152	167	137	152	145	42	65	133	129	125	142	134	36
11 pm-12 am	60	145	119	125	117	110	30	65	101	104	120	119	133	39
Totals:	1,213	4,310	5,226	5,134	5,128	4,849	2,003	1,134	3,714	4,209	4,215	4,247	3,894	1,806

HNTB	Made by: SMA	Date: 11/3/10	Job Number: 44829-PL-100
	Checked by: RML	Date: 11/8/10	Sheet Number: 4 of 8
For: Route I-80 Rockfall	Backchecked by: AL	Date: 11/9/10	

Westbound Raw Volumes (Vehicles, PCEs)

TOTAL (veh/hour)	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	490	328	429	455	419	460	664	637	472	506	539	668	690	832
1-2 am	288	192	302	258	303	309	423	406	301	320	388	372	530	552
2-3 am	191	122	214	205	213	203	261	315	182	273	260	278	277	387
3-4 am	131	129	181	187	198	181	212	196	178	220	227	237	298	282
4-5 am	112	138	198	205	189	229	183	162	207	245	263	280	267	273
5-6 am	132	244	286	290	289	265	180	222	381	364	328	349	433	354
6-7 am	194	369	436	426	392	421	324	383	582	568	614	689	713	621
7-8 am	477	624	652	685	513	687	758	739	825	847	909	956	1,135	1,207
8-9 am	870	694	750	829	710	904	1,247	1,084	962	969	1,006	1,084	1,068	1,954
9-10 am	1,024	682	847	807	504	961	1,432	1,822	987	957	1,037	1,099	1,484	2,408
10-11 am	1,159	777	901	854	618	982	1,693	2,210	1,382	1,243	1,237	1,593	1,651	2,681
11 am-12 pm	1,380	892	998	916	1,067	1,115	1,744	2,580	1,466	1,314	1,359	1,489	1,956	2,773
12-1 pm	1,567	946	1,028	1,032	1,042	1,369	1,735	2,559	1,607	1,225	1,389	1,479	2,038	2,302
1-2 pm	1,471	899	1,101	1,107	1,041	1,433	1,739	2,435	1,513	1,473	1,416	1,539	1,787	2,684
2-3 pm	1,445	1,135	1,184	1,204	1,286	1,742	1,672	2,180	1,570	1,397	1,480	1,611	2,032	2,410
3-4 pm	1,308	1,530	1,662	1,684	1,776	2,240	1,650	1,932	1,847	1,777	1,817	2,062	2,598	1,987
4-5 pm	1,219	2,037	2,251	2,219	2,245	2,565	1,573	1,822	2,333	2,269	2,403	2,520	2,783	1,831
5-6 pm	1,185	2,113	2,320	2,270	2,062	2,540	1,400	1,668	2,325	2,326	2,395	2,372	2,930	1,756
6-7 pm	1,015	1,775	1,842	2,001	1,828	2,656	1,243	1,445	1,952	1,943	2,051	2,128	2,610	1,522
7-8 pm	975	1,317	1,357	1,613	1,248	2,393	1,111	1,326	1,568	1,748	1,832	2,211	1,285	1,359
8-9 pm	838	975	1,017	1,083	1,028	2,015	891	1,147	1,155	1,209	1,345	1,634	2,115	1,206
9-10 pm	625	737	749	797	756	1,757	758	1,030	898	945	1,109	1,296	2,677	1,135
10-11 pm	492	531	628	597	629	1,264	711	830	817	758	771	1,234	2,306	927
11 pm-12 am	404	460	464	515	499	889	547	661	552	548	751	766	1,224	760
Totals:	18,992	19,646	21,797	22,239	20,855	29,580	24,151	29,791	26,062	25,444	26,926	29,946	36,887	34,203

pce factor: 1.5

TOTAL (pce/hour)	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	504	354	484	520	471	503	709	654	502	564	594	753	738	888
1-2 am	298	211	354	298	356	359	468	416	329	374	443	428	601	599
2-3 am	202	142	266	260	268	250	298	331	214	328	311	324	319	429
3-4 am	137	160	235	239	253	232	246	205	210	277	281	297	357	319
4-5 am	123	168	263	269	247	293	212	171	245	316	329	349	320	317
5-6 am	144	296	360	370	363	330	210	234	443	448	405	428	512	397
6-7 am	205	420	523	507	465	502	369	398	645	671	718	802	810	668
7-8 am	494	681	727	774	584	764	813	762	896	947	1,017	1,052	1,230	1,258
8-9 am	895	754	817	907	778	984	1,297	1,104	1,030	1,063	1,098	1,176	1,159	2,002
9-10 am	1,048	736	950	898	550	1,057	1,473	1,858	1,065	1,047	1,145	1,197	1,603	2,466
10-11 am	1,180	871	1,027	964	681	1,097	1,747	2,254	1,526	1,374	1,386	1,740	1,794	2,753
11 am-12 pm	1,409	996	1,143	1,037	1,228	1,228	1,793	2,624	1,594	1,454	1,500	1,633	2,102	2,834
12-1 pm	1,597	1,061	1,180	1,173	1,217	1,518	1,778	2,596	1,760	1,357	1,526	1,590	2,175	2,356
1-2 pm	1,502	1,003	1,249	1,255	1,188	1,561	1,777	2,463	1,648	1,653	1,570	1,683	1,913	2,738
2-3 pm	1,481	1,268	1,324	1,334	1,472	1,879	1,719	2,221	1,714	1,543	1,607	1,757	2,143	2,460
3-4 pm	1,330	1,666	1,801	1,825	1,953	2,369	1,684	1,967	1,997	1,922	1,958	2,193	2,724	2,034
4-5 pm	1,249	2,189	2,402	2,351	2,387	2,682	1,612	1,862	2,469	2,407	2,535	2,666	2,895	1,861
5-6 pm	1,207	2,243	2,450	2,398	2,186	2,649	1,430	1,698	2,456	2,444	2,525	2,480	3,034	1,795
6-7 pm	1,047	1,900	1,952	2,104	1,942	2,765	1,269	1,475	2,064	2,063	2,161	2,236	2,706	1,562
7-8 pm	1,002	1,404	1,440	1,717	1,322	2,487	1,137	1,362	1,667	1,856	1,959	2,342	1,345	1,387
8-9 pm	867	1,054	1,083	1,160	1,104	2,086	915	1,169	1,244	1,291	1,431	1,737	2,185	1,232
9-10 pm	650	817	811	876	816	1,818	777	1,057	976	1,024	1,189	1,372	2,777	1,160
10-11 pm	519	597	700	656	695	1,327	729	867	893	832	843	1,316	2,383	948
11 pm-12 am	430	523	516	569	550	937	560	699	610	608	820	834	1,300	783
Totals:	19,516	21,506	24,053	24,455	23,068	31,673	25,016	30,442	28,192	27,858	29,344	32,382	39,121	35,239

HNTB	Made by	SMA	Date	11/3/10	Job Number
					44829-PL-100
	Checked by	RML	Date	11/8/10	Sheet Number
	Backchecked by	AL	Date	11/9/10	
For: Route I-80 Rockfall					

Westbound Seasonal Factored Volumes (Vehicles, PCEs)

TOTAL (veh/hour)	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	568	380	497	527	485	533	769	555	411	441	470	582	602	725
1-2 am	334	222	350	299	351	358	490	354	262	279	338	324	462	481
2-3 am	221	141	248	238	247	235	302	275	159	238	227	242	241	337
3-4 am	152	149	210	217	229	210	246	171	155	192	198	207	260	246
4-5 am	130	160	229	238	219	265	212	141	180	214	229	244	233	238
5-6 am	153	283	331	336	335	307	209	194	332	317	286	304	377	309
6-7 am	225	428	505	494	454	488	375	334	507	495	535	601	622	541
7-8 am	553	723	755	794	594	796	878	644	719	738	792	833	990	1,052
8-9 am	1,008	804	869	960	823	1,047	1,445	945	839	845	877	945	931	1,704
9-10 am	1,186	790	981	935	584	1,113	1,659	1,588	860	834	904	958	1,294	2,099
10-11 am	1,343	900	1,044	989	716	1,138	1,962	1,927	1,205	1,084	1,078	1,389	1,439	2,337
11 am-12 pm	1,599	1,033	1,156	1,061	1,236	1,292	2,021	2,249	1,278	1,146	1,185	1,298	1,705	2,418
12-1 pm	1,816	1,096	1,191	1,196	1,207	1,586	2,010	2,231	1,401	1,068	1,211	1,289	1,777	2,007
1-2 pm	1,704	1,042	1,276	1,283	1,206	1,660	2,015	2,123	1,319	1,284	1,234	1,342	1,558	2,340
2-3 pm	1,674	1,315	1,372	1,395	1,490	2,018	1,937	1,901	1,369	1,218	1,290	1,405	1,772	2,101
3-4 pm	1,515	1,773	1,926	1,951	2,058	2,595	1,912	1,684	1,610	1,549	1,584	1,798	2,265	1,732
4-5 pm	1,412	2,360	2,608	2,571	2,601	2,972	1,822	1,588	2,034	1,978	2,095	2,197	2,426	1,596
5-6 pm	1,373	2,448	2,688	2,630	2,389	2,943	1,622	1,454	2,027	2,028	2,088	2,068	2,554	1,531
6-7 pm	1,176	2,057	2,134	2,318	2,118	3,077	1,440	1,260	1,702	1,694	1,788	1,855	2,275	1,327
7-8 pm	1,130	1,526	1,572	1,869	1,446	2,773	1,287	1,156	1,367	1,524	1,597	1,928	1,120	1,185
8-9 pm	971	1,130	1,178	1,255	1,191	2,335	1,032	1,000	1,007	1,054	1,173	1,425	1,844	1,051
9-10 pm	724	854	868	923	876	2,036	878	898	783	824	967	1,130	2,334	990
10-11 pm	570	615	728	692	729	1,464	824	724	712	661	672	1,076	2,010	808
11 pm-12 am	468	533	538	597	578	1,030	634	576	481	478	655	668	1,067	663
Totals:	22,004	22,762	25,254	25,766	24,163	34,272	27,982	25,972	22,721	22,183	23,475	26,108	32,159	29,819

pce factor: 1.5

TOTAL (pce/hour)	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	583	410	561	602	546	583	821	570	437	492	517	656	643	774
1-2 am	345	244	410	345	412	415	542	362	287	326	386	373	524	522
2-3 am	234	164	308	301	310	289	345	288	186	286	271	282	278	374
3-4 am	159	185	272	277	293	269	284	179	183	241	245	259	311	278
4-5 am	143	195	304	311	286	339	246	149	214	275	286	304	279	276
5-6 am	166	343	417	429	420	382	243	204	386	391	353	373	446	346
6-7 am	238	487	605	587	539	582	427	347	562	585	626	699	706	582
7-8 am	572	788	842	897	677	885	941	664	781	826	887	917	1,072	1,097
8-9 am	1,037	873	947	1,050	901	1,140	1,502	962	898	926	957	1,025	1,010	1,745
9-10 am	1,214	853	1,101	1,040	637	1,225	1,707	1,619	928	913	998	1,043	1,397	2,150
10-11 am	1,367	1,009	1,190	1,117	788	1,270	2,024	1,965	1,330	1,197	1,208	1,517	1,564	2,400
11 am-12 pm	1,632	1,153	1,324	1,201	1,422	1,423	2,077	2,288	1,390	1,268	1,307	1,423	1,833	2,471
12-1 pm	1,850	1,229	1,367	1,358	1,409	1,759	2,060	2,263	1,534	1,183	1,330	1,386	1,896	2,054
1-2 pm	1,740	1,162	1,447	1,453	1,376	1,809	2,059	2,147	1,437	1,441	1,368	1,467	1,667	2,387
2-3 pm	1,716	1,469	1,534	1,546	1,705	2,176	1,992	1,936	1,494	1,345	1,401	1,532	1,868	2,145
3-4 pm	1,541	1,930	2,087	2,114	2,262	2,744	1,951	1,715	1,741	1,676	1,707	1,912	2,374	1,773
4-5 pm	1,447	2,536	2,782	2,723	2,765	3,107	1,867	1,623	2,152	2,098	2,210	2,324	2,523	1,622
5-6 pm	1,398	2,598	2,838	2,778	2,533	3,069	1,656	1,480	2,141	2,131	2,201	2,162	2,645	1,564
6-7 pm	1,212	2,201	2,261	2,438	2,249	3,204	1,470	1,285	1,799	1,799	1,884	1,949	2,359	1,362
7-8 pm	1,161	1,626	1,668	1,989	1,531	2,881	1,317	1,187	1,453	1,618	1,707	2,042	1,172	1,209
8-9 pm	1,004	1,221	1,255	1,344	1,279	2,417	1,060	1,019	1,084	1,125	1,248	1,514	1,904	1,074
9-10 pm	753	947	940	1,014	945	2,106	900	921	850	892	1,037	1,196	2,421	1,011
10-11 pm	601	691	811	760	805	1,537	845	756	779	725	735	1,147	2,078	826
11 pm-12 am	498	605	597	659	637	1,085	649	609	532	530	715	727	1,133	682
Totals:	22,611	24,917	27,867	28,333	26,727	36,696	28,983	26,539	24,578	24,287	25,582	28,231	34,106	30,722

HNTB	Made by: SMA	Date: 11/3/10	Job Number: 44829-PL-100
	Checked by: HEC	Date: 11/4/10	Sheet Number: 6 of 8
For: Route I-80 Rockfall	Backchecked by: AL	Date: 11/5/10	

Westbound Truck Percentages (DRJTBC Truck Definition)

Truck percentage	Sun Jan 24	Mon Jan 25	Tue Jan 26	Wed Jan 27	Thu Jan 28	Fri Jan 29	Sat Jan 30	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	6%	16%	26%	28%	25%	19%	14%	5%	13%	23%	20%	25%	14%	13%
1-2 am	7%	19%	34%	31%	35%	32%	21%	5%	19%	34%	28%	30%	27%	17%
2-3 am	12%	32%	49%	54%	51%	46%	28%	10%	35%	40%	39%	33%	30%	22%
3-4 am	9%	47%	60%	56%	55%	56%	32%	9%	35%	51%	47%	51%	40%	26%
4-5 am	20%	43%	65%	62%	61%	56%	32%	11%	37%	58%	50%	49%	40%	32%
5-6 am	17%	43%	51%	55%	51%	49%	33%	10%	33%	46%	47%	45%	36%	24%
6-7 am	11%	28%	40%	38%	37%	38%	27%	8%	21%	36%	34%	33%	27%	15%
7-8 am	7%	18%	23%	26%	28%	22%	14%	6%	17%	24%	24%	20%	17%	8%
8-9 am	6%	17%	18%	19%	19%	18%	8%	4%	14%	19%	18%	17%	17%	5%
9-10 am	5%	16%	24%	22%	18%	20%	6%	4%	16%	19%	21%	18%	16%	5%
10-11 am	4%	24%	28%	26%	20%	23%	6%	4%	21%	21%	24%	18%	17%	5%
11 am-12 pm	4%	23%	29%	26%	30%	20%	6%	3%	17%	21%	21%	19%	15%	4%
12-1 pm	4%	24%	30%	27%	33%	22%	5%	3%	19%	22%	20%	15%	13%	5%
1-2 pm	4%	23%	27%	27%	28%	18%	4%	2%	18%	24%	22%	19%	14%	4%
2-3 pm	5%	23%	24%	22%	29%	16%	6%	4%	18%	21%	17%	18%	11%	4%
3-4 pm	3%	18%	17%	17%	20%	11%	4%	4%	16%	16%	16%	13%	10%	5%
4-5 pm	5%	15%	13%	12%	13%	9%	5%	4%	12%	12%	11%	12%	8%	3%
5-6 pm	4%	12%	11%	11%	12%	9%	4%	4%	11%	10%	11%	9%	7%	4%
6-7 pm	6%	14%	12%	10%	12%	8%	4%	4%	11%	12%	11%	10%	7%	5%
7-8 pm	6%	13%	12%	13%	12%	8%	5%	5%	13%	12%	14%	12%	9%	4%
8-9 pm	7%	16%	13%	14%	15%	7%	5%	4%	15%	13%	13%	13%	7%	4%
9-10 pm	8%	22%	17%	20%	16%	7%	5%	5%	17%	17%	14%	12%	7%	4%
10-11 pm	11%	25%	23%	20%	21%	10%	5%	9%	19%	20%	19%	13%	7%	4%
11 pm-12 am	13%	27%	22%	21%	20%	11%	5%	11%	21%	22%	18%	18%	12%	6%
Overall:	6%	19%	21%	20%	21%	14%	7%	4%	16%	19%	18%	16%	12%	6%

HNTB	Made by: SMA	Date: 11/3/10	Job Number: 44829-PL-100
	Checked by: RML	Date: 11/8/10	Sheet Number: 7 of 8
For: Route I-80 Rockfall	Backchecked by: AL	Date: 11/9/10	

Eastbound Raw Volumes

TOTAL (veh/hour)	Sun Apr 11	Mon Apr 12	Tue Apr 13	Wed Apr 14	Thu Apr 15	Fri Apr 16	Sat Apr 17	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2 am	341	386	269	272	306	336	296	434	593	261	342	342	397	365
2-3 am	207	297	267	202	210	289	244	306	444	327	285	292	358	311
3-4 am	167	406	352	345	340	365	205	233	489	215	366	399	396	268
4-5 am	172	721	618	569	639	576	279	264	838	715	700	715	678	359
5-6 am	254	1,643	1,298	1,321	1,368	1,277	449	327	1,868	1,587	1,530	1,561	1,485	494
6-7 am	368	2,651	2,426	2,412	2,406	2,228	657	465	2,628	2,300	2,054	2,312	1,972	713
7-8 am	466	2,417	2,340	2,255	2,252	2,156	764	542	2,126	2,013	1,715	2,067	1,812	875
8-9 am	600	1,762	1,686	1,662	1,735	1,623	988	756	1,643	1,611	1,604	1,652	1,505	1,037
9-10 am	872	1,408	1,375	1,281	1,384	1,354	1,154	1,097	1,534	1,451	1,360	1,488	1,394	1,307
10-11 am	1,295	1,192	1,221	1,214	1,266	1,252	1,417	1,658	1,454	1,308	1,156	1,245	1,314	1,643
11 am-12 pm	1,562	1,196	1,065	1,106	1,060	1,298	1,519	2,137	1,504	1,296	1,137	1,310	1,489	1,835
12-1 pm	1,870	1,072	970	1,110	1,114	1,308	1,607	2,440	1,542	1,199	1,082	1,354	1,580	2,046
1-2 pm	2,019	1,149	1,008	1,041	1,047	1,385	1,533	2,518	1,578	1,419	1,133	1,409	1,737	1,842
2-3 pm	2,249	1,160	1,100	1,117	1,191	1,460	1,601	2,813	1,626	1,494	1,191	1,601	1,797	1,931
3-4 pm	2,352	1,047	1,056	1,266	1,195	1,670	1,610	2,872	1,556	1,344	1,433	1,522	1,776	1,973
4-5 pm	2,557	1,030	976	1,060	1,302	1,586	1,671	3,039	1,469	1,367	2,052	1,571	1,780	1,853
5-6 pm	2,561	1,127	979	1,130	1,177	1,612	1,811	3,022	1,326	1,350	1,471	1,438	1,636	2,144
6-7 pm	2,422	1,067	989	1,050	1,118	1,562	1,698	3,064	1,361	1,295	1,250	1,471	1,590	2,061
7-8 pm	2,252	872	862	922	981	1,288	1,321	2,998	1,135	1,104	1,121	1,362	1,388	1,877
8-9 pm	1,882	789	691	764	874	997	1,069	2,958	1,077	1,019	1,041	1,116	1,247	1,918
9-10 pm	1,551	715	671	743	808	956	1,070	2,827	983	880	899	1,045	1,091	1,657
10-11 pm	1,209	655	583	702	711	823	853	2,647	856	747	776	907	922	1,260
11 pm-12 am	811	526	520	509	538	611	554	1,290	680	606	625	678	716	1,002
Totals:	30,039	25,288	23,322	24,053	25,022	28,012	24,370	40,707	30,310	26,908	26,323	28,857	30,060	30,771

Eastbound Seasonal Factored Volumes

Seasonal factors from 2009 DRJTBC data: APR 1.006 JUL 0.887

TOTAL (veh/hour)	Sun Apr 11	Mon Apr 12	Tue Apr 13	Wed Apr 14	Thu Apr 15	Fri Apr 16	Sat Apr 17	Sun Jul 18	Mon Jul 19	Tue Jul 20	Wed Jul 21	Thu Jul 22	Fri Jul 23	Sat Jul 24
12-1 am	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2 am	343	388	271	274	308	338	298	385	526	231	303	303	352	324
2-3 am	208	299	269	203	211	291	245	271	394	290	253	259	317	276
3-4 am	168	408	354	347	342	367	206	207	434	191	324	354	351	238
4-5 am	173	725	622	572	643	579	281	234	743	634	621	634	601	318
5-6 am	255	1,652	1,305	1,329	1,376	1,284	452	290	1,656	1,407	1,356	1,384	1,317	438
6-7 am	370	2,666	2,440	2,426	2,420	2,241	661	412	2,330	2,039	1,821	2,050	1,748	632
7-8 am	469	2,431	2,353	2,268	2,265	2,168	768	481	1,885	1,785	1,520	1,833	1,606	776
8-9 am	603	1,772	1,696	1,672	1,745	1,632	994	670	1,457	1,428	1,422	1,465	1,334	919
9-10 am	877	1,416	1,383	1,288	1,392	1,362	1,161	973	1,360	1,286	1,206	1,319	1,236	1,159
10-11 am	1,302	1,199	1,228	1,221	1,273	1,259	1,425	1,470	1,289	1,160	1,025	1,104	1,165	1,457
11 am-12 pm	1,571	1,203	1,071	1,112	1,066	1,305	1,528	1,895	1,333	1,149	1,008	1,161	1,320	1,627
12-1 pm	1,881	1,078	976	1,116	1,120	1,316	1,616	2,163	1,367	1,063	959	1,200	1,401	1,814
1-2 pm	2,031	1,156	1,014	1,047	1,053	1,393	1,542	2,232	1,399	1,258	1,004	1,249	1,540	1,633
2-3 pm	2,262	1,167	1,106	1,123	1,198	1,468	1,610	2,494	1,442	1,325	1,056	1,419	1,593	1,712
3-4 pm	2,366	1,053	1,062	1,273	1,202	1,680	1,619	2,546	1,380	1,192	1,270	1,349	1,575	1,749
4-5 pm	2,572	1,036	982	1,066	1,309	1,595	1,681	2,694	1,302	1,212	1,819	1,393	1,578	1,643
5-6 pm	2,576	1,133	985	1,137	1,184	1,621	1,821	2,679	1,176	1,197	1,304	1,275	1,450	1,901
6-7 pm	2,436	1,073	995	1,056	1,124	1,571	1,708	2,716	1,207	1,148	1,108	1,304	1,410	1,827
7-8 pm	2,265	877	867	927	987	1,295	1,329	2,658	1,006	979	994	1,208	1,231	1,664
8-9 pm	1,893	794	695	768	879	1,003	1,075	2,622	955	903	923	989	1,106	1,700
9-10 pm	1,560	719	675	747	813	961	1,076	2,506	872	780	797	926	967	1,469
10-11 pm	1,216	659	586	706	715	828	858	2,347	759	662	688	804	817	1,117
11 pm-12 am	816	529	523	512	541	615	557	1,144	603	537	554	601	635	888
Totals:	30,212	25,433	23,456	24,191	25,166	28,173	24,510	36,090	26,872	23,856	23,337	25,584	26,650	27,281

HNTB	Made by SMA	Date 11/3/10	Job Number 44829-PL-100
	Checked by RML	Date 11/8/10	Sheet Number 8 of 8
For: Route I-80 Rockfall	Backchecked by AL	Date 11/9/10	

WB Factored AAHT*

Total (veh/hr)	Sun	Mon	Tue-Thu	Fri	Sat
12-1 am	562	396	501	567	747
1-2 am	344	242	324	410	486
2-3 am	248	150	240	238	320
3-4 am	161	152	209	235	246
4-5 am	135	170	229	249	225
5-6 am	173	307	318	342	259
6-7 am	279	467	514	555	458
7-8 am	598	721	751	893	965
8-9 am	977	821	886	989	1,574
9-10 am	1,387	825	866	1,204	1,879
10-11 am	1,635	1,053	1,050	1,289	2,149
11 am-12 pm	1,924	1,156	1,180	1,499	2,219
12-1 pm	2,023	1,249	1,194	1,681	2,009
1-2 pm	1,914	1,180	1,271	1,609	2,177
2-3 pm	1,787	1,342	1,362	1,895	2,019
3-4 pm	1,600	1,691	1,811	2,430	1,822
4-5 pm	1,500	2,197	2,342	2,699	1,709
5-6 pm	1,414	2,238	2,315	2,749	1,576
6-7 pm	1,218	1,879	1,985	2,676	1,384
7-8 pm	1,143	1,446	1,656	1,946	1,236
8-9 pm	985	1,068	1,213	2,089	1,042
9-10 pm	811	818	931	2,185	934
10-11 pm	647	664	759	1,737	816
11 pm-12 am	522	507	585	1,049	648
Totals:	23,988	22,742	24,491	33,215	28,900

Total (pce/hr)	Sun	Mon	Tue-Thu	Fri	Sat
12-1 am	577	424	562	613	798
1-2 am	354	265	375	470	532
2-3 am	261	175	293	284	360
3-4 am	169	184	264	290	281
4-5 am	146	204	294	309	261
5-6 am	185	365	397	414	294
6-7 am	292	524	607	644	504
7-8 am	618	785	841	979	1,019
8-9 am	1,000	885	968	1,075	1,624
9-10 am	1,417	891	955	1,311	1,928
10-11 am	1,666	1,169	1,170	1,417	2,212
11 am-12 pm	1,960	1,272	1,324	1,628	2,274
12-1 pm	2,057	1,382	1,339	1,827	2,057
1-2 pm	1,944	1,299	1,425	1,738	2,223
2-3 pm	1,826	1,481	1,510	2,022	2,068
3-4 pm	1,628	1,835	1,960	2,559	1,862
4-5 pm	1,535	2,344	2,484	2,815	1,745
5-6 pm	1,439	2,370	2,440	2,857	1,610
6-7 pm	1,249	2,000	2,097	2,781	1,416
7-8 pm	1,174	1,540	1,759	2,027	1,263
8-9 pm	1,012	1,152	1,294	2,161	1,067
9-10 pm	837	899	1,004	2,263	955
10-11 pm	679	735	830	1,807	835
11 pm-12 am	554	569	644	1,109	666
Totals:	24,575	24,748	26,838	35,401	29,853

EB Factored AAHT*

Total (veh/hr)	Sun	Mon	Tue-Thu	Fri	Sat
12-1 am**	615	700	492	507	529
1-2 am	364	457	282	345	311
2-3 am	240	346	247	304	261
3-4 am	187	421	319	359	222
4-5 am	204	734	621	590	299
5-6 am	273	1,654	1,360	1,300	445
6-7 am	391	2,498	2,199	1,995	646
7-8 am	475	2,158	2,004	1,887	772
8-9 am	637	1,614	1,571	1,483	957
9-10 am	925	1,388	1,312	1,299	1,160
10-11 am	1,386	1,244	1,168	1,212	1,441
11 am-12 pm	1,733	1,268	1,095	1,313	1,577
12-1 pm	2,022	1,223	1,073	1,358	1,715
1-2 pm	2,132	1,277	1,104	1,466	1,587
2-3 pm	2,378	1,304	1,205	1,531	1,661
3-4 pm	2,456	1,216	1,225	1,627	1,684
4-5 pm	2,633	1,169	1,297	1,587	1,662
5-6 pm	2,627	1,155	1,180	1,536	1,861
6-7 pm	2,576	1,140	1,123	1,490	1,767
7-8 pm	2,461	942	994	1,263	1,496
8-9 pm	2,258	874	860	1,054	1,388
9-10 pm	2,033	795	790	964	1,273
10-11 pm	1,781	709	694	823	987
11 pm-12 am	980	566	545	625	723
Totals:	33,766	26,853	24,757	27,919	26,425

* AAHT = Average Annual Hourly Traffic - similar to AADT but provided for each hour of each day of the week. Here is AADT data:

AADT	
26,046	WB
27,033	EB
53,079	Total

Truck %	
14%	WB

** EB volume data from 12-1 am was not available from DRJTBC. It was estimated by comparing the preceding and following hours of EB data with the same hours of WB data to obtain a EB/WB factor. That factor was applied to WB 12-1 am volumes to obtain the EB volumes. To account for different weekend peak characteristics, EB Saturday from 12-1 am was compared to WB Sunday from 12-1 am and EB Monday from 12-1 am was compared to WB Saturday from 12-1 am.

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
MONDAY AFTERNOON TO TUESDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	1382	SHLD	2	3780	0	0	0	0	0.84			25		
1-2	1299	SHLD	2	3780	0	0	0	0	0.84			24		
2-3	1481	SHLD	2	3780	0	0	0	0	0.84			27		
3-4	1835	NO	2	4500	0	0	0	0	1.00			33		
4-5	2344	NO	2	4500	0	0	0	0	1.00			43		
5-6	2370	NO	2	4500	0	0	0	0	1.00			43		
6-7	2000	NO	2	4500	0	0	0	0	1.00			36		
7-8	1540	SHLD	2	3780	0	0	0	0	0.84			28		
8-9	1152	LANE	1	1620	0	0	0	0	0.36			21		
9-10	899	LANE	1	1620	0	0	0	0	0.36			16		
10-11	735	LANE	1	1620	0	0	0	0	0.36			13		
11p-12a	569	LANE	1	1620	0	0	0	0	0.36			10		
12-1 am	562	LANE	1	1620	0	0	0	0	0.36			10		
1-2	375	LANE	1	1620	0	0	0	0	0.36			7		
2-3	293	LANE	1	1620	0	0	0	0	0.36			5		
3-4	264	LANE	1	1620	0	0	0	0	0.36			5		
4-5	294	LANE	1	1620	0	0	0	0	0.36			5		
5-6	397	LANE	1	1620	0	0	0	0	0.36			7		
6-7	607	NO	2	4500	0	0	0	0	1.00			11		
7-8	841	NO	2	4500	0	0	0	0	1.00			15		
8-9	968	NO	2	4500	0	0	0	0	1.00			18		
9-10	955	SHLD	2	3780	0	0	0	0	0.84			17		
10-11	1170	SHLD	2	3780	0	0	0	0	0.84			21		
11a-12p	1324	SHLD	2	3780	0	0	0	0	0.84			24		
	25656							0						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
TUESDAY AFTERNOON TO WEDNESDAY MORNING AND WEDNESDAY AFTERNOON TO THURSDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	1339	SHLD	2	3780	0	0	0	0	0.84			24		
1-2	1425	SHLD	2	3780	0	0	0	0	0.84			26		
2-3	1510	SHLD	2	3780	0	0	0	0	0.84			27		
3-4	1960	NO	2	4500	0	0	0	0	1.00			36		
4-5	2484	NO	2	4500	0	0	0	0	1.00			45		
5-6	2440	NO	2	4500	0	0	0	0	1.00			44		
6-7	2097	NO	2	4500	0	0	0	0	1.00			38		
7-8	1759	SHLD	2	3780	0	0	0	0	0.84			32		
8-9	1294	LANE	1	1620	0	0	0	0	0.36			24		
9-10	1004	LANE	1	1620	0	0	0	0	0.36			18		
10-11	830	LANE	1	1620	0	0	0	0	0.36			15		
11p-12a	644	LANE	1	1620	0	0	0	0	0.36			12		
12-1 am	562	LANE	1	1620	0	0	0	0	0.36			10		
1-2	375	LANE	1	1620	0	0	0	0	0.36			7		
2-3	293	LANE	1	1620	0	0	0	0	0.36			5		
3-4	264	LANE	1	1620	0	0	0	0	0.36			5		
4-5	294	LANE	1	1620	0	0	0	0	0.36			5		
5-6	397	LANE	1	1620	0	0	0	0	0.36			7		
6-7	607	NO	2	4500	0	0	0	0	1.00			11		
7-8	841	NO	2	4500	0	0	0	0	1.00			15		
8-9	968	NO	2	4500	0	0	0	0	1.00			18		
9-10	955	SHLD	2	3780	0	0	0	0	0.84			17		
10-11	1170	SHLD	2	3780	0	0	0	0	0.84			21		
11a-12p	1324	SHLD	2	3780	0	0	0	0	0.84			24		
	26838							0						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
THURSDAY AFTERNOON TO FRIDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	1339	SHLD	2	3780	0	0	0	0	0.84			24		
1-2	1425	SHLD	2	3780	0	0	0	0	0.84			26		
2-3	1510	SHLD	2	3780	0	0	0	0	0.84			27		
3-4	1960	NO	2	4500	0	0	0	0	1.00			36		
4-5	2484	NO	2	4500	0	0	0	0	1.00			45		
5-6	2440	NO	2	4500	0	0	0	0	1.00			44		
6-7	2097	NO	2	4500	0	0	0	0	1.00			38		
7-8	1759	SHLD	2	3780	0	0	0	0	0.84			32		
8-9	1294	LANE	1	1620	0	0	0	0	0.36			24		
9-10	1004	LANE	1	1620	0	0	0	0	0.36			18		
10-11	830	LANE	1	1620	0	0	0	0	0.36			15		
11p-12a	644	LANE	1	1620	0	0	0	0	0.36			12		
12-1 am	613	LANE	1	1620	0	0	0	0	0.36			11		
1-2	470	LANE	1	1620	0	0	0	0	0.36			9		
2-3	284	LANE	1	1620	0	0	0	0	0.36			5		
3-4	290	LANE	1	1620	0	0	0	0	0.36			5		
4-5	309	LANE	1	1620	0	0	0	0	0.36			6		
5-6	414	LANE	1	1620	0	0	0	0	0.36			8		
6-7	644	NO	2	4500	0	0	0	0	1.00			12		
7-8	979	NO	2	4500	0	0	0	0	1.00			18		
8-9	1075	NO	2	4500	0	0	0	0	1.00			20		
9-10	1311	SHLD	2	3780	0	0	0	0	0.84			24		
10-11	1417	SHLD	2	3780	0	0	0	0	0.84			26		
11a-12p	1628	SHLD	2	3780	0	0	0	0	0.84			30		
	28221							0						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
FRIDAY AFTERNOON TO SATURDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	1827	SHLD	2	3780	0	0	0	0	0.84			33		
1-2	1738	SHLD	2	3780	0	0	0	0	0.84			32		
2-3	2022	SHLD	2	3780	0	0	0	0	0.84			37		
3-4	2559	NO	2	4500	0	0	0	0	1.00			47		
4-5	2815	NO	2	4500	0	0	0	0	1.00			51		
5-6	2857	NO	2	4500	0	0	0	0	1.00			52		
6-7	2781	NO	2	4500	0	0	0	0	1.00			51		
7-8	2027	SHLD	2	3780	0	0	0	0	0.84			37		
8-9	2161	SHLD	2	3780	0	0	0	0	0.84			39		
9-10	2263	LANE	1	1620	643	643	322	1620	0.36	6	251	41	1.5	0.21
10-11	1807	LANE	1	1620	187	831	737	1620	0.36	6	251	33	3.4	0.46
11p-12a	1109	LANE	1	1620	0	320	575	1620	0.36	6	251	20	2.5	0.34
12-1 am	798	LANE	1	1620	0	0	160	630	0.36	6	251	15	0.7	0.09
1-2	532	LANE	1	1620	0	0	0	0	0.36			10		
2-3	360	LANE	1	1620	0	0	0	0	0.36			7		
3-4	281	LANE	1	1620	0	0	0	0	0.36			5		
4-5	261	LANE	1	1620	0	0	0	0	0.36			5		
5-6	294	LANE	1	1620	0	0	0	0	0.36			5		
6-7	504	LANE	1	1620	0	0	0	0	0.36			9		
7-8	1019	LANE	1	1620	0	0	0	0	0.36			19		
8-9	1624	SHLD	2	3780	0	0	0	0	0.84			30		
9-10	1928	SHLD	2	3780	0	0	0	0	0.84			35		
10-11	2212	SHLD	2	3780	0	0	0	0	0.84			40		
11a-12p	2274	SHLD	2	3780	0	0	0	0	0.84			41		
	38054							5490						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
FRIDAY AFTERNOON TO SATURDAY MORNING - 15% HIGHER VOLUMES

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	2101	SHLD	2	3780	0	0	0	0	0.84			38		
1-2	1999	SHLD	2	3780	0	0	0	0	0.84			36		
2-3	2325	SHLD	2	3780	0	0	0	0	0.84			42		
3-4	2943	NO	2	4500	0	0	0	0	1.00			54		
4-5	3238	NO	2	4500	0	0	0	0	1.00			59		
5-6	3285	NO	2	4500	0	0	0	0	1.00			60		
6-7	3199	NO	2	4500	0	0	0	0	1.00			58		
7-8	2331	SHLD	2	3780	0	0	0	0	0.84			42		
8-9	2485	SHLD	2	3780	0	0	0	0	0.84			45		
9-10	2603	LANE	1	1620	983	983	492	1620	0.36	6	251	47	2.4	0.33
10-11	2078	LANE	1	1620	458	1441	1212	1620	0.36	6	251	38	5.7	0.78
11p-12a	1276	LANE	1	1620	0	1097	1269	1620	0.36	6	251	23	5.6	0.76
12-1 am	917	LANE	1	1620	0	394	746	1620	0.36	6	251	17	3.2	0.44
1-2	612	LANE	1	1620	0	0	197	633	0.36	6	251	11	0.8	0.11
2-3	414	LANE	1	1620	0	0	0	0	0.36			8		
3-4	323	LANE	1	1620	0	0	0	0	0.36			6		
4-5	300	LANE	1	1620	0	0	0	0	0.36			5		
5-6	338	LANE	1	1620	0	0	0	0	0.36			6		
6-7	580	LANE	1	1620	0	0	0	0	0.36			11		
7-8	1172	LANE	1	1620	0	0	0	0	0.36			21		
8-9	1867	SHLD	2	3780	0	0	0	0	0.84			34		
9-10	2218	SHLD	2	3780	0	0	0	0	0.84			40		
10-11	2544	SHLD	2	3780	0	0	0	0	0.84			46		
11a-12p	2615	SHLD	2	3780	0	0	0	0	0.84			48		
	43762							7113						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
SATURDAY AFTERNOON TO SUNDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	2057	SHLD	2	3780	0	0	0	0	0.84			37		
1-2	2223	SHLD	2	3780	0	0	0	0	0.84			40		
2-3	2068	SHLD	2	3780	0	0	0	0	0.84			38		
3-4	1862	SHLD	2	3780	0	0	0	0	0.84			34		
4-5	1745	SHLD	2	3780	0	0	0	0	0.84			32		
5-6	1610	SHLD	2	3780	0	0	0	0	0.84			29		
6-7	1416	SHLD	2	3780	0	0	0	0	0.84			26		
7-8	1263	SHLD	2	3780	0	0	0	0	0.84			23		
8-9	1067	SHLD	2	3780	0	0	0	0	0.84			19		
9-10	955	LANE	1	1620	0	0	0	0	0.36			17		
10-11	835	LANE	1	1620	0	0	0	0	0.36			15		
11p-12a	666	LANE	1	1620	0	0	0	0	0.36			12		
12-1 am	577	LANE	1	1620	0	0	0	0	0.36			10		
1-2	354	LANE	1	1620	0	0	0	0	0.36			6		
2-3	261	LANE	1	1620	0	0	0	0	0.36			5		
3-4	169	LANE	1	1620	0	0	0	0	0.36			3		
4-5	146	LANE	1	1620	0	0	0	0	0.36			3		
5-6	185	LANE	1	1620	0	0	0	0	0.36			3		
6-7	292	LANE	1	1620	0	0	0	0	0.36			5		
7-8	618	LANE	1	1620	0	0	0	0	0.36			11		
8-9	1000	LANE	1	1620	0	0	0	0	0.36			18		
9-10	1417	SHLD	2	3780	0	0	0	0	0.84			26		
10-11	1666	SHLD	2	3780	0	0	0	0	0.84			30		
11a-12p	1960	SHLD	2	3780	0	0	0	0	0.84			36		
	26409							0						

QUEUING WORKSHEET - ROUTE I-80 WESTBOUND
SUNDAY AFTERNOON TO MONDAY MORNING

Number of lanes when there is no work zone:	2	Per-lane roadway capacity, no work zone:	2250	pcephpl
Number of lanes when work zone is in place:	1	Estimated free-flow speed (mph):	55	
Lane width in work zone (ft):	12	Passenger car equivalents per truck:	1.5	
Length of work zone (miles):	2	Per-lane capacity, shoulder closed (pcephpl):	1890	
Posted work zone speed limit (mph):	40	Per-lane capacity, lane closed (pcephpl):	1620	

					Units of passenger cars per hour									
Hour	Demand (pce/hr)	Work Zone	Lanes Open	Roadway Capacity (pce)	Added Queued Vehicles	Queued Vehicles at End of Hour	Average Queued Vehicles	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)
12-1 pm	2057	SHLD	2	3780	0	0	0	0	0.84			37		
1-2	1944	SHLD	2	3780	0	0	0	0	0.84			35		
2-3	1826	SHLD	2	3780	0	0	0	0	0.84			33		
3-4	1628	SHLD	2	3780	0	0	0	0	0.84			30		
4-5	1535	SHLD	2	3780	0	0	0	0	0.84			28		
5-6	1439	SHLD	2	3780	0	0	0	0	0.84			26		
6-7	1249	SHLD	2	3780	0	0	0	0	0.84			23		
7-8	1174	SHLD	2	3780	0	0	0	0	0.84			21		
8-9	1012	SHLD	2	3780	0	0	0	0	0.84			18		
9-10	837	LANE	1	1620	0	0	0	0	0.36			15		
10-11	679	LANE	1	1620	0	0	0	0	0.36			12		
11p-12a	554	LANE	1	1620	0	0	0	0	0.36			10		
12-1 am	424	LANE	1	1620	0	0	0	0	0.36			8		
1-2	265	LANE	1	1620	0	0	0	0	0.36			5		
2-3	175	LANE	1	1620	0	0	0	0	0.36			3		
3-4	184	LANE	1	1620	0	0	0	0	0.36			3		
4-5	204	LANE	1	1620	0	0	0	0	0.36			4		
5-6	365	LANE	1	1620	0	0	0	0	0.36			7		
6-7	524	NO	2	4500	0	0	0	0	1.00			10		
7-8	785	NO	2	4500	0	0	0	0	1.00			14		
8-9	885	NO	2	4500	0	0	0	0	1.00			16		
9-10	891	SHLD	2	3780	0	0	0	0	0.84			16		
10-11	1169	SHLD	2	3780	0	0	0	0	0.84			21		
11a-12p	1272	SHLD	2	3780	0	0	0	0	0.84			23		
	23075							0						

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO:	**Record**
FROM:	**Bhavesh Shah- North Region** **Division of Project Development**
DATE:	**May 11, 2011**
PHONE:	**(609) 530- 8078**
SUBJECT:	**Rt. I-80, MP. 1.04- 1.45** **Township of Hardwick, Warren County** **Projected Traffic Count Volume**

Traffic Design Data

2011 ADT (2-way)	= 78,880 vpd
2031 ADT (2- way)	= 117,210 vpd
2031 DHV (2- way)	= 11,710 vph
2031 Directional Distribution	= 66%
2031 Heavy Truck % in Peak Hour	= 17%

Pavement Design Data

2011 ADT (1-way)	= 39,630 vpd
2031 ADT (1-way)	= 58,900 vpd
2031 Heavy Truck % in 24 Hour	= 20%
2031 Total Truck in 24 Hours	= 32%

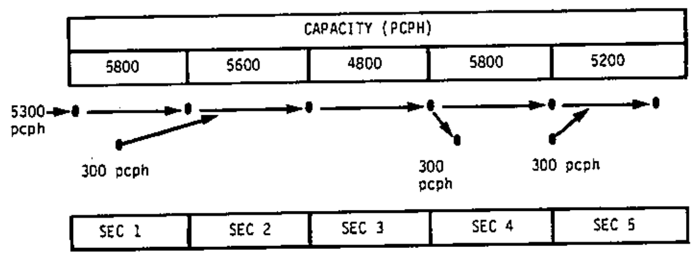


Figure 6-9. Potential for hidden bottlenecks.

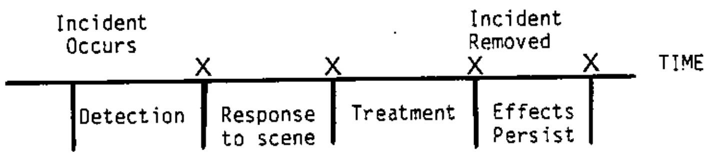


Figure 6-10. Phases of a traffic incident.

now outputs a flow rate higher than 5,200 pcph, a *bottleneck will appear at segment 5 for the first time.* It was always there, but only the solution of the segment 3 problem allowed the demand to attain levels necessary to exhibit it. That is, it was "hidden" by the upstream bottleneck in segment 3.

A complete capacity analysis of the facility should be conducted to avoid the "hidden bottleneck" problem. In doing so, changes in flow due to the improvements must be anticipated. For instance, is the off-ramp in segment 4 shown at a level of 300 pcph because it is the true demand or because it is, the observed amount which could get past the original bottleneck? In addition, it must be recognized that the service flow rates in some sections (e.g., weaving sections) are functions of the traffic mix, which may change.

Because the flow pattern may be distorted, it is important to have some knowledge of the origin-destination pattern of traffic. Further, the origin-destination pattern influences what *can* be done and what *should* be done. Consider a freeway on which virtually all the outlying ramp entries stay on the facility until it terminates in the downtown area. Consider an identical physical facility, but with traffic using it for many short trips, with much outlying traffic exiting before another "layer" of traffic enters. The control opportunities and the equity of various control options vary radically between these two extremes.

INCIDENTS

Incidents occur relatively commonly on traffic facilities, although it is standard practice to design to a level of service for the nonincident condition. Clearly, incidents require attention because they:

- Disrupt the level of service being provided.
- Reduce the capacity radically.
- Present hazards to the motorists, particulary those directly involved.

Certainly incident response is desired in order to provide assistance to the motorists involved (tow, medical, police) as the need arises. Incident response can also be directed to minimizing the impact on other vehicles and to recovering use of the facility.

One study (*4*) showed that an incident removed to the shoulder on a three-lane facility still reduced capacity by one-third; a single-lane blockage reduced capacity by 50 percent; a two-lane blockage reduced capacity by 79 percent. In addition to the magnitude of the impact, the *duration* must also be considered. Refer to Figure 6-10, which identifies four critical phases of an incident history. Analogous to the ramp metering illustration under section heading, "Control Elements," the effect can persist long after the incident itself is removed because of the backups created. At one facility (*5*), it was estimated that peak-period incidents were responsible for more delay than recurrent peak period congestion at the location in question.

Incidents may be detected by video-observation, audio-reports (call-boxes, CB), or roadway sensors. Incidents may be responded to by some combination of required assistance, ramp restrictions or closure, and alternative route advisories. The control actions may be preplanned or dynamic decisions.

IV. CAPACITY OF FREEWAY WORK ZONES

One of the more frequently occurring disruptions to traffic flow on freeways is the required maintenance operations that must take place periodically, either as part of regular maintenance programs or to correct physical defects in the roadway, roadside, or supporting structures. An assessment of capacity is a necessary part of the planning of traffic control strategies during maintenance operations if severe disruptions and delays to traffic are to be avoided. This section details the results of several work zone capacity studies that provide considerable insight (*26, 27, 28*).

It should be noted that work zone capacities will vary depending on the exact nature of the work being done, the number and size of equipment at the site, and the exact location of equipment and crews with respect to moving lanes of traffic. Thus, the criteria and observations cited herein must be taken as averages subject to some variation.

CAPACITY WITH WORK CREW AT SITE

Figure 6-11 shows the range of capacities measured at several worksites in Texas, with an active work crew at the site. The observations are taken to be approximate capacities, as continuous queues of vehicles were present upstream of the sites included.

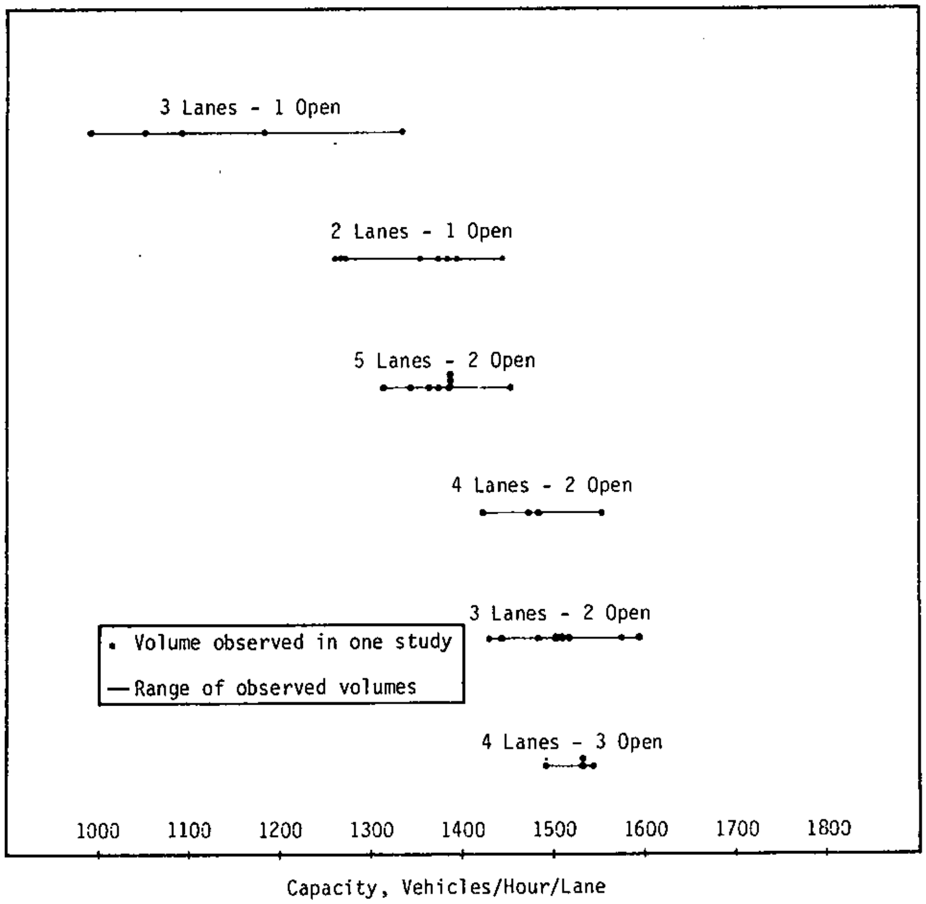


Figure 6-11. Range of observed work zone capacities—work crew at site. (Source: C.L. Dudek and S.H. Richards, "Traffic Capacity Through Urban Freeway Work Zones in Texas," *Transportation Research Record 869,* 1982)

The designation (A,B) is used to identify the various lane closure situations evaluated. "A" represents the normal number of lanes in one direction, while "B" represents the number of lanes open during maintenance operations. Table 6-1 gives the *average* capacity for each closure situation studied.

Average open-lane capacities for (4,2), (3,2), and (4,3) closures are approximately 1,500 vphpl. For (5,2) and (2,1) closures, the reductions are more severe, in the range of 1,350 vphpl. The capacities of (3,1) closures were the most damaging, averaging only 1,170 vphpl.

Figure 6-12 shows the cumulative distributions of the observed work zone capacities. The function of this illustration is to assist analysts in identifying the risks in using certain capacity values for given lane closures. For example, the 85th percentile capacity for a (3,1) closure is only 1,030 vphpl. The average capacity for this situation (1,170 vphpl) occurs at the 58th percentile. Thus, use of the average value in analysis leads to an overestimate in capacity (and consequently, an underestimate of queues and delays) in 42 percent of the cases to which it is applied, based on the observed range of values. Given the variation in observed capacities, analysts may wish to use 85th or higher percentile values, rather than averages, to reduce the risk of capacity overestimates.

Because of the limited amount of data available, it is not possible to statistically correlate capacity to the particular type of road work taking place. Table 6-2, however, tabulates individual observations vs. the type of maintenance operations for informational purposes. Note that flow through the work zone is also affected by presence of merging, diverging, or weaving movements, grades, alignment, truck presence, and other factors. The data in Table 6-2 reflect studies in both Texas and California. California observations represent peak flow rates, while the Texas data reflect full-hour capacities.

TABLE 6-1. MEASURED AVERAGE WORK ZONE CAPACITIES

NUMBER OF LANES A NORMAL	NUMBER OF LANES B OPEN	NUMBER OF STUDIES	AVERAGE CAPACITY (VPH)	AVERAGE CAPACITY (VPHPL)
3	1	7	1,170	1,170
2	1	8	1,340	1,340
5	2	8	2,740	1,370
4	2	4	2,960	1,480
3	2	9	2,980	1,490
4	3	4	4,560	1,520

SOURCE: Ref. *29*

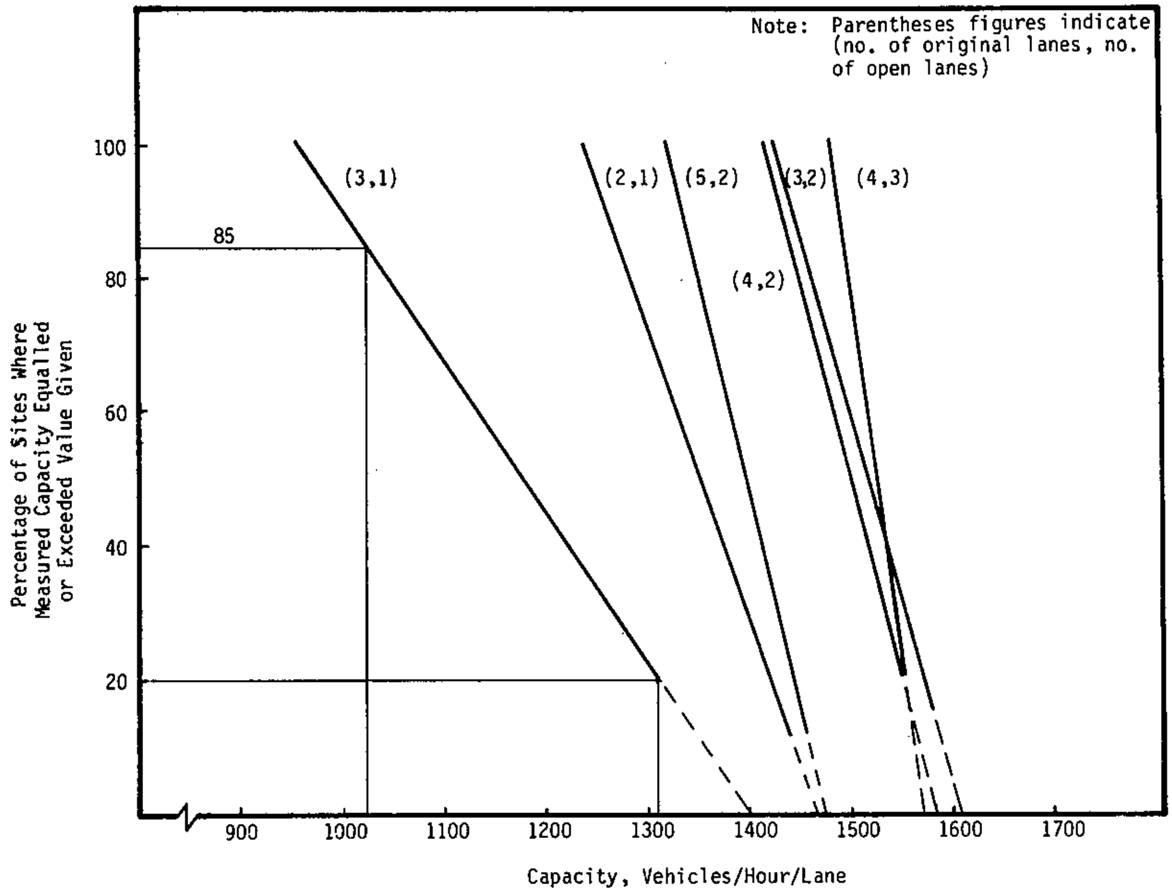


Figure 6-12. Cumulative distribution of observed work zone capacities. (Source: C.L. Dudek and S.H. Richards, "Traffic Capacity Through Urban Freeway Work Zones in Texas," *Transporation Research Record 869,* 1982)

TABLE 6-2. SUMMARY OF OBSERVED CAPACITIES FOR SOME TYPICAL OPERATIONS (VPH)*

NO. OF LANES IN ONE DIR. NORMAL OPER. / DURING WORK	3 / 1	2 / 1	5 / 2	3 or 4 / 2	4 / 3
TYPE OF WORK					
Median Barrier/Guardrail Installation/Repair	—	1,500	—	3,200 2,940[a]	4,800 4,570[a]
Pavement Repair	1,050[a]	1,400	—	3,000 2,900[a]	4,500
Resurfacing, Asphalt Removal	1,050[a]	1,200 1,300[a]	2,750[a]	2,600 2,900[a]	4,000
Striping, Slide Removal	—	1,200	—	2,600	4,000
Pavement Markers	—	1,100	—	2,400	3,600
Bridge Repair	1,350[a]	1,350[a]	—	2,200	3,400

[a] Texas data, full-hour capacities; all other data are from California, expressed as peak flow rates.
* Adapted from Ref. *31*.

TABLE 6-3. CAPACITY OF LONG-TERM CONSTRUCTION SITES WITH PORTABLE CONCRETE BARRIERS

NUMBER OF LANES NORMAL	OPEN	NUMBER OF STUDIES	CAPACITY RANGE (VPHPL)	AVG. CAPACITY VPH	VPHPL
3	2	7	1,780–2,060	3,720	1,860
2	1	3	—	1,550	1,550

SOURCE: Ref. *29*

LONG-TERM CONSTRUCTION SITES—WORK AREA SEPARATED FROM TRAFFIC BY PORTABLE CONCRETE BARRIERS

Table 6-3 illustrates the results of 10 studies of locations with long-term, more permanent types of construction operations in progress. Note that the capacities at such sites are higher than those for more temporary disruptions primarily because of the use of more permanent barriers and other controls, and the dissipation of "rubber-necking" as drivers become familiar with the site.

CAPACITY AT SHORT-TERM MAINTENANCE SITES WITH NO WORK ACTIVITY ADJACENT TO TRAFFIC

One study was conducted in Houston, Texas, where the right two lanes of a four-lane section were closed to traffic. No work activity, however, was in the lane immediately adjacent to moving traffic. In effect, the closure included one full buffer lane between traffic and maintenance operations. Although capacity operations were not observed, capacity of the location was estimated to be about 1,800 vphpl, considerably larger than a standard (4,2) closure with work activities taking place in the lane adjacent to moving traffic.

SHOULDER USE AND TRAFFIC SPLITTING ON THREE-LANE SEGMENTS

Generally, when work is required on the middle lane of a three-lane section, both the middle and one of the exterior lanes are closed. Table 6-1 indicates that the average capacity of the single open lane is 1,170 vphpl. Several studies have indicated that this capacity can be increased to 3,000 vph by using a traffic control approach called "shifting," in which drivers are encouraged to use the shoulder as an additional traffic lane, thereby leaving two effective lanes for traffic movement. "Shifting" is generally accomplished through the use of traffic cones directing drivers onto the shoulder and adjacent shoulder lane.

This same capacity could be achieved using the "splitting" approach, in which only the middle lane is closed, and traffic is permitted to move on both sides of the work activity. Since such an operation is often confusing to drivers, a control approach is recommended in which the left lane is closed as much as 1,000 to 1,500 ft upstream of the site. Thus, only two lanes approach the site. At the maintenance zone, cones are used to direct one lane to the left and one lane to the right of the closed middle lane.

LANE NARROWING

One study in Houston considered the effect of lane narrowing without closures due to maintenance or construction operations. The subject sites included lane-width reductions to 10 and 11 ft, with portable concrete barriers used to separate moving traffic from work operations. Capacities in the range of 1,800 vphpl were observed at these sites, which included both three- and four-lane segments.

ESTIMATING QUEUE LENGTH AND DELAY

Figure 6-6, presented earlier, illustrates a graphic technique for estimating queue buildup and delays for breakdown conditions. This same technique can be applied to work zones where arrival or demand flows exceed the capacity of the work zone for some period of time. In particular, the length of the queue may be estimated as:

$$L_t = \frac{Q_t \times \ell}{N} \tag{6-1}$$

where:

L_t = length of queue, in ft;
Q_t = number of vehicles in queue at time t;
N = number of open lanes upstream of the site; and
ℓ = average length of vehicle.

The value of Q_t would be found using the graphic technique illustrated in Figure 6-6.

SAMPLE CALCULATION

Consider the case of a maintenance operation requiring the closure of the median lane of a three-lane freeway segment. The work will require four hours to complete, including the installation and removal of traffic control devices. Data obtained from a nearby traffic counter during the previous two weeks were used to estimate the following demand pattern:

Time Period	Volume Anticipated (vph)
9 to 10 AM	2,920
10 to 11	3,120
11 to 12 Noon	3,200
12 to 1 PM	3,500
1 to 2	3,830
2 to 3	3,940
3 to 4	4,620
4 to 5	5,520

Referring to Table 6-1 and Figure 6-11, it is seen that the average capacity for a (3,2) work zone configuration is 1,500 vphpl or 3,000 vph. The 85th percentile capacity is 1,450 vphpl or 2,900 vph, and the 100th percentile capacity is 1,420 vphpl or 2,840 vph. Assuming these capacity values, Figure 6-13 illustrates the graphical depiction of queue build-up and delays.

In Figure 6-13, work is assumed to begin at 9 AM. The estimated queue length at 1 PM, four hours after the beginning of work, and the time work is assumed to stop, is 2.1 mi based on the average capacity of 3,000 vph. This, however, is a 58th percentile value. Thus, the queue would be longer than this value 42 percent of the time. If the 85th percentile capacity is used, the queue reaches 2.9 mi, but would be exceeded only 15 percent of the time. The 100th percentile queue length reaches 3.5 mi, which is not expected to be exceeded under most circumstances.

Clearly, such a back-up would be most undesirable, and other options would be explored in terms of the work zone operations, including:

and maintenance activities, adverse weather, and traffic accidents/vehicular breakdowns. Conversely, capacity can be increased to match field measurements. In analyzing adjusted capacity, use of an alternative speed-flow relationship is important. The computational details for this case are provided later in this chapter.

Permanent Capacity Reduction

A lane drop is in many ways the simplest capacity-reducing situation to deal with. Capacity in both segments, that with the smaller number of lanes and that with the larger number, can be calculated using Chapter 23, 24, or 25 methodologies. So long as the arriving demand is less than the lower capacity, no queue will form upstream of the lane drop. If the arriving demand begins to exceed the reduced capacity, a queue will begin to form immediately upstream of the reduced-capacity section, which will have become a bottleneck. Some results suggest that a poorly designed merge at the lane drop can negatively affect the capacity of the segment with the smaller number of lanes because of the increase in friction and turbulence, but this effect has not yet been quantified.

Construction Activities Capacity Reduction

Capacity reductions due to construction activities can be divided into short-term maintenance work zone lane closures and long-term construction zone closures. One of the primary distinctions between short-term work zones and long-term construction zones is the nature of the barriers used to demarcate the work area. Long-term construction zones generally have portable concrete barriers; short-term work zones use standard channeling devices (traffic cones, drums) in accordance with the *Manual on Uniform Traffic Control Devices* (2). Generally, reduction of capacity brought about by reconstruction or major maintenance activities will last for several weeks or even months, although some short-term maintenance activities last only a few hours.

Short-Term Work Zones

Research (*3*) suggests that a capacity of 1,600 pc/h/ln be used for short-term freeway work zones, regardless of the lane closure configurations. For some types of closures, capacity may be higher (*3*).

The base value should be adjusted for other conditions, as follows.

Intensity of work will affect capacity

• Intensity of work activity: The intensity of work activity refers to the number of workers on site, the number and size of work vehicles in use, and the proximity of work to the travel lanes in use. Unusual types of work also contribute to the apparent intensity, simply in terms of the rubbernecking factor. Research data did not result in explicit quantification of these effects, but it is suggested that the capacity of 1,600 pc/h/ln be adjusted by up to ±10 percent for work activity that is more or less intense than normal (*3*). The research did not define what constitutes normal intensity. Hence, this factor should be applied on the basis of professional judgment, recognizing that 1,600 pc/h/ln is an average over a variety of conditions.

Heavy vehicles should be accounted for

• Effects of heavy vehicles: It is recommended that the heavy-vehicle adjustment factor, f_{HV}, found elsewhere in the manual be used to account for the effect of heavy vehicles in the traffic stream moving through the work zone, as shown in Equation 22-1.

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \quad (22\text{-}1)$$

where

f_{HV} = heavy-vehicle adjustment factor,
P_T = proportion of heavy vehicles, and
E_T = passenger-car equivalent for heavy vehicles.

The value of E_T can be taken from Chapter 23, Basic Freeway Segments.

Entrance ramps within 500 ft of a lane closure will affect capacity

- Presence of ramps: If there is an entrance ramp within the taper area approaching the lane closure or within 500 ft downstream of the beginning of the full lane closure, the ramp will have a noticeable effect on the capacity of the work zone for handling mainline traffic. This arises in two ways. First, the ramp traffic will generally force its way in, so it will directly reduce the amount of mainline traffic that can be handled. Second, the added turbulence in the merging area due to the entrance ramp may itself reduce the capacity slightly. If at all possible, ramps should be located at least 1,500 ft upstream from the beginning of the full closure to maximize the total work zone throughput. If that cannot be done, then either the ramp volume should be added to the mainline volume to be served or the capacity of the work zone should be decreased by the ramp volume (up to a maximum of half of the capacity of one lane, on the assumption that at very high volumes mainline and ramp vehicles will alternate). Equation 22-2 is used to compute the resulting reduced capacity.

$$c_a = (1{,}600 + I - R) * f_{HV} * N \qquad (22\text{-}2)$$

where

c_a = adjusted mainline capacity (veh/h);
f_{HV} = adjustment for heavy vehicles as defined in Equation 22-1;
I = adjustment factor for type, intensity, and location of the work activity, as discussed above (ranges from –160 to +160 pc/h/ln);
R = adjustment for ramps, as described in the preceding paragraph; and
N = number of lanes open through the short-term work zone.

Long-Term Construction Zones

For long-term construction zones, capacity values are given in Exhibit 22-4. If traffic crosses over to lanes that are normally used by the opposite direction of travel, the capacity is close to the 1,550 veh/h/ln value in Exhibit 22-4 (*5*). If no crossover is needed, but only a merge down to a single lane, the value is typically higher and may average about 1,750 veh/h/ln (*6*).

EXHIBIT 22-4. SUMMARY OF CAPACITY VALUES FOR LONG-TERM CONSTRUCTION ZONES

No. of Normal Lanes	Lanes Open	Number of Studies	Range of Values (veh/h/ln)	Average per Lane (veh/h/ln)
3	2	7	1780–2060	1860
2	1	3	–	1550

Source: Dudek (*4*).

Lane Width Consideration

An additional adjustment factor can be added to the long-term and short-term reduction model for the effect of lane width (*7*). For traffic with passenger cars only, headways increase by about 10 percent in going from 11-ft widths to 10.5- or 10-ft widths and by an additional 6 percent in going to 9-ft widths. These increases in headways translate to 9 and 14 percent drops in capacity for the narrower lane widths within construction zones.

Adverse Weather Capacity Reduction

There have been several research studies on the effect of rain, snow, and fog. It has become clear that adverse weather can significantly reduce not only capacity but also operating speeds. The following sections discuss the effects of each of these weather conditions and address the issue of when and how to take these effects into account in applying the methodology.

FINAL REPORT

EVALUATION OF CONSTRUCTION WORK ZONE OPERATIONAL ISSUES: CAPACITY, QUEUE AND DELAY

Rahim F. Benekohal
Ahmed-Zameem Kaja-Mohideen
Madhav V. Chitturi

Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
205 N. Mathews Ave.
Urbana, Illinois 61801
Phone (217) 244-6288
Fax (217) 333-1924
Email rbenekoh@uiuc.edu

A study report for
ITRC Project IVA-H1, FY 00/01
Evaluation of Construction Work Zone Operational Issues

Report prepared for
Illinois Department of Transportation

Through
Illinois Transportation Research Center

December 2003

EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) Bureau of Design and Environment (BDE) Manual requires that traffic control plans for freeway reconstruction projects include, as a minimum, a queuing analysis to determine the anticipated traffic backups. Based on the results of the queuing analysis a decision is made to consider restricting construction operations to off-peak or night hours, using alternative routes, making temporary capacity improvements, or providing real-time information to motorists. To reduce delay and inconvenience to motorists, contractual procedures (such as lane rental and incentive/disincentive (I/D)) are used to shorten the duration of construction time. The monetary gains/losses in the contractual procedures depend, to a large degree, on the results of the queuing analysis. A limited number of methods are available to estimate motorist delays and queuing in work zones, but they are not considered "user-friendly," do not give accurate estimates in all situations, and are not uniformly applied by all IDOT districts. The purpose of this research project was to study contract incentive/disincentive procedures for minimizing lane closures; to evaluate queuing analysis procedures and relevant factors affecting queue length and road user costs; to evaluate the performance of current techniques for estimating delays and queue lengths, to assess the role of intelligent transportation systems (ITS) in work zones, and to recommend a queuing analysis and road user cost estimation method.

Literature reviews on incentive/disincentive and lane rental, work zone capacity calculation, and role of ITS in work zones were conducted. A survey was conducted among the 9 IDOT districts offices on the issues of I/D, capacity, queue length, road user costs, and motorist signing. Also, another survey was conducted among all 50 state DOTs on contract procedures, techniques used for calculating capacity, queue, delay and road user costs, cost figures used, motorist signing, and use of ITS technologies in work zones. On 14 work zones in Illinois, data on traffic flow, speed, capacity, and queuing were collected. The sites included five short-term and 8 long-term work zones. Comparisons were made between field data and software that are used in the calculation of delay, queue length and road user costs. The three software programs selected for evaluations were FRESIM, QUEWZ and Quick Zone. New UIUC Models were developed to determine capacity, speed reduction, delay, and queue length. The UIUC Models consider effects of heavy vehicles, work intensity, narrow lanes and shoulders. Three examples based on actual field data are given to illustrate the application of the proposed methodology.

The findings of this study are:

- Incentive/Disincentive and lane rental procedures were more effective in reducing the delay in work zones. However, there was no consensus on the I/D or lane rental dollar amount to be used.

- Highway Capacity Manual (HCM) techniques to calculate capacity, queue length, delay and road user costs were used in five IDOT Districts. Their satisfaction level with the techniques varied from somewhat satisfied to very satisfied. Among the state DOTs, HCM technique for capacity calculation was used more often than other techniques. For estimating queue length and delay, QUEWZ, Quick Zone, and HCM technique were used more often than other techniques. For road users cost calculation, QUEWZ and spreadsheets were used more often than other techniques. States were very satisfied with their spreadsheets for road users cost calculations.
- About 68% of the responding DOTs said they used the vehicle operating costs and 38% said they used motorist delay costs in calculating the road user costs. However not many states use crash costs in such calculations.
- About 57% of the responding DOTs said they use ITS technologies in work zones.
- About 70% of DOTs said that major contributing factors for the loss of credibility of work zone signs are: failure to remove signs when there is no work going on, incorrect information, lack of enforcement, and overuse of signs.
- QUEWZ overestimated the capacity and average speed, but underestimated the average queue length. This was true with the default-input values as wells as modified capacity values.
- FRESIM requires calibration, which requires knowledge of how the model works. Speeds computed in FRESIM were comparable to the average speeds from the field data, when there is no queuing at work zones. However, when there was queuing, FRESIM overestimated the speed. FRESIM did not return the queue lengths directly. The queue lengths obtained from the suggested procedure were shorter than the field values in half of the cases and longer in the other half of the cases.
- QuickZone requires capacity as an input value. The queue lengths from QuickZone did not match the field data and generally QuickZone underestimated the queue lengths. QuickZone consistently underestimated the total delay observed in the field. When demand is less than capacity, QuickZone does not return any user delay because it does not consider the delay due to slower speeds in work zones.

Recommendations for Future Research

The following recommendations are made for future studies:

- A spreadsheet or other computer program should be written to make the proposed UIUC methodology more user friendly and more efficient.

- The data used in developing the UIUC models came from work zones on interstate highways with two lanes per direction. Similar studies or extension of this study is need for work zones on other types of highways or work zones with different number of lanes.
- Speed reduction models developed in this study were based on small number of participants and construction sites. It is recommended to do a future study with a larger number of participants and various work zone types and configurations.
- This study is based on data for one lane closure on interstate highway work zones. For work zones with crossover and different number of lane closures, the results may not be directly applicable. It is recommended to do further study for those conditions.
- The operating speed computed using the methodology discussed in this report is for conditions when there is no flow breakdown. A detailed study is needed to determine the causes of flow breakdown and its consequences on work zone speed.
- The speed – flow curve developed in this study did not have enough data to quantify the rapid decrease in capacity during flow breakdown. Further field data is needed to quantify the decrease in capacity for different work zone conditions.
- The adjustment values for lateral clearance, lane width, and passenger car equivalents (PCE) for trucks are directly taken form the HCM for basic freeway sections. There is a need to collect field data to determine if these values are applicable for work zones..
- There are other factors such as grade, weather conditions, road surface conditions that may affect capacity and speed in work zones. These effects need to be determined.
- Using ITS technologies may affect work zone capacity. Effect of using ITS technologies on speed-flow curve and capacity needs to be studied.
- A detailed analysis of benefits and costs of using ITS technologies in work zones is needed.
- The Department uses a procedure for calculating road user cost that relies on knowing speed and capacity of the work zone. However, it does not provide a procedure for determining speed and capacity. The models in this report provide procedures to estimate work zone operating speed and capacity. The UIUC methodology should be used on interim basis to see if it should be refined, modified, and improved before it is considered for inclusion in the BDE manual
- A long-term data collection effort should be initiated to answer many of the issues that need to be addressed about work zone traffic operations.

CHAPTER 8 - MODEL FOR CAPACITY IN WORK ZONES

This chapter is divided into two major parts, a thorough analysis of the data, and the development of a model for capacity in work zones based on the results of the analysis. The model for the estimation of queue and delay are discussed in chapter 7.

8.1 Analysis of Data

Eleven sites, where speed of individual vehicle was computed from the videotapes, were chosen for detailed data analysis. Out of the eleven sites, three were short-term and eight were long-term construction sites. Three of the long-term construction sites had queuing. Data was collected for about 4 hours at these three sites and in one of the short-term sites. The data was grouped for two-hour time intervals in each site. As a result, there were fifteen two-hour data sets. Most of the analyses were done using Excel spreadsheet and Statistical Analysis System (SAS).

8.1.1 Platooning Criteria

Vehicles were classified into platoon or non-platoon based on speed and spacing. Spacing is the distance between the front bumper of leading vehicle and the front bumper of following vehicle. The spacing for a vehicle was computed by multiplying its headway by its speed. During the data reduction, a vehicle was initially considered to be a part of a group of vehicle if it was spatially close to other vehicles. This determination was only based on the judgments of the persons reducing the data. After analyzing the headway, speed and spacing of the vehicles in the field data, the criteria for platooning were established. A vehicle is consider being in platoon if its headway is less than or equal to four seconds or its spacing is less than or equal to 250 ft.

8.1.2 Time Series Plots

After establishing the condition for platooning vehicles, the time series plots of flow and speed were studied to find how the presence of non-platoon vehicles affects the flow. Three groups of plots were studied, platoon, non-platoon and both platoon and non-platoon vehicles combined. The time series was plotted for an interval of 5 minutes. The time series plots for the platoon, non-platoon and all vehicles Is given in Appendix C.

Comparison of the time series plots for platoon, non-platoon and all vehicles shows that the plot for platoon vehicles is smoother plots than non-platoon vehicles. The time series plots for non-platoon vehicles show significant fluctuations in speed and flow. Similar fluctuations are also reflected in the plots for all the vehicles. The fluctuations indicate that non-platoon vehicles should not be used in determining the capacity of work zones. Capacity should be determined when a continuous flow of traffic exists and vehicles are in platoon. In a queuing condition, almost all the vehicles will be in a platoon, but in undersaturated conditions not all the vehicles will be in platoon. In order to measure the capacity of work zone, only the vehicles that are in platoon are considered.

8.1.3 Maximum Flow or Ideal Capacity

Using the time series plots for platooning vehicles, a 15-minute time period is found, that is either before a rapid speed drop or after a rapid speed increase, that sustained the highest flow level with little or no fluctuation in flow. Such a time period would represent the ideal capacity of the site. When there was no significant change in speed, a 15-minute time period that had highest sustained flow was used. The maximum 15 minute sustained flow for each site was calculated. The values are given in Table 8.1. The max 15-minute mixed flow observed in the field (in unit of vehicle per hour (vph)) was converted to all passenger car equivalents (in unit of passenger car per hour (pcph)) using the conversion factor given in HCM 2000. The passenger car equivalency factor is 1.5 for level terrain, which was used for all sites.

Table 8.1 Maximum 15-minute sustained flows

site no	Sites	Maximum 15-min flow	% truck in 15-min	Maximum 15-min flow	Average Speed in 15-min
		vph	%	pcph	mph
1	I57_NB_271_0718	1832	28.40	2092	43
2	I55_NB_224_0723	1697	37.19	2013	44
3	I57_NB_250_0724	1798	31.30	2079	50
4	I74_WB_79_0723	2062	29.40	2365	45
5	I80_EB_43-44_0725	1710	34.70	2007	42
6	I80_WB_39-40_0725	2088	38.20	2487	53
7	I74_EB_5_0725	1981	6.05	2041	43
8	I70_EB_145-146_0801	1615	42.60	1959	50
9	I57_SB_212_0801	2167	16.90	2350	57
10	I55_SB_56-55_0802	2033	18.90	2225	45
11	I55_NB_55-56_0802	2004	14.50	2149	60

The maximum 15-min sustained flow indicates that under ideal conditions during that particular 15-min period, this is the maximum flow that can be processed (assuming all vehicles are in platoon). As the conditions changes these flows will also change. Therefore to determine the maximum flow that can be processed in a work zone, a more detailed study of the work zone conditions have to be done.

The values in Table 8.1 indicate that there is variation in ideal flow, but also that there is consistency. For the three short-term construction sites, the ideal capacity values are 2092, 2013, and 2079. These capacity values are practically the same and indicate the consistency in finding the ideal capacity values. Similarly for long term construction sites there was consistency when similar conditions were compared. The highest ideal capacity value was for I 80 WB where the speed limit was 55 and there were no workers present. The drivers in platoon in that 15-minute time period were traveling at a speed of 53 mph. The ideal capacity value is comparable to the 2400 pcph that HCM recommends for a single lane of such a freeway. Since there were only 8 long-term construction sites with detailed data, the field data rather than statistical analysis was used to understand the relationship between different variables and capacity and in developing the capacity model for work zones.

8.2 Estimating Work Zone Capacity

To estimate work zone capacity, speed-flow curves for work zones were needed. Then, the adverse effects of work zone conditions on speed needed to be determined in terms of speed reduction.

8.2.1 Speed Flow Curves

Based on the 5-minute flow and speed data, the relationship between the speed and flow in work zone under maximum flow conditions (continuous discharge flow which means that all vehicles are in platoon) was established. Figure 8.1 gives the speed flow curve for the maximum flow conditions. A relationship in the form of a power function was found to represent the data points in Figure 8.1 very well. The equation for the power function was obtained using regression analysis and it is expressed as:

$$q = 145.68 \times U^{0.6857} \tag{8.1}$$

Where,

q = flow in passenger cars per hour per lane (pcphpl)

U = speed in mph (the speed used in equation must be lower than the speed at capacity)

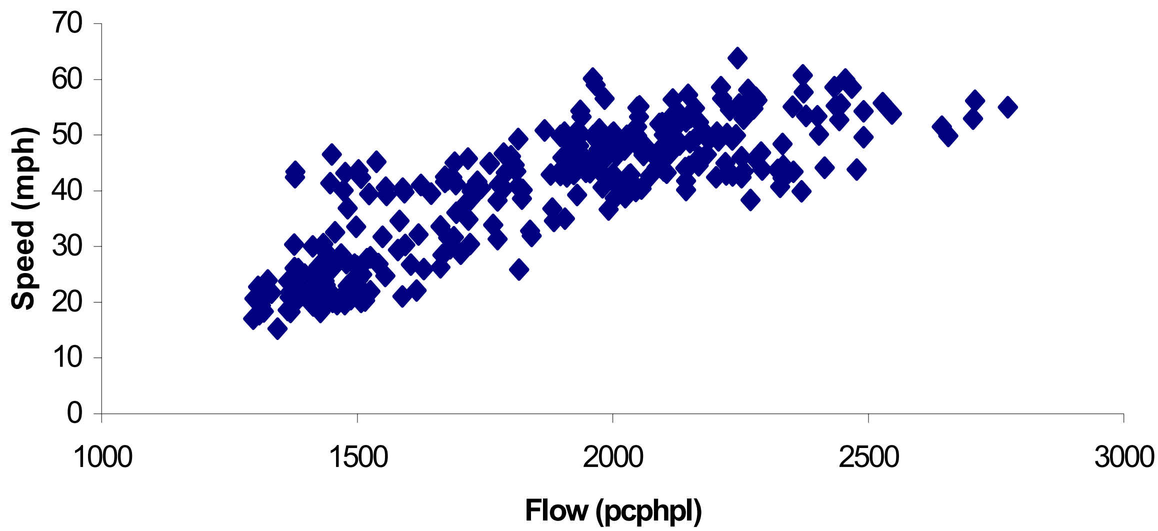


Figure 8.1 Flow Vs Speed for Maximum Flow Conditions

This equation was used to establish the lower part (congested part) of the speed-flow curve. Thus, it is used in determining capacity values and flow rates when speed is below the optimal speed (speed at capacity). The free flow part of the curve (when speed is higher than the optimal speed) is based on information from HCM 2000, ideal capacity values from the field data as shown in Table 8.1, and knowledge of the authors. A speed range of 65 mph to 40 mph was used to establish the speed-flow curves. The capacity for each speed level was decided considering all of the above mentioned factors. It was also decided that the flow at which the free flow speed begins to drops is at 1300 pcphpl. This value is based on the information in HCM2000 and knowledge of the authors. The speed drop between 1300 pcphpl and the capacity value is based on the following equation which is obtained from the above discussion:

$$Speed = FFS - (FFS - U_c) * \left[\frac{flow - 1300}{capacity - 1300} \right]^{2.6} \qquad (8.2)$$

Where,

FFS = free flow speed (mph)

U_c = Speed at Capacity (optimal speed) in mph obtained from equation 8.1

The exponent of 2.6 used in Equation 8.2 is used in HCM 2000 for comparable equations (Chapter 23 – Basic Freeway Sections). Putting the upper and lower parts of the speed-flow curves resulted in a series of speed-flow curve as shown in Figure 8.2. Figure 8.2 is developed in this study and there is no specific reference for this curve in the literature. It is based on the findings from the field data, knowledge of authors about capacity and traffic flow and information that is available in HCM.

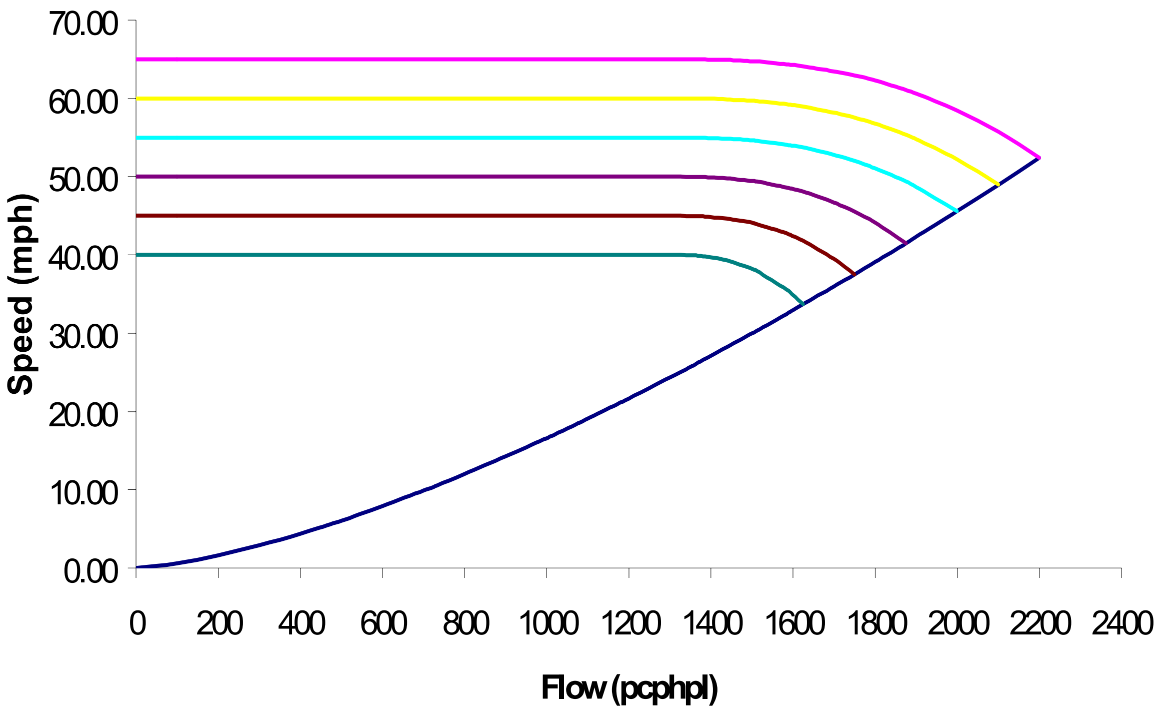


Figure 8.2 Speed-Flow Curves for Work Zones

8.2.2 Operating Speed

Operating speed in a work zone is defined as the speed at which the vehicles would travel through the work activity area after reducing their speed due to work intensity, lane width and lateral clearance. The equation for operating speed is given as:

$$U_o = FFS - R_{WI} - R_{LW} - R_{LC} - R_o \tag{8.3}$$

Where,

U_o = Operating Speed (mph)

FFS = free flow speed (It is assumed that FFS= Speed limit + 5 mph)

R_{WI} = Reduction in speed due to work intensity (mph)

R_{LW} = Reduction in speed due to lane width (mph), see Table 8.2

R_{LC} = Reduction in speed due to lateral clearance (mph), see Table 8.2

R_o = Reduction in speed due to all other factors that may reduce speed (mph) (including those that may cause a flow breakdown)

Table 8.2 Adjustments due to lane width and lateral clearance

<table>
<tr><th colspan="5">Adjustment for lane width</th></tr>
<tr><th>Lane width (ft)</th><th colspan="4">Reduction in speed (mph)</th></tr>
<tr><td>12 ft or more</td><td colspan="4">0.0</td></tr>
<tr><td>11</td><td colspan="4">1.9</td></tr>
<tr><td>10</td><td colspan="4">6.6</td></tr>
<tr><td>9</td><td colspan="4">15.0*</td></tr>
<tr><td>8</td><td colspan="4">25.0*</td></tr>
<tr><th colspan="5">Adjustment for left shoulder</th></tr>
<tr><th>Left shoulder (ft) width</th><th colspan="4">Reduction in speed (mph)</th></tr>
<tr><td>2 ft or more</td><td colspan="4">0</td></tr>
<tr><td>1</td><td colspan="4">1</td></tr>
<tr><td>0</td><td colspan="4">2</td></tr>
<tr><th colspan="5">Adjustment for right shoulder</th></tr>
<tr><th rowspan="3">Right shoulder width (ft)</th><th colspan="4">Reduction in speed (mph)</th></tr>
<tr><th colspan="4">No of Lanes in one direction (without work zone)</th></tr>
<tr><th>2</th><th>3</th><th>4</th><th>>= 5</th></tr>
<tr><td>6 ft or more</td><td>0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td>5</td><td>0.6</td><td>0.4</td><td>0.2</td><td>0.1</td></tr>
<tr><td>4</td><td>1.2</td><td>0.8</td><td>0.4</td><td>0.2</td></tr>
<tr><td>3</td><td>1.8</td><td>1.2</td><td>0.6</td><td>0.3</td></tr>
<tr><td>2</td><td>2.4</td><td>1.6</td><td>0.8</td><td>0.4</td></tr>
<tr><td>1</td><td>3.6</td><td>2.0</td><td>1.0</td><td>0.5</td></tr>
<tr><td>0</td><td>3.9</td><td>2.4</td><td>1.2</td><td>0.6</td></tr>
</table>

(*: Based on author's best estimate)

8.2.3 Work Intensity

The work intensity in a work zone is characterized by two main factors. The factors are:

1) Number of workers and construction equipment in the closed lane that is adjacent to the open lanes
2) Proximity of the workers and equipment to the nearest open lane (how far the crew/equipment is from the traveled lane)

To quantify the reduction in speed due to the work activity, a ratio called the work intensity ratio is developed. Work intensity ratio is obtained by dividing the sum of the number of workers and equipment in the active work area in the closed lane by the distance between the active work area and the open lane. It is expressed as:

$$WI_r = \frac{w + e}{p} \tag{8.4}$$

Where,

WI_r = work intensity ratio

w = number of workers in the active work area (w varies from 0 to a maximum of 10)

e = number of equipment in active work area (e varies from 0 to a maximum of 5)

p = distance between the active work area and the open lane (feet) (p varies from 1 to a maximum of 9 ft)

The speed reduction due to work intensity in long term work zone (e.g. using concrete barriers) will be different from the reduction for short term work zones (e.g. using barrels), because of the different types of traffic control devices used.

8.2.4 Speed Reduction in Short Term Work Zones

For short-term work zones, the relationship between work intensity ratio and speed reduction was developed based on a survey conducted among the drivers at a rest area. A sample of the survey sheet is given in Appendix D. The total number of observations was 120. The collected data was examined and any inconsistent and inaccurate responses that did not reflect valid speed reductions were deleted. After this reduction 90 observations were plotted against the different work intensity conditions. Different models were examined and the one, which had the best fit, was chosen. The relationship was further verified with the field data. The relationship is given as

$$SR_S = 11.918 + 2.6766 \ \ln(W.I) \qquad (8.5)$$

$$R^2 = 0.1213$$

Where,

SR_s = speed reduction in short term work zones (mph)

WI_r = Work intensity ratio

Figure 8.7 gives the relationship for this equation. The values obtained from this graph are very close to those observed in field.

Figure 8.3 Work Intensity Ratio Vs Speed reduction- Short Term

The data used for arriving at this relationship had wide variation in speed reduction because different drivers react differently. We could average the data and could get higher R^2 values but that will conceal the variation in data that will give a wrong impression. So we took the actual values.

8.2.5 Speed Reduction in Long Term Work Zones

The relationship between work intensity ratio and speed reduction for long term work zones was developed based on the field data. For computing the proximity of the long-term work zone, a distance of 2 feet is added to the distance from the travel lane to account for the width of the concrete barrier. The relationship is given by the equation

$$SR_L = 2.6625 + 1.2056 \ln(WI_r) \qquad (8.6)$$
$$R^2 = 0.1472$$

Where,

SR_L = speed reduction (mph)

WI_r = work intensity ratio

Figure 8.8 gives the relationship for this equation.

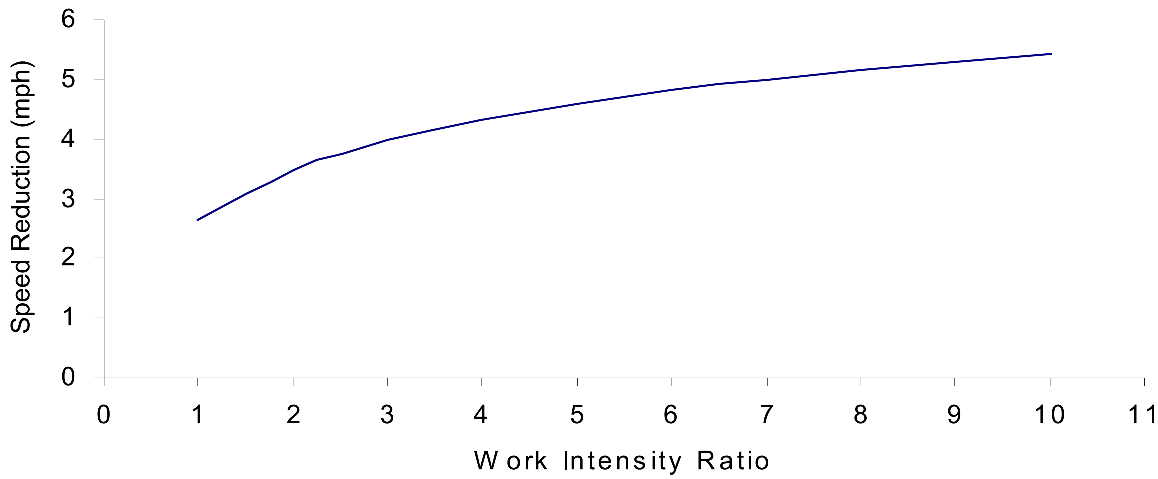


Figure 8.4 Work Intensity Vs Speed Reduction - Long Term

8.2.6 Lane Width and Lateral Clearance

Speed reduction due to lane width and lateral clearance are based on the values given by HCM 2000. Exhibit 23-4 in HCM 2000 gives the reduction speed for lane width and Exhibit 23-5 gives the reduction in speed for lateral clearance for 2 lane freeways.

8.2.7 Work Zone Capacity

The capacity model given in this section is based on the principle that the work zone factors (intensity, lane width, and lateral clearance) cause a reduction in the speed of the vehicles, which will again affect the work zone capacity. So, by establishing a relationship between speed reduction and the work zone factors, the capacity of the work zone can be estimated. The basic capacity model is given in equation 8.7.

$$C_{adj} = C_{U_o} * f_{HV} \tag{8.7}$$

Where,

C_{adj} = adjusted capacity (vphpl)

Cu_o = capacity at operating speed U_o (pcphpl)

f_{HV} = Heavy vehicle factor

The heavy vehicle factor is calculated from the following equation:

$$f_{HV} = \frac{1}{1 + P_T (PCE - 1)} \tag{8.8}$$

The heavy vehicle adjustment factor is the same one used in HCM. The passenger car equivalent (PCE) factors change with terrain of the roadway environment. For example, for large trucks PCE is 1.5, 2.5, and 4.5 for level, rolling, and mountainous terrains, respectively. It should be mentioned that when the length of an upgrade or its steepness causes a significant speed reduction in trucks, the procedure uses different PCE values to account for the adverse effects. The HCM factors are not developed based on work zone data, but they can be used for work zone without significant concerns until more data becomes available.

8.2.8 Step-by-Step Approach to Estimate Work Zone Capacity

The steps involved in finding the adjusted work zone capacity is given below:

1. Find speeds reduction due to narrow lane width (R_{LW}) and lateral clearance (R_{LC}) from Table 8.2.
2. Compute the work intensity ratio (WI_r) using equation 8.4.
3. Compute the speed reduction (R_{WI}) due to work intensity from equation 8.5 for short term work zones and equation 8.6 for long term work zones.
4. Calculate the Operating speed (Uo) based on the equation 8.3
5. Find the capacity (Cu_0) corresponding to the operating speed from the speed flow curve given in Figure 8.2.
6. Compute the heavy vehicle factor (f_{HV}) using the equation 8.8
7. Calculate the adjusted capacity (C_{adj}) from Equation 8.7

8.3 Calibration of the Capacity Model

The capacity model was based on three data sites, which were not used in the development of the model. The three data sets used are, I-270 EB MP9, I-290/IL-53 EB MP4 and I-57 SB MP355. The observed values and the estimated models are given in table 8.3.

Table 8.3 Observed Flows Vs Estimated Flows

Site	Hour	Average speed (mph)	Observed flow (vph)	# of trucks	% trucks	Observed flow (pcphpl)	Estimated flow (pcphpl)
I-290/IL-53 EB MP9	1	19.96	1321	44	3.33	1343	1135
	2	20.6	1321	36	2.73	1361	1160
I-57 SB MP 355	1	21.88	1418	154	10.86	1495	1209
	2	23.69	1518	122	8.04	1579	1276
I-270 EB MP9	1	49.85	938	267	28.46	1072	1072

The sites I-290/IL-53 and I-57 were 3 lane sites reduced to 2 lanes. The data was collected on the left lane. There was very low percentage of trucks in the left lane. The observed flows were higher than the estimated flows because the estimated flows were based on a 2 lane to 1 lane reduction. So, This difference between the observed flow and the estimated flow is expected. The site I-270 had 2 lanes reduced to 1 lane. In this site, due to the local condition there was a queue before the location of data collection and the queue length remained around 0.6 miles. At the location where speed and flow data was collected, the traffic flow was not influenced by queue. Average speeds based on a systematic sampling of vehicles were found out to be 49 mph. This represents a free flow condition at the location. Based on our field observation and video taping of the site, we determined that the traffic operation at the location of the site was not under the influence of the stationary queue. In fact, there were large gaps between the vehicles and they were mostly free flowing traffic. This represented an undersaturated condition. As a result we should compare the data point with the flow speed curve for the undersaturated condition.

Five data points provided the data that supports the validity of this model. There was a good agreement between the 5 data points; further validation of this model under a variety of roadway conditions would be helpful in gaining the confidence of model users.

Word count – 7,350 **TRB Paper Number: 06-2496**

Development of a Methodology to Estimate the Interstate Highway Capacity for Short-Term Work Zone Lane Closures

Wayne A. Sarasua
Department of Civil Engineering
Clemson University, Clemson, SC 29634-0911
Phone: (864) 656-3318, FAX (864) 656-2670
E-mail: sarasua@clemson.edu

William J. Davis
Department of Civil & Environmental Engineering
The Citadel, 171 Moultrie Street, Charleston, SC 29409
Phone: (843) 953-7686, FAX: (843) 953-6328
E-mail: jeff.davis@citadel.edu

Mashrur A. Chowdhury
Department of Civil Engineering
Clemson University, Clemson, SC 29634-0911
Phone: (864) 656-3313, FAX (864) 656-2670
E-mail: mac@clemson.edu

Jennifer H. Ogle
Department of Civil Engineering
Clemson University, Clemson, SC 29634-0911
Phone: (864) 656-0883, FAX (864) 656-2670
E-mail: Ogle@clemson.edu

November 21, 2005

ABSTRACT

Defining and understanding traffic flow parameters within short-term interstate work zones is a crucial step in developing effective policies to manage construction and maintenance work conducted on the nation's heavily traveled freeways. The South Carolina Department of Transportation (SCDOT) initiated a research study to develop a methodology for use in determining an updated lane closure policy for interstate highway work zones. Phase 1 of the research was completed in May, 2003 and findings identified threshold volumes for two-to-one lane closure work zone configurations. Phase 2 of the research further expanded numerically derived relationships and contained analysis of other short-term lane closure configurations including three-to-two and three-to-one lane closures. Both research phases concentrated on methods to determine the number of vehicles per lane per hour that can pass through short-term interstate work zone lane closure with minimum or acceptable levels of delay as defined by the SCDOT. Phase 2 includes an expanded list of data collection sites with differing work zone characteristics. This paper presents the analysis and results of Phase 2 of the research. Headway analysis revealed that passenger car equivalents (PCEs) differed for various speed ranges and modified PCE's for various speed groups were applied in calculating capacity. The authors recommended a model to be used for calculating work zone capacity that incorporates base capacity, PCEs for various speed groups, adjustment factors related to specific work zone characteristics, and number of lanes open through the work zone.

INTRODUCTION

The Manual of Traffic Control Devices Handbook (MUTCD, 2003) defines a short-term work zone as stationary daytime work that occupies a location for more than one hour within a single daylight period(1). The need to maintain adequate traffic flow through short-term interstate work zones is paramount on today's heavily traveled freeways. Numerous states have policies related to traffic flow thresholds, vehicle delay and vehicle queue lengths that provide guidance on conditions when short-term lane closures can be instituted. Generally, traffic flow threshold limits are a function of traffic stream characteristics, highway geometry, work zone location, type of construction activities and work zone configuration. The South Carolina Department of Transportation (SCDOT) initiated a research study to develop a methodology for use in determining an updated lane closure policy within work zones along the interstate highway system. The research was completed in two phases, with the second addressing research needs identified in the initial research. Both phases of this research focused on determining the number of vehicles per lane per hour that can pass through short-term, interstate work zone lane closures, with minimum or acceptable levels of delay.

Based on the original research project (Phase 1) completed in May 2003 (2), the following model was developed to describe traffic capacity in short-term work zones:

$$C_{WZ} = (1460 + I) * f_{HV} * N$$

where: C_{WZ} = is the estimated capacity of a short-term work zone (veh/hr)
f_{HV} = heavy vehicle adjustment factor
N = number of lanes open through the work zone
I = adjustment factor for type, intensity, length and location of the work activity

(Note: The initial model was based on data collected from 23 work zones with two-to-one lane closures across South Carolina.)

Roadway Grades

All work zone locations used in this study exhibited rolling terrain and were well within typical design parameters for interstate freeways–e.g. moderate grades not extending more than one-half miles in length. Only one of the project sites could be considered a flat section and none of the sites existed along a continuous grade. Therefore, stratifying data by roadway grade was not feasible. Additionally, grouping work zone site data according to region did not indicate noticeable difference in estimated capacity. For example, two-to-one lane closures on Interstate 85 were compared to similar lane closures on all other interstates. Scatter plots of speed versus density followed nearly identical trends and the 85th percentile volumes were roughly the same. Further, the overall cumulative density functions were comparable. With regard to PCE's, the analysis indicates that PCE values identified in this study for trucks correlated closely with the PCE's for trucks on rolling terrain as identified in the 2000 Highway Capacity Manual (10) for basic freeway segments. It stands to reason that HCM values for specific freeway grades are also applicable to work zones, as well.

Work Zone Activity

The initial regression model created from the combined database was modified using dummy variables for work zone type, work zone intensity, and work zone length. A value of one was assigned to a work zone with a high degree of activity and a value of zero coded otherwise. Similarly, a value of one was assigned to a longer work zone and a value of zero coded otherwise. Stepwise regression was used to analyze the individual effect of each dummy variable. Results from the procedure indicate no significance for either of these variables. This finding was not surprising in that most work zones with heavy activity did not have a sufficient range of volume to indicate the activity or length affected work zone capacity, even with a higher threshold value of 1,000 vph currently in use. Clearly, this research does not contain sufficient data to conclude the effect of work zone activity, intensity, and length on capacity.

One observation that was made during the data collection is that the variable positioning of lane closure barricades can considerably influence work zone speed. At data collection site, a few barricades straddled a lane, forcing drivers to encroach on a narrow shoulder in the vicinity of guardrail causing drivers to slow significantly for a short period before speeding up once they were clear of the barricades.

Weather Conditions

Adverse weather was never experienced at any of project sites. SC DOT's policy avoids short-term lane closures in times of adverse weather. Several projects were cancelled and in most cases rescheduled if weather was a factor. Thus, weather was not considered in the model.

Final Form of Short-Term Work Zone Capacity Model

Model formulation identified a capacity in passenger car equivalents as 1,426 pcphpl for a 1-hour period for a two-to-one lane closure. This is only 34 fewer pcphpl that the capacity identified in the Phase 1 research. A value of 1,425 (rounding to the nearest 25) was considered a starting point for estimating work zone capacity for the boundary conditions identified in Phase 2. As per Highway Capacity Manual procedures, use of a heavy vehicle adjustment is necessary to determine a realistic PCE value. Additionally, a variable for number of lanes should also be included to address multi-lane work zone capacities. Adding a variable for heavy vehicle adjustment, determined using Highway Capacity Manual methods, and accounting for number of lanes, the work zone capacity model takes the following form:

$$C'' = 1425 * f_{HV} * N$$

where: C'' = adjusted based on the number of lanes open through the work zone (veh/hr)
f_{HV} = heavy vehicle adjustment factor
N = number of lanes open through the work zone.

Data analysis conducted in Phase 2 indicate 1,425 pcphpl is likely too conservative a value if two or more lanes are provided through the work zone and may result in under estimating capacity by as much as 600 pcph for a two lane configuration. To account for this in the model, the 1,425 pcphpl base capacity was replaced with a variable C_B and suggested values, based on the number of discharge lanes through the work zone and are summarized as follows:

- Single lane provided through work zone, C_B = 1,425 passenger car per hour per lane
- Two lanes provided through work zone, C_B = 1,750 passenger car per hour per lane

A general consensus exists among highway engineers and researchers is that work zone intensity does have an effect traffic capacity, however, results from the literature review and data analysis conducted for this project were unsuccessful in quantifying this effect. HCM (10) suggests a base value for capacity can be subjectively adjusted up or down by 10% depending on whether the work zone activity is higher or lower than normal intensity. Another variable (I) has been introduced to the model to account for the intensity of the work zone as well as the number of lane drops. Taking this factor into account, the final form of the work zone capacity equation becomes:

$$C_{WZ} = (C_B + I) * f_{HV} * N$$

where: C_{WZ} = is the estimated capacity of a short-term work zone (veh/hr),
C_B = base capacity
f_{HV} = heavy vehicle adjustment factor
N = number of lanes open through the work zone
I = adjustment factor for type, intensity, length and location of the work activity (As discussed, this value ranges from -146 to +146). If a double lane closure is present, the value for I should be adjusted by -150 in addition to other adjustments.

The work-zone capacity model presented above will likely hold true for long term work zones however, this model is based on data that best fits the definition of short-term work zone lane closures as defined by the MUTCD.

Example Application of the Model

This section illustrates the use of the work zone capacity model developed in the previous section. Given a typical planned three-to-one short-term lane closure with an estimated volume of 1,100 vehicles during its busiest hour, the truck and RV proportions are estimated to be 18% and 2% respectively. Determine whether the closure should be moved to night time hours. The problem solution is provided in a step-by-step fashion as follows:

1. Calculate f_{HV}: Using E_T = 1.90 and E_{RV} = 1.44., f_{HV} = 0.85, from Phase 1 (2) and based on the heavy vehicle equation contained in HCM (10).
2. Calculate C_{WZ}: Based on a double lane closure, an adjustment to I of -150 must included. Assuming average activity, no further adjustment to I is necessary. With N = 1 in this case, using the equation for C_{WZ} = 1,084 veh/hr.

Paper No. 01-0566

A New Methodology to Estimate Capacity for Freeway Work Zones

by

Taehyung Kim
Graduate Research Assistant
E-mail: thkim@wam.umd.edu
Tel: 301-405-3636

David J. Lovell
Assistant Professor
E-mail: lovell@eng.umd.edu
Tel: 301-405-7995

1179 Martin Hall
Department of Civil and Environmental Engineering
University of Maryland
College Park, MD 20742
Fax: 301-405-2585

and

Jawad Paracha
Traffic Development & Support Division
Office of Traffic & Safety
MD State Highway Administration
E-mail: JParacha@sha.state.md.us
Tel: 410-787-5891
Fax: 410-582-9469

November 16, 2000

Submitted to the 2001 Transportation Research Board Annual Meeting,
Washington D.C., January 2001

Words count: 6,025 words

Corresponding author: David J. Lovell

ABSTRACT

The objectives of this study were to investigate various independent factors that contribute to capacity reduction in work zones and to suggest a new methodology to estimate the work zone capacity. To develop the new capacity estimation model, traffic and geometric data were collected at 12 work zone sites with lane closures on four normal lanes in one direction, mainly after the peak-hour during daylight and night.

The multiple regression model was developed to estimate capacity on work zones for establishing a functional relationship between work zone capacity and several key independent factors such as the number of closed lanes, the proportion of heavy vehicles, grade and the intensity of work activity. The proposed model was compared with other existing capacity models, and showed improved performance for all of the validation data.

Keywords: work zones, capacity estimation, multiple regression

Table 2 summarizes the data collected for each site. At each site, traffic volume was divided into two classes: (a) passenger cars and (b) heavy trucks, and work time also was divided into two types, i.e., day and night. The intensity of work activity was classified into three levels such as low, medium, and heavy based on the types of work activities, the number of workers and the size of the equipment. We assumed that the driver population was not commuters because traffic data were collected after the peak-hour during daylight and night. The durations of all the work zone sites were short-term, and the weather was sunny during lane closures.

CAPACITY ESTIMATION MODEL FOR WORKZONES

We developed a multiple regression model to estimate capacity for work zones because it provides a simple method for establishing a functional relationship between work zone capacity and several key independent factors such as the number of closed lanes, the proportion of heavy vehicles and the intensity of work activity. Several categorical variables, such as the location of closed lanes (e.g., left or right) and intensity of work activity (e.g., low, medium or heavy), were represented as dummy variables such as 1 or 0. For the variable of the location of closed lanes, it was classified into two types as right and left because we have no data where middle lanes were closed. The following variables were identified as potential independent factors for estimating the capacity at work zone sites:

- Number of closed lanes
- Location of closed lanes (right = 1, otherwise = 0)
- Proportion of heavy vehicles
- Lateral distance to the open lanes
- Work zone length

- Work zone grade
- Intensity of work activity (1 or 0 for medium intensity, and 1 or 0 for heavy intensity)

Table 3 shows the correlation matrix between independent variables. We notice that the number of closed lanes and the intensity of work zone activity in category heavy are highly correlated with work zone capacity. Moreover, it shows that the grade and the combination of grade and heavy vehicles are also another important factors that are highly correlated to work zone capacity. The capacity estimation model is developed based on the field data collected at 12 work zone sites as shown in Table 2. Stepwise addition and subtraction were used to refine the variable set. Table 4 summarizes the final results of the stepwise regression analysis.

$$\begin{gathered} \mathrm{CAPACITY} = 1857 - 168.1\mathrm{NUMCL} - 37.0\mathrm{LOCCL} - 9.0\mathrm{HV} + 92.7\mathrm{LD} \\ - 34.3\mathrm{WL} - 106.1\mathrm{WI_H} - 2.3\mathrm{WG} * \mathrm{HV} \end{gathered}$$

MODEL PERFORMANCE

We compared models by investigating the root mean square (RMS) error between actual and predicted capacity values, for a particular data set. This statistic is equivalent (in the sense that it is monotonically transformable) to the objective being minimized under least squares regression. To compare models objectively, it was critical to use a validation set that was not used to calibrate any of the models being compared.

Existing capacity estimation models

The following existing capacity estimation models were considered:

TABLE 3 Correlation matrix table between the independent variables

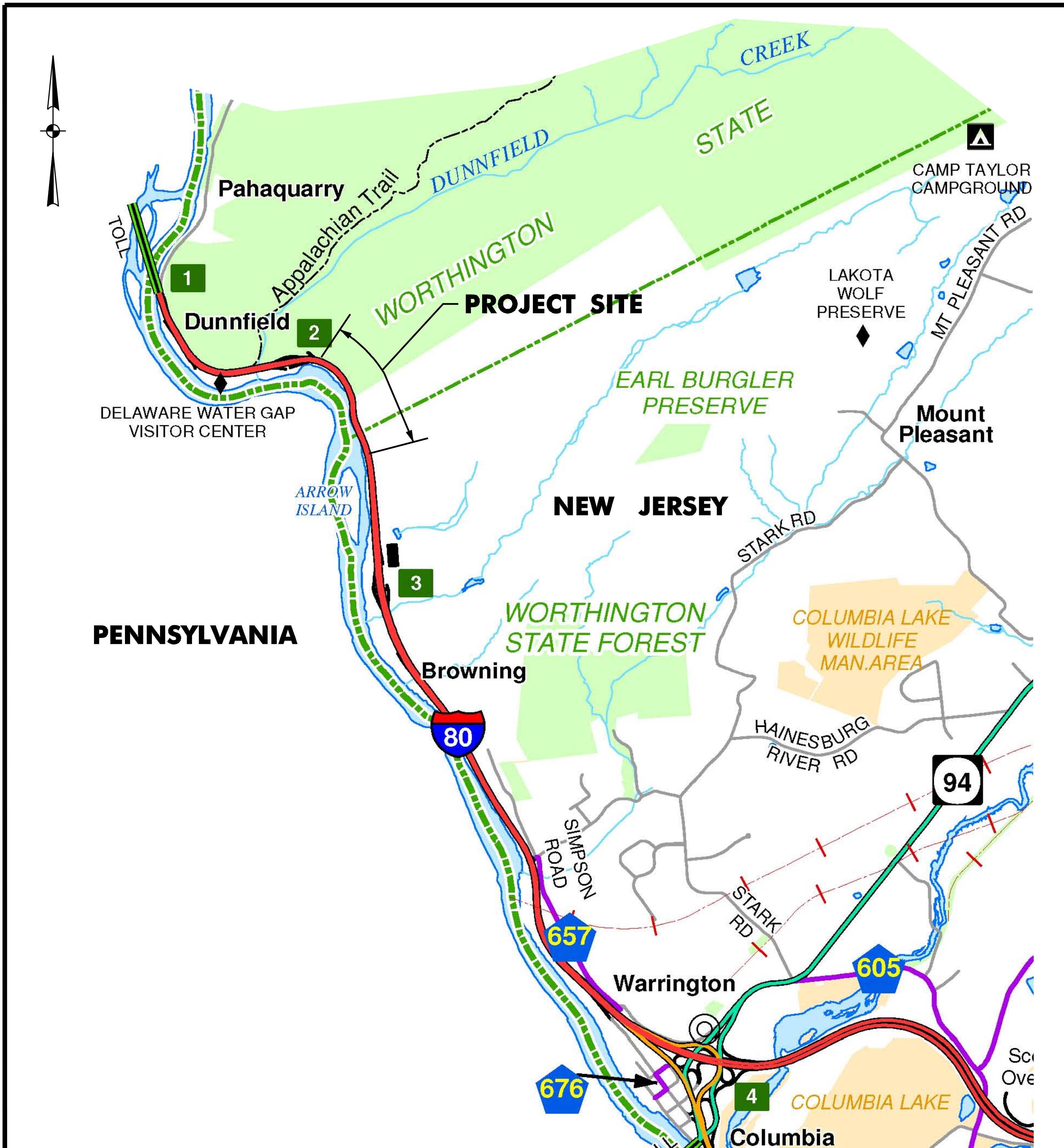
	CAPA-CITY	NUMCL	LOCCL	HV	LD	WL	WG	WI_M	WI_H	WG*HV	WL*WG
CAPA-CITY	1.00										
NUMCL	-0.89	1.00									
LOCCL	-0.18	-0.17	1.00								
HV	-0.31	0.22	0.07	1.00							
LD	0.42	-0.24	-0.04	0.25	1.00						
WL	-0.50	0.58	0.08	0.00	0.29	1.00					
WG	-0.73	0.52	0.37	0.08	-0.45	0.26	1.00				
WI_M	-0.09	0.19	-0.10	-0.32	-0.14	0.04	0.56	1.00			
WI_H	-0.84	0.71	0.12	0.49	-0.34	0.35	0.37	-0.41	1.00		
WG*HV	-0.73	0.52	0.39	0.04	-0.46	0.24	0.99	0.55	0.36	1.00	
WL*WG	-0.56	0.55	0.17	0.50	0.42	0.86	0.24	-0.16	0.52	0.22	1.00

TABLE 4 The results of regression analysis for the capacity model

Factor	Variable	Coefficient	Standard error	t-Stat	P-value
	CONSTANT	1856.64	75.83	24.49	1.65E-05
Number of closed lanes	NUMCL	-168.11	37.95	-4.43	0.011
Location of closed lanes	LOCCL	-37.00	24.06	-1.54	0.199
Proportion of heavy vehicles	HV	-9.00	6.07	-1.48	0.212
Lateral distance to the open travel lanes	LD	92.74	47.89	1.93	0.125
Work zone length	WL	-34.32	20.30	-1.69	0.166
Intensity of work zone activity in category heavy	WI_H	-106.14	39.34	-2.70	0.054
Work zone grade * Proportion of heavy vehicles	WG*HV	-2.34	0.69	-3.38	0.028
R-square					0.993
Adjusted R-square					0.981

APPENDIX E

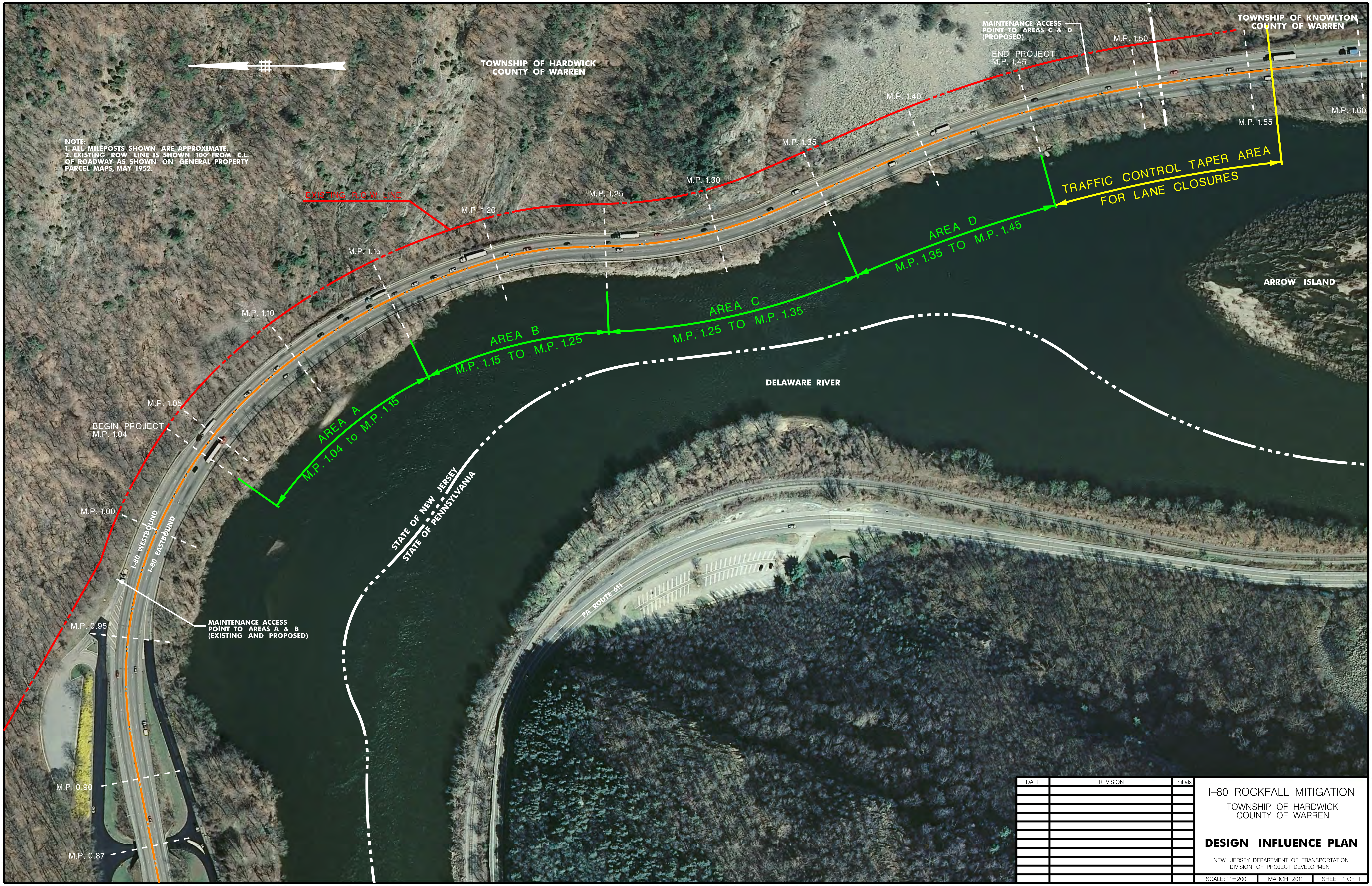
PROJECT LOCATION PLAN, DESIGN INFLUENCE PLAN, USGS MAP, AND PHOTOGRAPHS



NOTE:
IMAGES OBTAINED FROM NJDOT GIS SYSTEM

NOT TO SCALE (N.T.S.)

CONCEPT DEVELOPMENT STUDY ROUTE I-80 ROCKFALL MITIGATION MP 1.04 TO MP 1.45	CLIENT: NEW JERSEY DEPARTMENT OF TRANSPORTATION	PREPARED BY: HNTB 145 Route 46 West Wayne, NJ 07470-6830 TEL (973) 237-1650 FAX (973) 237-9185
PROJECT LOCATION MAP		



DATE	REVISION	Initials

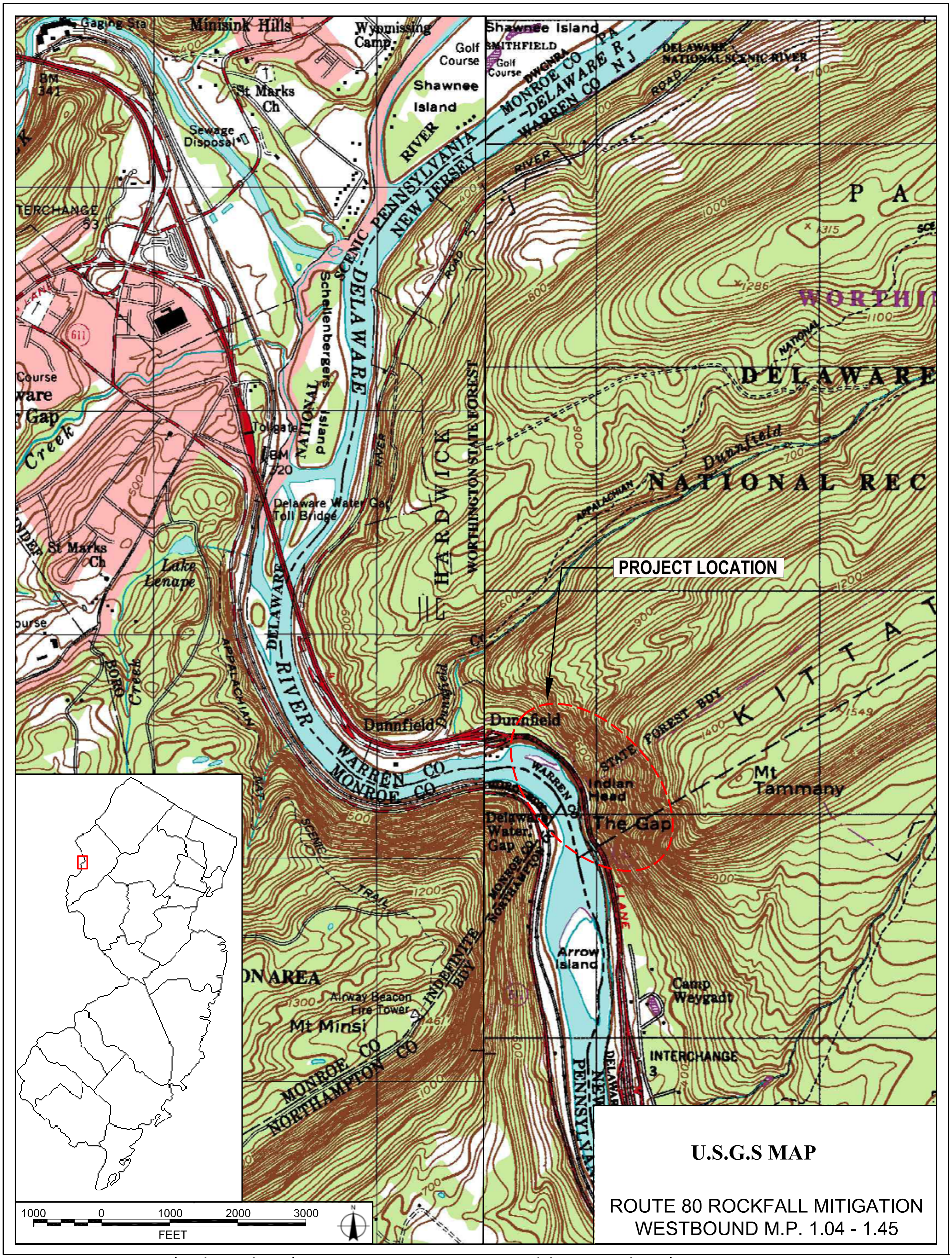
I–80 ROCKFALL MITIGATION

TOWNSHIP OF HARDWICK
COUNTY OF WARREN

DESIGN INFLUENCE PLAN

NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF PROJECT DEVELOPMENT

SCALE: 1" = 200' | MARCH 2011 | SHEET 1 OF 1



Basemap: USGS Portland Quadrangle PA-NJ, 1997 & USGS Stroudsburg Quadrangle PA-NJ, 1999

AREA A

Photo 1 – Existing Drainage Ditch With Stacked Stone Wall to the Left

Photo 2 – Back of Stacked Stone Wall

Photo 3 – Broken Tree Trunk, Evidence of Recent Rockfall

Photo 4 – 18"± Corrugated Metal Pipe Across Route I-80

AREA B

Photo 5 – Typical Rock of Area B

Photo 6 – Typical Rock of Area B

Photo 7 – General view of Westbound Route I-80, Looking West

Photo 8 – Close-up View of Stacked Stone Wall on top of Barrier Curb

AREA C


Photo 9 – Large Rock Face in Area C


Photo 10 – Overhang near Top of Large Rock Face in Area C

Photo 11 – Close-up view of Top of Large Rock Face in Area C

Photo 12 – East end of the Large Rock Face in Area C

Photo 13 – Loose Rock Accumulated at bottom of Rock Cut

Photo 14 – View of Typical Rock in Area C

Photo 15 – Typical Catchment Area in East side of Area C

Photo 16 – Existing Gabion Wall

AREA D

Photo 17 – Talus Slope in Area D

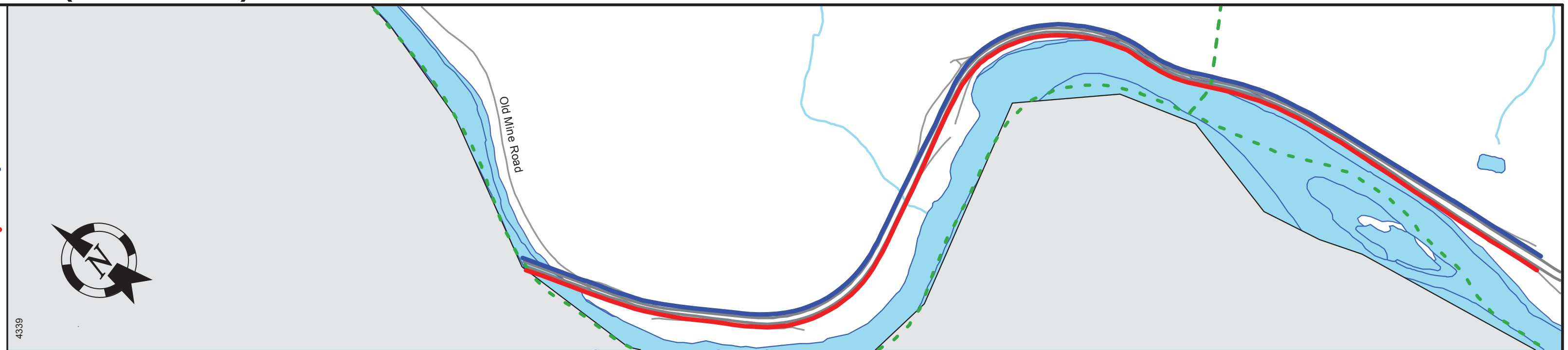
Photo 18 – General View of Talus Slope in Area D

Photo 19 – Large Boulders near the Bottom of the Talus Slope

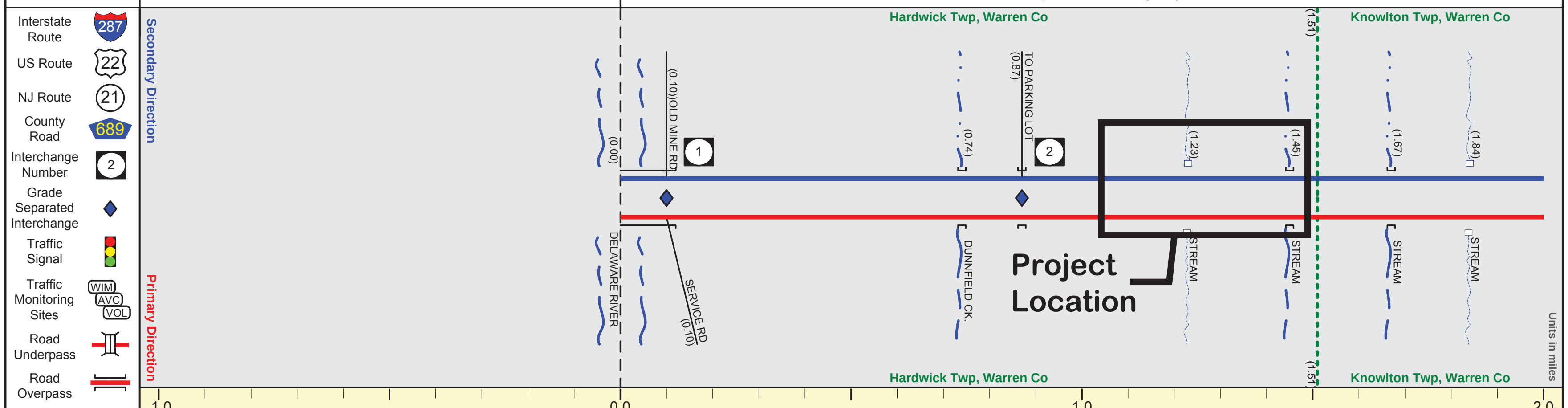

Photo 20 – General View of Westbound Route I-80 with Talus Slope

APPENDIX F

STRAIGHT LINE DIAGRAM AND ROADWAY DESIGN CRITERIA



Pavement	24
Shoulder	0 | 10 | 12 | 4 | 10 | 12
Number of Lanes	2
Speed Limit	50 | 55
Street Name	Christopher Columbus Highway



Street Name	Christopher Columbus Highway
Jurisdiction	D.R.J.T.B.C. | N.J.D.O.T.
Functional Class	Rural Interstate
Federal Aid - NHS Sy	STRAHNET Inter.
Control Section	2100 | 2114
Speed Limit	50 | 55
Number of Lanes	2
Med. Type	Positive
Med. Width	26 | 8 | VAR
Pavement	24
Shoulder	0 | 10 | 12 | 6 | 10 | 12
Traffic Volume	55,072 (2005)
Traffic Sta. ID	1-2-017
Structure No.	N/A, 2114150, 2114151, N/A, 2114152, 2114153, N/A
Enlarged Views	See Enlarged View #34

Begin I-80 MP=0.00

SRI = 00000080__

Date last inventoried: June 2008

Page Created: May 2009

Route I-80 Rockfall Mitigation
Design Criteria

Route I-80 Mainline Design Criteria		
Design Feature	**Design Criteria**	**Source**
Classification	Rural Interstate	NJDOT - Straight Line Diagrams - 2009
Design Speed	**55 MPH**	NJDOT - Roadway Design Manual Table 2-1, Page 2-4
Posted Speed	50 MPH	NJDOT - Straight Line Diagrams - 2009
Min. Horizontal Curve Radius	1060 FT	NJDOT - Roadway Design Manual Table 4-5, Page 4-17
Minimum Radius For NC	Greater Than 9,410 FT	NJDOT - Roadway Design Manual Figure 4B, Page 4-6
Stopping Sight Distance	495 FT	NJDOT - Roadway Design Manual Table 4-1, Page 4-2
Number of Travel Lanes	2 each direction (existing)	NJDOT - Straight Line Diagrams - 2009
Lane Width	12 FT	NJDOT - Roadway Design Manual Section 5.03, Page 5-4
Auxiliary Lane Width	12 FT	NJDOT - Roadway Design Manual Section 5.03, Page 5-4
Right Shoulder Width	12 FT Desired 10 FT Minimum 10 FT Adj. to Aux. Lanes	NJDOT - Roadway Design Manual Section 5.04.2, Page 5-5
Left Shoulder Width	5 FT Desired 4 FT Minimum	NJDOT - Roadway Design Manual Section 5.04.2, Page 5-6
Cross Slope:		
Thru Lanes (NC)	1.5% Minimum	NJDOT - Roadway Design Manual Section 5.02.2, Page 5-1
Thru Lanes (Superelevated)	6% Maximum 1.5% Minimum	NJDOT - Roadway Design Manual Section 4.03.2, Page 4-5
Shoulder	4% Desired 2% Minimum	NJDOT - Roadway Design Manual Section 5.04.3, Page 5-6
Profile Grade	0.30% Minimum 4% Maximum (Rolling)	NJDOT - Roadway Design Manual Table 4-8, Page 4-21
Maximum Rollover	7.00%	NJDOT - Roadway Design Manual Section 5.04.3, Page 5-7
Maximum Angle Point	0.30%	NJDOT - Roadway Design Manual Table 4-9, Page 4-22
Rate of Vertical Curvature, K:		
Crest	K = 114	NJDOT - Roadway Design Manual Figure 4-I, Page 4-24
Sag	K = 115	NJDOT - Roadway Design Manual Figure 4-J, Page 4-25
Ramps:		
Min. Design Speed	25 MPH	NJDOT - Roadway Design Manual Section 7.04.5, Page 7-3
Min. Horizontal Curve Radius	150 FT	NJDOT - Roadway Design Manual Figure 7-A, Page 7-5

APPENDIX G

MANAGEMENT SYSTEM DATA

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO: LIST (see table)

FROM: Bhavesh Shah
Principal Engineer
Division of Project Development (North)

DATE: May 28, 2010

PHONE: (609) 530-8078

SUBJECT: Route I-80 Rockfall Mitigation
Townships of Hardwick and Knowlton, Warren County

The Division of Project Development (DPD) is initiating Concept Development for the above-mentioned project.

DPD is looking for a fast-track review of the available information, development of a scope of work, and assignment to the appropriate project delivery pipeline if there is a way to resolve this problem in an efficient manner with respect to cost as well as time.

The DPD is requesting any input/information that may be relevant to this project from each of you. Items such as the following as they pertain to your office would be helpful in our investigation:

- Relative ranking on the management systems
- Final rating
- Available traffic
- Crash data, rates, summaries and details
- Recently completed work-orders/projects
- Other relevant information…….

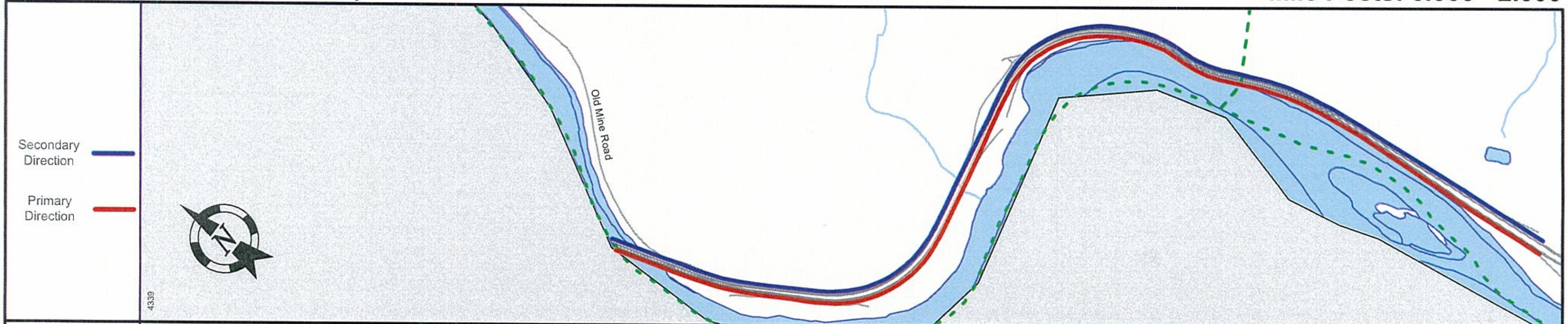
In addition, we are specifically looking to obtain the following information from each of your areas of expertise.

NJDOT Contact List	**Unit and Management System**	**Data requested**
Ira Levinton	Systems Development and Analysis *Congestion Management System (CMS)*	Ranking on CMS (0-10; 10 is highest priority)
Susan Gresavage	Pavement Management Unit *Pavement Management System (PMS)*	ARAN and skid test results
Greg Renman	Structural Engineering *Bridge Management System (BMS)*	BMS ranking , recent repairs etc.
William Day	Safety Programs *Safety Management System (SMS)*	Crash data, rates, summaries and details
Susan Gresavage	Drainage Management Unit *Drainage Management System (DMS)*	Are there any drainage projects in area; Ranking on DMS
Richard Shaw	Operations Support *Maintenance Management System (MMS)*	Ranking on MMS; recent, pending or active work, etc.
John Jamerson	Geotechnical Engineering *Rockfall Hazard Rating System* *Underground Strata*	Rockfall Hazard Rating Underground Strata information
Doug Bartlett	Traffic Engineering and Investigations	Recent, pending or active work orders in project area, etc.
Paul Truban	Transportation Data Development	Functional classification; Existing traffic counts, truck %, etc.

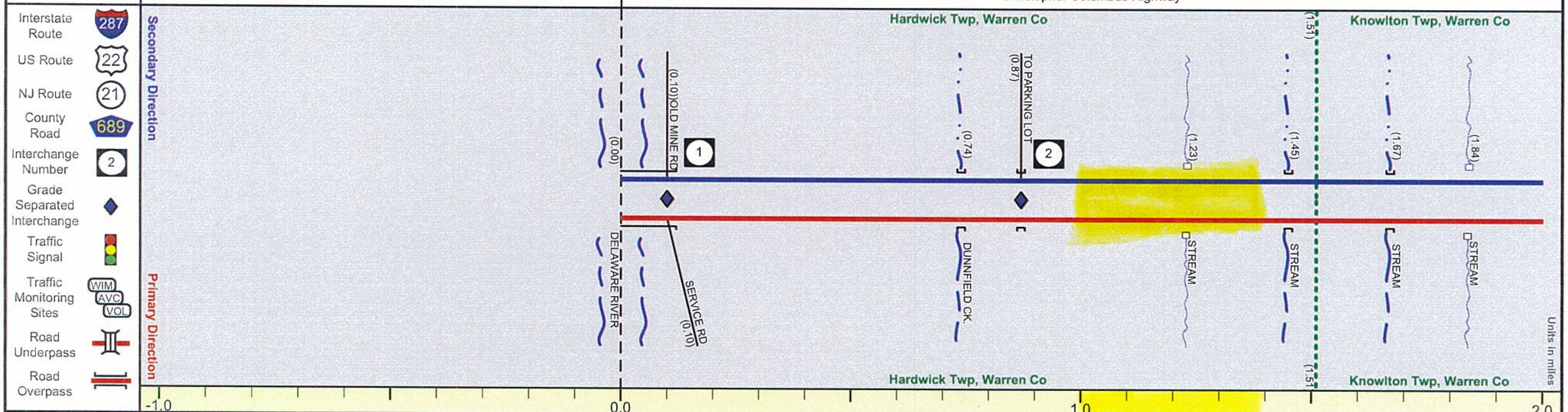
A response by **June 18, 2010** would be appreciated. Thank you in advance for your attention in this matter, if you have any questions please contact me at 5-8078

Attachment included (straight line-diagram)

c:	Andy Swords	Systems Development and Analysis
	Dick Dunne	Structural Engineering
	Pat Ott	Traffic Engineering and Safety
	Laine Rankin	Project Development
	Steve Manera	HNTB Corp.



Pavement	24
Shoulder	0 / 10 / 12 / 4 / 10 / 12
Number of Lanes	2
Speed Limit	50 / 55
Street Name	Christopher Columbus Highway



Street Name	Christopher Columbus Highway
Jurisdiction	D.R.J.T.B.C. / N.J.D.O.T.
Functional Class	Rural Interstate
Federal Aid - NHS Sy	STRAHNET Inter.
Control Section	2100 / 2114
Speed Limit	50 / 55
Number of Lanes	2
Med. Type	Positive
Med. Width	26 / 8 / VAR
Pavement	24
Shoulder	0 / 10 / 12 / 6 / 10 / 12
Traffic Volume	55,072 (2005)
Traffic Sta. ID	1-2-017
Structure No.	N/A / 2114150 / 2114151 / N/A / 2114152 / 2114153 / N/A
Enlarged Views	See Enlarged View #34

Begin I-80 MP=0.00

Page Created: May 2009

From:	Kamlesh Shah
To:	Steven Manera
Subject:	Fwd: Re: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Thursday, June 10, 2010 7:22:55 AM
Attachments:	I-80 MP 1.04 - 1.35.xlsx

Steve,

Attached for your use, thanks.

Kamlesh

>>> Ira Levinton 6/9/2010 3:43 PM >>>

Ira Levinton
Project Engineer, Planning
Bureau of Systems Development & Analysis
1035 Parkway Ave
Trenton, NJ 08625
(609) 530-2846
FAX: (609) 530-3723

>>> Neha Galgali 6/9/2010 3:37 PM >>>
Hi Ira

See attached NJCMS scoring and rating for the requested project location.
Thanks.

Ira, cc this to Kamlesh since Bhavesh is on vacation.

Neha

>>> Ira Levinton 6/3/2010 9:26 AM >>>
Neha,

Please return this E-mail with the data sheet rather than the Email from Bhavesh

Thank you

Ira

>>> Kamlesh Shah 6/3/2010 7:29 AM >>>
Please CC the info to me, as Bhavesh will be on vacation. Thanks.

Kamlesh R. Shah, P.E.
Supervising Engineer 2
Division of Project Development
NJDOT, 3rd Floor E.&O. Building
1035 Parkway Avenue
Trenton, NJ 08625
Phone No. 609- 530- 5539
Fax No. 609-530-3595
E-Mail : kamlesh.shah@dot.state.nj.us

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

New Jersey Department of Transportation

Bureau of Systems Planning

CMS Priority Ranking

I-80 (MP 1.04 - 1.35) Rockfall Mitigation

Hardwick and Knowlton Twps., Warren County

CMS Link Number	Route	Begin Milepost	End Milepost	One-Way ADT (2006) (Veh./Day)	No. of Lanes (NB/EB)	No. of Lanes (SB/WB)	Summer V/C	Overall Score	Priority Rating	System Top Percentile	County	County Top Percentile	MPO	MPO Top Percentile
3201	80	1.00	1.45	27682	2	2	1.05	6.96	Medium	20	Warren	5	NJTPA	24

This section of roadway gets "Very Congested" during summer.

- Highest Score in this section

The Overall Score shown above considers V/C ratio and ADT per lane. Each factor is weighted 50%.
Priority Ratings are based on the Overall Score of 0 to 10, as follows:

HIGH = 7.00+ MEDIUM = 5.00 - 6.99 LOW < 5.00

The summer V/C was developed by applying an adjustment to the average weekday V/C. The actual summer V/C at this location may be higher, especially for summer weekends.

From:	Kamlesh Shah
To:	Steven Manera
Subject:	Fwd: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Monday, June 14, 2010 7:35:16 AM
Attachments:	80rockfallMaSystem.docx I-80 Rockfall SLD.pdf Rt_80_MP_1.xls

FYU. Thanks.

>>> Philip Bertucci 6/10/2010 1:49 PM >>>
Copy of email sent to Bhavesh Shah

>>> Philip Bertucci 6/10/2010 1:46 PM >>>
Please see attached Excel file for pavement data.

Thanks,
Phil

Philip Bertucci, P.E.
Administrative Analyst 1 (Data Processing)
New Jersey Department of Transportation
Civil Engineering-Pavement Technology Unit
1035 Parkway Avenue, P.O. Box 600
Trenton, NJ 08625
(609) 530-4489
Philip.Bertucci@dot.state.nj.us

>>> Susan Gresavage 6/4/2010 1:46 PM >>>
Please provide the requested data.

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

Pavement Management & Technology Unit
Skid/Roughness/Surface Distress/Rut Data
Route I-80 Mileposts 1.04 - 1.35

Note: IRI = International Roughness Index (in/mile); SDI = Surface Distress Index (0-5 scale)

Route	Dir	MP Start	MP End	Speed Limit	Skid Test Date	Skid Value (SN40R)	Profiler Test Date	IRI	SDI	Avg Rut Depth (In)
080	E	1.00	1.10	50	7/18/2006	48	5/30/2009	75	5.00	0.1
080	E	1.10	1.20	50	7/18/2006	57	5/30/2009	105	5.00	0.1
080	E	1.20	1.30	50	7/18/2006	57	5/30/2009	84	5.00	0.1
080	E	1.30	1.40	50	7/18/2006	58	5/30/2009	71	5.00	0.1
080	W	1.00	1.10	50	7/18/2006	56	5/30/2009	103	5.00	0.1
080	W	1.10	1.20	50	7/18/2006	55	5/30/2009	87	5.00	0.1
080	W	1.20	1.30	50	7/18/2006	55	5/30/2009	92	5.00	0.1
080	W	1.30	1.40	50	7/18/2006	60	5/30/2009	81	5.00	0.1

Mileposts 1.0 to 1.4				
Dir	**Avg IRI**	**Rating**	**Avg SDI**	**Rating**
E	84	Good	5.00	Good
W	91	Good	5.00	Good

Color Code	
	Substandard Skid Value (speed dependent)
	Deficient Roughness (IRI) > 170 in/mi
	Deficient Surface Distress (SDI) ≤ 2.4
	Excessive Rut ≥ 0.5 in

From: Bhavesh Shah [mailto:Bhavesh.Shah@dot.state.nj.us]
Sent: Tuesday, July 27, 2010 10:41 AM
To: Steven Manera
Cc: Kamlesh Shah
Subject: Fwd: Re: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35

FYI

>>> Greg Renman 6/22/2010 7:36 AM >>>
Bhavesh,

There are no bridges on this section of I-80, only a pipe (less than 5 feet in length) for which we have no data.

Greg

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

From: RajendraR Patel
To: Kamlesh Shah
Cc: Kiong Chan
Subject: Fwd: Rt. 80 Rockfall Mitigation
Attachments: Reply Rt.80 Rockfall Mitigation June10.docx
Maintenance Drainage Expenditure Route 80 Mp 1-1.4 June10.xls

---

As requested.

Thanks,

Raj Patel
Drainage Unit

>>> RajendraR Patel 6/4/2010 9:29 AM >>>
Hi,

Attached is Drainage Management Unit's response to your request for the above project.

Thanks,

Raj Patel
Drainage Unit
5-2198

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO: Bhavesh Shah
Division of Project Development (North)

FROM: Raj Patel
Drainage Unit
Division of Design Services

DATE: June 4, 2010

PHONE: 609-530- 2198

SUBJECT: Route I-80 Rockfall Mitigation
Townships of Hardwick and Knowlton, Warren County
UPC No. 095450

In response to your request dated June 2, 2010, Route I-80 Rockfall Mitigation project limit is not ranked in Drainage Management Unit's DMS Ranking List.

No flooding records are on file for the above project limit.

Maintenance Crew Expenditure records for the project limits are attached for your information.

CC: Manager, K. Chan, file

DWR DATE	CREW	ACTY ID	ACTY DESCR	WORK DESCR	RTE PREFIX	RTE	RTE SUFFIX	BEG MP	END MP	TOT LAB $	TOT EQUIP $	TOT MATL$
16-Apr-07	2160	552	STORMS & FLOOD WORK	FLOOD ACTIVITIES	I	80	0	0.5	2.9	933	140	0
18-Dec-07	2570	414	RECONSTRUCT INLET/MANHOLE	RESET HEAD / PLATE / GRATE	I	80	0	0.7	0.7	489	122	0
31-Jan-06	2160	746	CLEAN DITCHES/CHANNELS		I	80	0	0.8	1.4	272	35	0
01-Aug-06	2570	414	RECONSTRUCT INLET/MANHOLE	RESET HEAD / PLATE / GRATE	I	80	0	0.8	0.8	1265	244	0
20-Feb-07	2570	414	RECONSTRUCT INLET/MANHOLE	RESET HEAD / PLATE / GRATE	I	80	0	0.9	0.9	1222	111	0
12-Sep-07	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	0.9	1.2	324	34	0
14-Feb-08	2570	414	RECONSTRUCT INLET/MANHOLE	RECONSTRUCT INLET	I	80	0	0.9	0.9	682	70	44
13-Mar-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.4	473	88	0
15-May-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.4	291	35	0
08-Jun-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.4	462	68	0
26-Jun-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.5	272	54	0
14-Sep-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.4	308	54	0
27-Apr-07	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.5	437	51	0
11-Apr-08	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.1	300	35	0
10-Jul-08	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.3	334	34	0
24-Jul-08	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.3	300	35	0
06-Oct-08	2160	744	CLEAN PIPES	ROUTINE	I	80	0	1	1.1	227	19	0
29-Oct-08	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1	1.2	70	9	0
09-May-06	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1.1	1.8	469	68	0
11-Mar-08	2160	745	CLEAN INLETS AND MANHOLES	INLET CLEANING	I	80	0	1.1	1.4	143	25	0
15-Aug-06	2570	414	RECONSTRUCT INLET/MANHOLE	RECONSTRUCT INLET	I	80	0	1.8	1.8	1565	211	122
12-Sep-06	2570	414	RECONSTRUCT INLET/MANHOLE	RECONSTRUCT INLET	I	80	0	1.8	1.8	1737	279	273
21-Dec-07	2570	414	RECONSTRUCT INLET/MANHOLE	RESET HEAD / PLATE / GRATE	I	80	0	1.9	1.9	682	122	0

From:	Kamlesh Shah
To:	Steven Manera
Subject:	Fwd: Re: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Wednesday, June 09, 2010 7:29:33 AM
Attachments:	80rockfallMaSystem.docx I-80 Rockfall SLD.pdf

FYI.

>>> John Jamerson 6/8/2010 2:50 PM >>>
Kamlesh/Bhavesh-
In response to your request, Geotechnical Engineering has checked our 2 management systems for relevant data for the referenced CD screening. Our Rockfall Hazard Management System shows 4 rock cuts, details for which were previously been included within our initial problem statement for this project; in addition, our Geotechnical Data Management System indicates existing soil boring information for the retaining wall at the northern terminus of the project limits. If so desired, this information may be accessed through the Department's home page or through the following link:
www.state.nj.us/transportation/refdata/geologic/

Please contact our office at 5-3730 if you have any questions.
John
—-----------------

John P. Jamerson
Project Engineer, Geology
Geotechnical Engineering
NJ Department Of Transportation
office: 609.530.3733
cell: 609.273.5631
fax: 609.530.2704
email: John.Jamerson@dot.state.nj.us
-
>>> Kamlesh Shah 6/3/2010 7:29 AM >>>
Please CC the info to me, as Bhavesh will be on vacation. Thanks.

Kamlesh R. Shah, P.E.
Supervising Engineer 2
Division of Project Development
NJDOT, 3rd Floor E.&O. Building
1035 Parkway Avenue
Trenton, NJ 08625
Phone No. 609- 530- 5539
Fax No. 609-530-3595
E-Mail : kamlesh.shah@dot.state.nj.us

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

From:	Kamlesh Shah
To:	Steven Manera
Subject:	Fwd: Re: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Thursday, June 10, 2010 7:31:45 AM
Attachments:	I80 MP 1 Rockfall.xls

Steve,

This is for your use, thanks.

Kamlesh

>>> Michael Pilsbury 6/9/2010 4:43 PM >>>
Gentlemen, here are rockfall type incidents between Feb of 2003 and March of 2008.

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

RECORD #	RTE	FREEWAY/ ARTERIAL	MUNI	COUNTY	START MP	END MP	MAINLINE OR RAMP	DATE	INPUT TIME	UPDATE TIME	WEATHER RELATED	INCIDENT DETAILS	# OF LANES CLOSED	# OF LANES OPEN	Total # Of Lanes	HAZ-MAT	DIR	EST. DURATION	Final Duration (in Hours)	NJ State Police Involved?
2426	80	Freeway	Hardwick Twp.	Warren	1		Mainline	8/13/04	5:18 AM	6:06 AM	N	5:20AM Initial : Two right lane closed at exit 2 due to debris in roadway. Crew 216 responding, NJSP on scene. 6:06AM Final: All lanes reopened.	2	1		N	East	2-4 Hours	1	N
13099	80	Freeway	Hardwick Twp.	Warren Co.	1.5	1.5	Mainline	4/15/07	5:59 PM	7:42 PM	Y	6:00PM Initial: Westbound lanes closed/WALL COLLAPSED/MUD SLIDE. NJSP on scene with detour, crew-216 enroute with loader. 6:20PM Update#1:ESP-1714 on scene with NJSP, left lane reopened, right lane will remain closed for cleanup.7:10PM Update#2: NJSP clos	2		2	N	West	2-4 Hours	1.5	Y
13116	80	Freeway	Hardwick Twp.	Warren Co.	1.5		Mainline	4/15/07	10:04 PM	11:04 AM	Y	10:05PM Initial : Right lane closed due to a washout.04/16/2007, 11:04AM Final: right lane reopened, Incident cleared.	1	2	3	N	West	2-4 Hours	13	N

From:	Bhavesh Shah
To:	Steven Manera
Cc:	Kamlesh Shah
Subject:	Fwd: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Thursday, June 03, 2010 8:58:10 AM
Attachments:	80rockfallMaSystem.docx I-80 Rockfall SLD.pdf

FYI

>>> Mark Tozzi 6/3/2010 8:23 AM >>>
Bhavesh, a search of our files reveals that Traffic Engineering & Investigations does not have any recent, pending, or active work orders in the project area. If you have any questions, please call me at 5-2622. Thanks, Mark

>>> Bhavesh Shah 6/2/2010 3:37 PM >>>
To All:

Please see attached shotgun memo requesting Management Systems information on Route I-80 Rockfall Mitigation MP 1.04 to 1.35 located in Hardwick and Knowlton, Warren County. Please provide the information by June 18, 2010.

Thanks,

Bhavesh

From:	Bhavesh Shah
To:	Steven Manera
Cc:	Kamlesh Shah
Subject:	Fwd: Route I-80 Rockfall Mitigation, MP 1.04 - 1.35
Date:	Wednesday, June 02, 2010 4:05:56 PM
Attachments:	092110-wrpt-10_04_08_10.xls

FYI

>>> Chris Zajac 6/2/2010 3:50 PM >>>
Bhavesh,

See the attached report.

Regards,
Chris

PS.
You can obtain the same information by using a Data Viewer 2 located at the following link: http://njdotintranet.dot.state.nj.us/tools/

New Jersey Department of Transportation

Daily Volume from 01/18/2010 through 01/21/2010

Site Names: 092110, , I-80-1.5, 00000080__, Knowlton Twp
County: WARREN
Funct. Class: Urban Principal Arterial - Interstate
Location: Bet Interchange 2 and Interchange 3

Seasonal Factor Type: 1 Urban Interstates
Daily Factor Type: 1 Urban Interstates
Axle Factor Type: 1
Growth Factor Type: 1 Urban Interstates

	01/17/2010			01/18/2010			01/19/2010			01/20/2010			01/21/2010			01/22/2010			01/23/2010		
	ROAD	W	E	ROAD	W	E	ROAD	W	E	ROAD	W	E	ROAD	W	E	ROAD	W	E	ROAD	W	E
00:00							1,498	845	653	1,342	793	549	1,527	879	648						
01:00							1,319	642	677	1,192	658	534	1,313	697	616						
02:00							1,216	491	725	1,139	466	673	1,199	538	661						
03:00							1,526	471	1,055	1,446	503	943	1,496	493	1,003						
04:00							2,427	484	1,943	2,466	603	1,863	2,173	412	1,761						
05:00							3,873	637	3,236	3,707	765	2,942	3,168	238	2,930						
06:00							4,284	974	3,310	4,147	987	3,160	4,187	1,055	3,132						
07:00							3,940	1,296	2,644	3,767	1,196	2,571	3,954	1,346	2,608						
08:00							3,647	1,432	2,215	3,618	1,445	2,173	3,920	1,725	2,195						
09:00							3,570	1,587	1,983	3,497	1,558	1,939	3,484	1,521	1,963						
10:00							3,501	1,805	1,696	3,538	1,784	1,754	3,715	1,932	1,783						
11:00							3,664	1,908	1,756	3,557	1,855	1,702	3,728	1,999	1,729						
12:00							3,749	2,090	1,659	3,707	1,997	1,710	3,794	2,066	1,728						
13:00							3,891	2,093	1,798	3,713	2,027	1,686									
14:00							3,979	2,213	1,766	4,008	2,164	1,844									
15:00							4,486	2,773	1,713	4,496	2,802	1,694									
16:00				6,561	3,267	3,294	5,170	3,473	1,697	5,254	3,575	1,679									
17:00				6,062	3,063	2,999	4,935	3,326	1,609	4,843	3,224	1,619									
18:00				5,386	2,608	2,778	4,190	2,752	1,438	4,153	2,703	1,450									
19:00				4,115	1,978	2,137	3,370	2,163	1,207	3,431	2,171	1,260									
20:00				3,479	1,611	1,868	2,801	1,649	1,152	3,156	1,872	1,284									
21:00				2,929	1,448	1,481	2,485	1,290	1,195	2,604	1,474	1,130									
22:00				2,432	1,161	1,271	2,128	1,103	1,025	2,179	1,111	1,068									
23:00				1,782	952	830	1,685	980	705	1,850	1,026	824									
Volume				32,746	16,088	16,658	77,334	38,477	38,857	76,810	38,759	38,051	37,658	14,901	22,757						
AM Peak Vol							4,370	1,908	3,535	4,147	1,865	3,241	4,312	2,000	3,283						
AM Peak Fct							0.97	0.93	0.97	0.95	0.89	0.93	0.88	0.94	0.97						
AM Peak Hr							5.45	11.00	5.30	6.00	10.15	5.30	7.30	10.30	5.45						
PM Peak Vol							5,170	3,489	1,811	5,259	3,575	1,844									
PM Peak Fct							0.96	0.93	0.92	0.95	0.97	0.89									
PM Peak Hr							16.00	16.15	13.15	16.15	16.00	14.00									
Seasonal Fct				1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107	1.107						
Daily Fct				0.897	0.897	0.897	0.878	0.878	0.878	0.968	0.968	0.968	0.961	0.961	0.961						
Axle Fct				0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432	0.432						
Pulse Fct				2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000						

Created 04/07/2010 10:56:10 AM **ROAD AADT** **69,869** **W AADT** **33,968** **E AADT** **35,901**

APPENDIX H

GEOTECHNICAL INFORMATION AND RHRS RATINGS

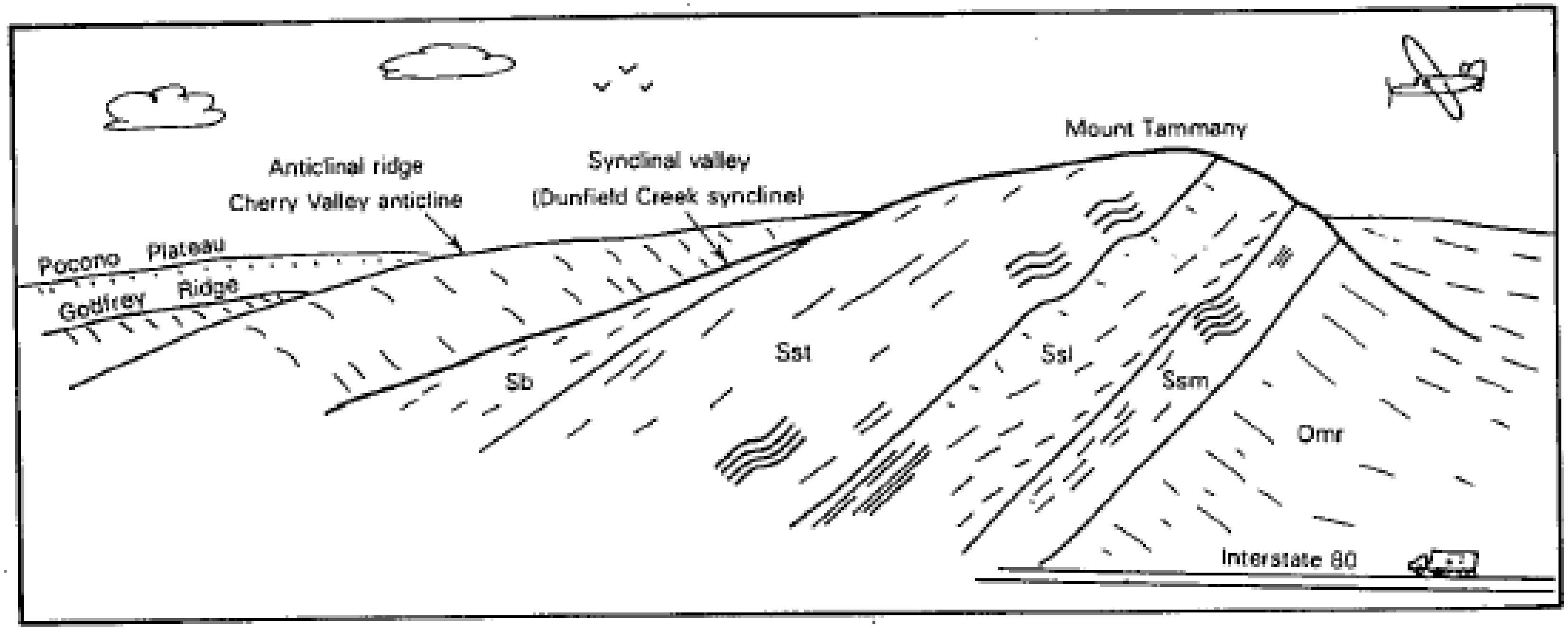


Figure 11.

Sketch from photograph looking northeastward into New Jersey from Stop 4 showing the geology at Delaware Water Gap. A few satellitic folds in the Shawangunk Formation are indicated. Relief between the Delaware River and Mt. Tammany is 1260 feet (384 m). Sb, Bloomsburg Red Beds; Sst, Ssl, and Ssm, Tammany, Lizard Creek, and Minsi Members of the Shawangunk Formation; Omr, Ramseyburg Member of the Martinsburg Formation, which is talus covered in the area of the sketch.

FIGURE 1 – GEOLOGIC CROSS SECTION OF THE DELAWARE WATER GAP

Geology of the Ridge and Valley Province, Page 82

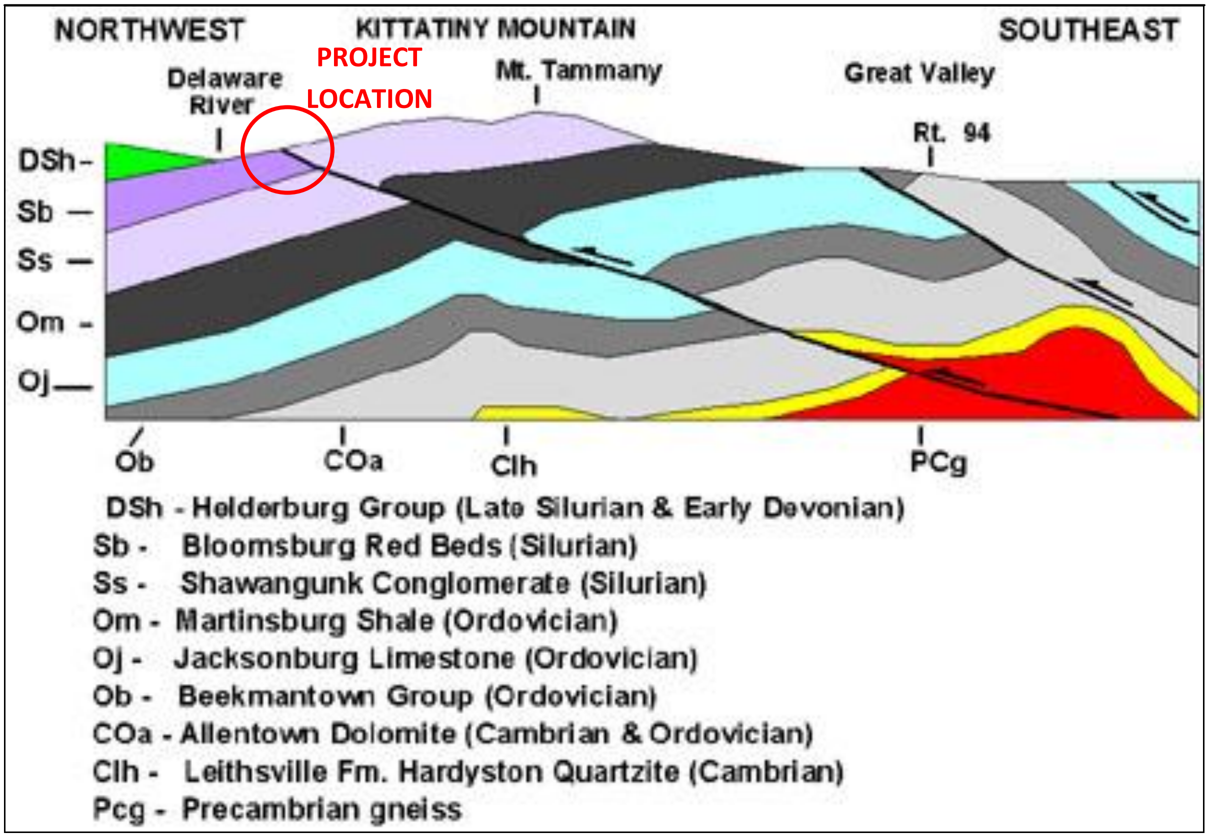
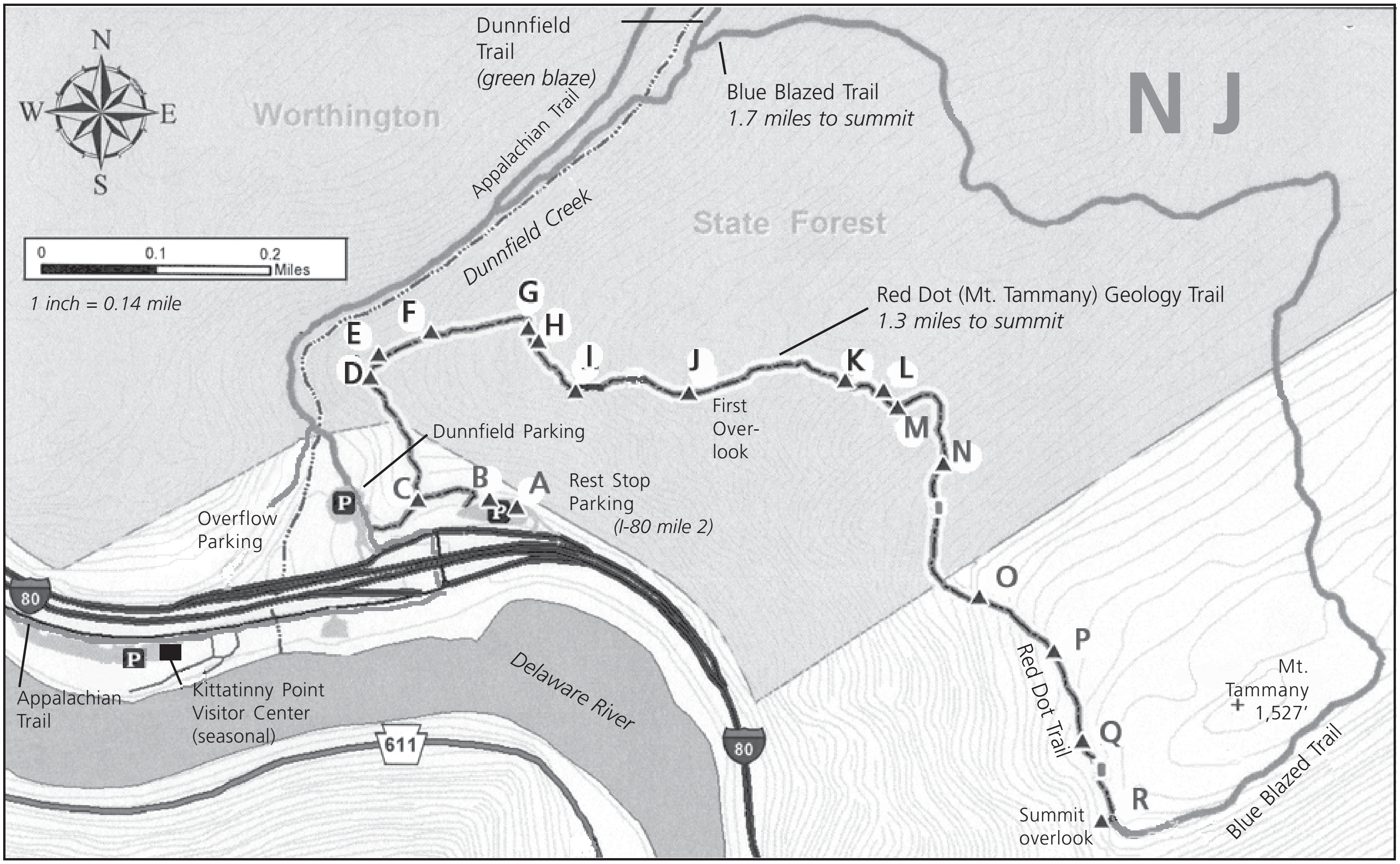


Figure 2 –Generalized Geologic Cross Section of Kittatinny Mountain at the Delaware Water Gap Area (after Lyttle & Epstein, 1987)

Advanced Mt. Tammany Geology
Stops along the Red Dot/Mt. Tammany Trail



Coordinates x	Coordinates y	Stop	Feature *(this itinerary is recommended for those with a knowledge of geology)*
489657	4535648	**A**	Contact between Shawangunk Formation and Bloomsburg Redbeds
618	659	**B**	Eight-foot-long boulder with slickensides
518	653	**C**	Glacial kame terrace on sand and gravel
450	828	**D**	Glacial Striae
462	859	**E**	Rutted limestone glacial errratic
535	891	**F**	Rib of Bloomsburg bedrock
673	897	**G**	Greenish-gray & red siltstone, sandstone & shale of Bloomsburg Formation
687	879	**H**	Large glacial erratic. Schoharie Formation (?)
740	809	**I**	First Overlook (Arrow Island)
899	808	**J**	Glacially-polished red sandstone and siltstone. Glacial striae.
490117	827	**K**	Springs
171	814	**L**	Beginning of Shawangunk Formation on steep slope
191	790	**M**	Talus
256	712	**N**	Rib of quartzite with joints
289	528	**O**	Crossbeds. Glacial cobbles.
413	452	**P**	Gentle slop underlain by shale
454	328	**Q**	Evidence of forest fire
481	217	**R**	Summit Overlook (Indian Head) junction with Blue Blazed Trail Sedimentary Structures. Mt. Tammany 1,527 ft.

FIGURE 3 - GEOLOGY STOPS ON MT. TAMMANY

FIGURE 1: ROCKFALL HAZARD FIELD DATA SHEET

State Hwy Name & No. 80 WB

Beginning M. P. 1.0

L or R of Centerline *

Ending M. P. 600'

Preliminary Rating

Cut Class A or B or C

Proposed Correction ________

County Name & No. WARREN

Date of Rating (YYMMDD) 3/12/09

Posted Speed Limit 50

ADT 33968

Rater A. McElwain

Detailed Rating Score 406

Cost Estimate $

Preliminary Rating Remarks: (Continue on Back)

DETAILED RATING

Slope Height Score 100

Slope Height in Feet 500' +

Ditch Effectiveness Score 10

Catchment Letter G M L N *

Average Vehicle Risk Score 100

Percent of Time 321%

Site Distance Score 56

Percent Design Value 47%

Site Distance 320'

Roadway Width Score 24

Roadway Width in Feet 29'

GEOLOGIC CHARACTER CASE 1

Structural Condition Score ________

Fracture Letter D C *

Orientation Letter F R A *

Rock Friction Score ________

Friction Letter R I U P C S *

GEOLOGIC CHARACTER CASE 2

Structural Condition Score 60

Erosion Feature Letter F O N M *

Diff in Erosion Rate Score 10

Diff in Erosion Rate Letter S M L E*

Block Size/Quant. Per Event 40

Block Size in Feet 3'

Quantity in Cubic Yards ________

Climate & H_2O Score 3

Precipitation Letter L M H *

Freezing Period Letter N S L *

Water Letter N I C *

Rockfall History Score 3

Rockfall History Letter F O M C *

* Circle One

Remarks:

FIGURE 1: ROCKFALL HAZARD FIELD DATA SHEET

State Hwy Name & No. 80 WB
Beginning M. P. 1.15
L or R of Centerline *
Ending M. P. 650'
Preliminary Rating
Cut Class A or B or C
Proposed Correction

County Name & No. WARREN
Date of Rating (YYMMDD) 3/12/09
Posted Speed Limit 50
ADT 33968
Rater A. McELWAIN
Detailed Rating Score 630

Cost Estimate $

Preliminary Rating Remarks: (Continue on Back)

Large backslope, stone at catch

DETAILED RATING

Slope Height Score 100
Slope Height in Feet 500 +

Ditch Effectiveness Score 60
Catchment Letter G M L N *

Average Vehicle Risk Score 100
Percent of Time 340%

Site Distance Score 100
Percent Design Value 27%
Site Distance 200'
Roadway Width Score 24
Roadway Width in Feet 29'

GEOLOGIC CHARACTER CASE 1

Structural Condition Score 100
Fracture Letter D C *
Orientation Letter F R A *

Rock Friction Score 40
Friction Letter R I U P C S *

GEOLOGIC CHARACTER CASE 2

Structural Condition Score 80
Erosion Feature Letter F O N M *

Diff in Erosion Rate Score 40
Diff in Erosion Rate Letter S M L E*

Block Size/Quant. Per Event 100
Block Size in Feet 4-5'
Quantity in Cubic Yards

Climate & H_2O Score 3
Precipitation Letter L M H *
Freezing Period Letter N S L *
Water Letter N I C *

Rockfall History Score 3
Rockfall History Letter F O M C *

* Circle One

Remarks:

FIGURE 1: ROCKFALL HAZARD FIELD DATA SHEET

State Hwy Name & No. 80 WB

Beginning M. P. 1.3

L or R of Centerline *

Ending M. P. 410'

Preliminary Rating

Cut Class A or B or C

Proposed Correction ________

County Name & No. WARREN

Date of Rating (YYMMDD) 3/12/09

Posted Speed Limit 50

ADT 33968

Rater A. McElWAIN

Detailed Rating Score 660

Cost Estimate $

Preliminary Rating Remarks: (Continue on Back)

Vertical face, large hanging blocks

DETAILED RATING

Slope Height Score 100

Slope Height in Feet 200+

Ditch Effectiveness Score 90

Catchment Letter G M L N *

Average Vehicle Risk Score 100

Percent of Time 226%

Site Distance Score 100

Percent Design Value 27%

Site Distance 200'

Roadway Width Score 24

Roadway Width in Feet 29'

GEOLOGIC CHARACTER CASE 1

Structural Condition Score 100

Fracture Letter D C *

Orientation Letter F R A *

Rock Friction Score 40

Friction Letter R I U P C S *

GEOLOGIC CHARACTER CASE 2

Structural Condition Score 80

Erosion Feature Letter F O N M *

Diff in Erosion Rate Score 40

Diff in Erosion Rate Letter S M L E*

Block Size/Quant. Per Event 100

Block Size in Feet 4-5'

Quantity in Cubic Yards ________

Climate & H_2O Score 3

Precipitation Letter L M H *

Freezing Period Letter N S L *

Water Letter N I C *

Rockfall History Score 3

Rockfall History Letter F O M C *

* Circle One

Remarks:

FIGURE 1: ROCKFALL HAZARD FIELD DATA SHEET

State Hwy Name & No. 80 WB
Beginning M. P. 1.4
L or R of Centerline *
Ending M. P. 435'
Preliminary Rating
Cut Class A or B or C
Proposed Correction

County Name & No. WARREN
Date of Rating (YYMMDD) 3/12/09
Posted Speed Limit 50
ADT 33968
Rater A. McELWAIN
Detailed Rating Score 422

Cost Estimate $

Preliminary Rating Remarks: (Continue on Back)

Large boulder / talus slope - measured to gabion wall where meets cliff face.

DETAILED RATING

Slope Height Score 100
Slope Height in Feet 200' +

Ditch Effectiveness Score 10
Catchment Letter G M L N *

Average Vehicle Risk Score 100
Percent of Time 226%

Site Distance Score 9
Percent Design Value 80%
Site Distance 600'
Roadway Width Score 32
Roadway Width in Feet 27'

GEOLOGIC CHARACTER CASE 1

Structural Condition Score
Fracture Letter D C *
Orientation Letter F R A *

Rock Friction Score
Friction Letter R I U P C S *

GEOLOGIC CHARACTER CASE 2

Structural Condition Score 60
Erosion Feature Letter F O N M *

Diff in Erosion Rate Score 5
Diff in Erosion Rate Letter S M L E*

Block Size/Quant. Per Event 100
Block Size in Feet 10' +
Quantity in Cubic Yards

Climate & H_2O Score 3
Precipitation Letter L M H *
Freezing Period Letter N S L *
Water Letter N I C *

Rockfall History Score 3
Rockfall History Letter F O M C *

* Circle One

Remarks:

APPENDIX I

DESIGN COMMUNICATION REPORTS
AND NJDOT COMMUNICATIONS

new
jersey
department of
transportation

Design Communications Report Approval
Design and Construction Phases

Project Name : Route 80 Rockfall Mitigation MP 1.04 to 1.45	**UPC#: 095450**
Consulting Firm: HNTB Corp.	**Designer Project Manager: Steven Manera**
DOT Project Manager: Bhavesh Shah	**Program Manager: Laine Rankin**

Design Communications Report (DCR Entry No. 1)

Pursuant to the Interactive Communications Procedure and the Interactive Communications Process of the New Jersey Department of Transportation (the Department), the Department's Project Manager has approved the DCR identified above, (approved by Entry No(s).) subject to the certification below of the Designer.

This approval by the Department's Project Manager is not a certification by the Department that the above project has been designed in accordance with all applicable State and Federal design standards and requirements or that comments and decisions made during Interactive Communications with the Department on design elements and features of the project to this point have been incorporated or satisfactorily resolved and the Contract Documents have been revised accordingly, and the Department is fully relying in this regard upon the certification below by the Designer.

Furthermore, the Project Manager, by signing below on behalf of the Department, has not waived the Designer's obligation to provide contract documents that are constructible and free from errors and/or omissions.

11-5-10 | Bhavesh N Shah / 11/8/10

Designer's Project Manager / Date | NJDOT Project Manager / Date

Project Review Certification

In accordance with the Interactive Communications procedure and the Interactive Communication Process of the Department, in the Designer's professional opinion, and to the best of the Designer's knowledge, information and belief and based upon the performance of the Designer's duties as set forth in the NJDOT and the Designer Agreement, the Designer represents that the above project has been designed in accordance with all applicable State and Federal design standards and requirements. Comments and decisions made during the Interactive Communications with the Department on design elements and features of the project to this point have been incorporated or satisfactorily resolved, and that the approved DCR entry (or entries) identified above will be incorporated into the Contract Documents accordingly.

11-5-10
Designer's Project Manager / Date

11-5-10
Designer's Principal / Date

Design Communications Report

for

I-80 Rockfall Mitigation
Concept Development
Townships of Hardwick and Knowlton
County of Warren
Mileposts 1.04 to 1.35
DB No. 09545, DOT Job No. 2204527

Program Manager: Laine Rankin

Project Manager: Bhavesh Shah

UPC: 095450

Date: October 29, 2010

Design Communications Report (I-80 Rockfall Mitigation)

<table>
<tr><td>Design Activity No. 6910</td><td>(Approved date by Departments PM)</td><td>DCR Entry No. 001

Prepare Purpose & Needs Statement</td></tr>
<tr><td></td><td colspan="2">Who (PM/ SME /Stakeholder /Designer): During preparation of the Purpose and Needs Statement, HNTB recognized a discrepancy in the project limits shown in the scope of work (MP 1.04 to 1.35) compared with the limits described by Mr. Jamerson in various meeting minutes (MP 1.04 to 1.45). On 9/28/10, HNTB e-mailed John Jamerson (SME) about this discrepancy and subsequently spoke to Mr. Jamerson on 9/29/10 about how to resolve this issue.</td></tr>
<tr><td></td><td colspan="2">Design Element issue: Project Limits</td></tr>
<tr><td></td><td colspan="2">Decision and reasoning: Mr. Jamerson indicated that it was the Geotechnical Unit's intention that the milepost limits be from 1.04 to 1.45. An inadvertent error in the original problem statement led to this discrepancy. Mr. Jamerson further indicated that he would request approval of the Department's Capital Program Committee to extend the eastern project limit to MP 1.45, to be in conformance with the original intent for this project.</td></tr>
</table>

MEETING NOTES

May 19, 2010

Re: I-80 Rockfall Mitigation Concept Development
Townships of Hardwick and Knowlton, Warren County
UPC # 095450

Location: On Site

Purpose: Scope Team Kick off/Field Meeting

Attending: Kamlesh Shah, NJDOT DPD
Bhavesh Shah, NJDOT DPD
John Jamerson, NJDOT Geotechnical
George Worth, NJDOT Project Management
Paul Hartle, NJDOT Traffic Operations
Frank Cole, NJDOT Region North Construction
Robert Abitz, NJDOT Value Solutions
Binh Vo, NJDOT Value Solutions
Robert Bird, NJDOT Environmental
Scott Sheldon, NJDOT Region North Maintenance
Matt Riegel, HNTB
Brian Felber, HNTB
Andre' Luboff, HNTB
Steve Manera, HNTB

Region North Maintenance crews established a right lane closure prior to the start of the field meeting to facilitate the field inspection of the site.

The meeting began shortly after 10:00 a.m. on Wednesday May 5, 2010.

Bhavesh Shah opened the meeting with a short introduction of the project and then asked team members to introduce themselves.

Steve Manera provided team members with a copy of the meeting agenda and a briefing paper and reviewed the overall goal of the project which is to undertake/implement rockfall mitigation measures such that the site can be removed from the Rockfall Hazard Management System.

This section of westbound I-80 consists of a center barrier curb, 2 travel lanes, a narrow shoulder and a barrier curb adjacent to the shoulder. Highway lighting standards and foundations are situated and integrated with the barrier curb. There is gravel material behind and up to the top of the barrier curb at most locations throughout the project limits. Some areas have a short, stacked stone wall placed on top of the fill material.

John Jamerson provided a description of the project location in terms of four (4) specific areas noted by approximate mileposts;

- Area A MP 1.04 to 1.15
- Area B MP 1.15 to 1.25
- Area C MP 1.25 to 1.35
- Area D MP 1.35 to 1.45

The project team started at the eastern end of the project (Area D) and continued walking toward the western limit (Area A), stopping at various points to discuss conditions, makes observations and take photographs of each area.

Area D observations; in this area, a large rock face is set some distance back from the roadway making the mobilization of equipment difficult. A large area of broken rock slopes down toward the roadway and ends at a 2'-3' stacked stone wall that sits approximately 1' behind the barrier face. This area may be a candidate for a catchment fence.

Area C observations; this area has a large vertical face that is very close to the roadway and will prove challenging to implement remediation strategies. Large scaling is likely prohibitive due to the potential for damage to the roadway surface however, small selective scaling seems possible. The vertical face may also be a candidate for mesh and/or shotcrete.

Area B observations; there is a drainage crossing located in this area. There is a very large vertical face set a far distance back from the roadway however, this face will not be directly addressed. There is stacked stone set at the height of the barrier curb which extends 3’-4’ high. The area is a possible candidate for catchment fencing however, special treatment in the area of the drainage crossing will need to be addressed.

Area A observations; there is a drainage ditch which runs parallel to the roadway and approximately 8' – 10' behind the barrier curb for most of area A. The ditch ends at an approximately 18" CM pipe which is believed to cross under I-80. Further investigation of this crossing is required as the 18" pipe appears to run along westbound I-80 and uphill rather than along the roadway, and surface indications in the area were lacking. Scott Sheldon indicated that Maintenance forces would need future access to this area in order to keep the ditch cleaned of debris. Several team members expressed concern about triggering environmental issues by implementing mitigation measures in this area.

John Jamerson and Matt Riegel agreed to confer on the need for a follow up field trip with a crane for better observations. They also agreed to consider consulting a rockfall mitigation contractor for an opinion.

The aesthetic aspect of any mitigation measures that are incorporated into the project may need to be considered due to the location of the project in the Delaware Water Gap National Recreation area.

Paul Hartle offered that traffic conditions along I-80 westbound begin building in early afternoon and lane closures after 1 PM are typically not permitted by Traffic Operations.

Region North Crew Supervisor Joe Popelka who was on site to set up the lane closure but did not attend the meeting reported that a very larger boulder tumbled down onto the westbound roadway bouncing across the lanes, through the concrete median barrier and came to rest in the eastbound lane. The boulder was struck by a motorist and resulted in a fatality. The incident was recalled to have occurred 'a few years ago'.

Action Items

1. Bhavesh Shah will request preliminary lane closure hours from Paul Hartle of Traffic Operations North.
2. John Jamerson and Matt Riegel to determine if a follow up on site meeting will be needed, if it will require a crane for closer observations (Area C) and whether or not to invite a rockfall mitigation contractor along for this inspection.
3. HNTB is in the process of requesting accident data, traffic incident data and maintenance reports, traffic counts, ROW plans and other pertinent data from NJDOT.

Submitted by,

HNTB CORPORATION

Steven Manera

cc: Attendees
Samir Mody, HNTB
Harold Calero, HNTB
Laura Wolfe, HNTB
File

MEETING NOTES

Re: I-80 Rockfall Mitigation Concept Development
Townships of Hardwick and Knowlton, Warren County
UPC # 095450

Location: On Site – Rt 80 MP 1

Date: August 4, 2010

Purpose: Field Inspection Meeting

Attending: John Jamerson, NJDOT Geologist
Matt Riegel, HNTB Geotechnical
John Szturo, HNTB Geology
Brian Felber, HNTB Geotechnical
Andrew Salmaso, Janod

Highway occupancy permit was filed by HNTB with the State. HSA crews established a right lane closure prior to the start of the field meeting to facilitate the field inspection of the site.

The meeting began at 10:30 a.m. on Tuesday July 20, 2010.

John Jamerson provided a description of the project location in terms of four (4) specific areas noted by approximate mileposts;

- Area A MP 1.04 to 1.15
- Area B MP 1.15 to 1.25
- Area C MP 1.25 to 1.35
- Area D MP 1.35 to 1.45

Key Considerations

- Aesthetics of rock fall mitigation are to be considered due to the location of the project in the Delaware Water Gap National Recreation area.
- Limited working hours will be available during construction because of maintenance of traffic. The roadway is only two lanes with insufficient shoulders.

Field Reconnaissance
The project team started at the western end of the project (Area A) and continued toward the eastern limit (Area D), stopping at various points to discuss conditions, making observations and taking photographs of each area.

Area A Observations:

- Solution – Consensus NJ Standard catchment fence..

Area B Observations:

- Solution – Consensus NJ catchment fence.

Area C Observations:
Consensus Solutions

- Small quantity of selective slope scaling
- Investigate the use of a hybrid system, which would include a fence at the first crest to catch rockfall from the upper slope and allow it to funnel down behind drapery attached to the lower slope.
- This proposed solution should minimize maintenance.
- John Szturo to call Peter Perreaut (Mountain Management Inc) about the Igor Hybrid System.

-
- The drapery portion of the hybrid system will be equipped with breakable decelerators or tag lines to slow the rate of decent of the rock.
- The anchors to the fence at the crest of the hybrid system would be constructed of reinforcing bar grouted into rock similar to a rock bolt.
- Estimates that 15' long bolts would likely be the worst case needed.
- To prevent catchment collected at the bottom of the drapery from entering the roadway a catchment fence will also be installed just behind the barrier curb.
- NJDOT recommends that the standard NJDOT fence detail be used, but that silt fence be placed behind it.
- It was discussed that shotcrete and rock bolts be put in the contract as an item to obtain a unit cost from the contractor, but it will likely not be needed.
- At the end of Area C where there are existing gabion walls, it was recommended that no treatment be performed because there is sufficient catchment and the gabions appear to be working well.

Area D Observations:
- Additional study to model risk and provide recommendations should be performed before proceeding with design.
- John Szturo recommends utilizing a sub-consultant Norm Norrish of Wyllie and Norrish for this task. Analysis might include modeling rock fall, and subsequent alternatives for risk mitigation. Analysis would include options of catchment and review of possible work at source area.
- Solider pile wall or gravity walls such as gabions might be options at the toe of slope.
- The thickness of talus is unknown. John Jamerson to look for as-built data.
- It may be difficult to construct gabion wall because of limited space between edge of roadway and toe of slope. If large pieces of talus are removed from the toe of slope, it may cause instability to the entire slope.
- It may be difficult to construct a solider pile wall because drilling through boulders is difficult and the depth to rock is not known.
- Further investigations are necessary to define rock elevation.
- The largest rock on talus slope appears to be ~10'x10'x5' (500 cubic feet @ 150 lbs ft^3 = 37 tons).
- Thumbnail estimates are approximately ~$3 Million not including Area D, which could be very expensive depending on how much mitigation NJDOT chooses to install based on the potential of a major rockfall event.

<u>Action Items</u>
1. John Szturo to contact Peter Perrault at Mountain Management about the Igor hybrid system.
2. John Szturo to contact Norm Norrish of Wyllie and Norrish about modeling the risk at Area D.
3. John Jamerson to see if NJDOT can provide NJDOT As-Built drawing showing rock elevation.

Submitted by,

HNTB CORPORATION

Matthew Riegel

cc: Attendees
Steve Manera, HNTB
Samir Mody, HNTB
Andre Luboff, HNTB
Harold Calero, HNTB
Laura Wolfe, HNTB
File

Rt. 80 Rockfall Mitigation
November 30, 2010 Field Visit

Attendees:
John Jamerson (NJDOT)
Norm Norrish (Wyllie and Norrish)
John Szturo (HNTB)
Matt Riegel (HNTB)
Brian Felber (HNTB)

Discussion During and Following Site Visit:

Area A:
- May consider taller barrier curb (pre-cast) with esthetic form instead of stacked stone wall with fence. Clean out catchment (drainage feature) area. Install timber energy absorption.
- If not acceptable to NJDOT, we need to use a proprietary fence of know capacity and deflection.

Area B:
- Same as Area A except we will need to excavate a rock outcrop near roadway to install barrier with catchment. Minor blasting may be considered for this excavation.
- May continue barrier curb through all 4 areas to keep continuity in esthetics.

Area C:
- Norm is ok with proposed hybrid system.
- Use matching color vinyl mesh for esthetics.
- Terminate mesh about 5 feet above ground to prevent the snow from anchoring the bottom.
- May use cable mesh.
- Spot bolting required.
- Granular backfill from barrier curb sloped down to toe of slope.
- Inspection during construction for placement of bolts.

Area D:
- Slope was approximately measured to be 37 degrees.
- Perform borings as part of final design:
    - Determine depth of bedrock with vertical air percussive hammer holes on slope.
    - To get core for unconfined compressive strength test take core boring in roadway.
- Alternative for consideration is to grout and anchor talus into bedrock.
- Then, excavate slope back.
- Then, place granular backfill from new barrier curb sloped down to toe of slope.
- Grouting of talus was considered feasible by grouting professional (Marcello).
    - Drill holes to bottom of talus.
    - Grout holes with low slump grout (0"-3").
    - Stop pumping grout when it comes out of the face.
    - Undercut the slope to provide adequate catchment width.
    - Shotcrete the newly created face.
    - Drill anchors into bedrock.
    - Sophisticated monitoring of excavation may be utilized.
    - Ask local grouting professional (Gram Smith, Structural Preservation Systems) to visit the site and assess grouting feasibility.

Miscellaneous:
- John Jamerson was ok with incentives and disincentives for amount of time occupying the highway.
- Prequalification of the contractor will be included as a submission for approval of the engineer.
- Nightly lane closings are still adequate for new concepts developed by Norm.
- A work plan for the design phase should be included in the CD report.

Action Items:
1. Brian to interview NJDOT maintenance to determine (Joe Popelka 908-496-4088 yard 908-966-6169 cell):
    - Type of rockfall (debris flow or rock pieces)
    - Frequency
    - Size
    - Time of year
    - Weather
    - Location (How far from slope, EB or WB)

2. Height of barrier impact on snow removal from NJDOT Maintenance inquiry by Brian.

3. Brian to inquire about history of gabion wall with Maintenance.

4. Brian to provide Norm an Area D Cross Section.

5. Site characterization
    - Strikes and Dips measured by Brian
    - Location, length, width, and height of fallen rock recorded by Brian
    - Lidar done in final design
    - Drilling done in final design (Area D – On slope percussive and in road core drilling)

6. Back slope condition and purpose of gabion wall investigated by Brian.

7. Other side of Rt. 80 slope observed by Brian.

8. Norm to develop conceptual sketches of barrier system and grouted and anchored excavation.

9. Norm to review preliminary report.

10. Norm to perform rock fall simulation.

11. Norm to perform risk analysis of rockfall.

12. Norm to provide report.

13. Rock hazard rating for all 4 areas from John Jamerson for early 1990's and current.

Rockfall History:

Interviewee:
Joe Popelka
NJDOT Maintenance
908-496-4088 yard
908-966-6196 cell

Interviewer:
Brian Felber
HNTB Corporation
973-237-1650

Date of Interview:
Tuesday December 6, 2010

Interview Media:
Phone

Type of Rockfall:
Big pieces of solid rock are more common than debris flows, which only seem to occur during heavy rain.

Frequency of Rockfall:
Rockfall is more frequent in Areas A and B. At about milepost 1 a motorist was killed about 5 or 6 years ago. The rock responsible for this death was about 7 tons and went through the center barrier. The motorist drove into the rock in the roadway. The rock from the 2010 incident which caused a truck to lose its load was about 1.5 tons. About every two months maintenance picks up 30 to 50 pound rock pieces, which did not cause a traffic incident.

Size of Fallen Rock:
Typical rockfall size is between 12" and 36".

Time of Year:
Events occur mostly in the spring.

Weather Related:
Events occur after heavy rain.

Location:
Events occur mostly to the west of the rock face (Areas A and B)in the westbound lanes.

Impact of Taller Barrier Curb on Snow Removal:
Snow removal in this area is already a problem. A taller barrier will make this worse and is not acceptable.

History of Gabion Wall:
From recollection, IEW was the Contractor. The wall was built two or three years ago and was put there after a small landslide.

Field Visit Notes:

Strikes and Dips were measured (see attached)

Rockfall sizes measured to show distribution of rockfall size (see attached)

Ice was observed on the face and is included in photos

The area behind the gabion wall appears to be soil with vegetation. The ground surface was probed several inches with a stick, but the depth to rock could not be determined. The soil slopes up from the top of the gabion. Rockfall was observed on the slope and top of gabion. There is no rockfall mitigation in place at this location. I believe a barrier like the one used in the hybrid barrier in Area C would be beneficial. Photos were taken of this area.

Across Route 80 there appears to be shallow soil deposits with vegetation. Rock outcrops in one location (see photo). Some rockfall was present on the slope, but likely predated the construction of Rt. 80. One large rock piece was observed near mp 1.0. The center barrier was patched in this location. I believe this rock may be the one which caused the fatal accident mention in the interview. In Area D a talus slope is also present. The talus begins about 14 feet below the pavement at the bottom of a retaining wall and six feet south (towards the river) from the retaining wall. It slopes down to the river.

Project:	Route 80 Rockfall Mitigation	Weather:	Sunny ~30°F		
Location:	MP 1.04 - 1.45 West, Hardwick and Knowlton Townships	Inspector:	Brian Felber and Pete Tomos		
Client:	New Jersey Department of Transportation	DateInspected:	12/7/2010	Project No.:	44829

HNTB

DISCONTINUITY DESCRIPTION DATA SHEET

LOCATION	DISCONTINUTIY	DEPTH (ft)	STRIKE (degrees)	DIP (degrees)	PERSISTENCE	TERMINATION	WIDTH	TYPE OF FILLING	STRENGTH OF FILLING (psf)	SURFACE ROUGHNESS	SURFACE SHAPE	WATER FLOW	SPACING (inches)	REMARKS
A			198	46										
A			170	41										
A			179	35										
A			294	54										
A			181	89										
A			258	46										
A			184	58										
A			70	34										
B			190	44										
B			184	31										
B			160	38										
B			180	46										
B			181	51										
B			133	24										
C			186	35										
C			190	36										
C			180	41										
C			187	39										
C			176	30										
C			185	40										
C			178	34										
C			170	34										
C			130	38										
C			181	36										
C			178	44										

Remarks:

1.
2.
3.
4.
5.
6.
7.
8.

Project:	Route 80 Rockfall Mitigation	Weather:	Sunny ~30°F		
Location:	MP 1.04 - 1.45 West, Hardwick and Knowlton Townships	Inspector:	Brian Felber and Pete Tomos		
Client:	New Jersey Department of Transportation	Date Inspected:	12/7/2010	Project No.:	44829

HNTB

ROCKFALL DESCRIPTION DATA SHEET FOR AREA A

CATEGORY	ITEM	PARAMETER							
General Information	Location	6' Behind Barrier ~100' E MP1.0	9' Behind Barrier ~200' E MP 1.0	7' Behind Barrier ~15' E MP 1.1	8' Behind Barrier ~25' E MP 1.1	15' Behind Barrier ~100' E MP 1.1	15' Behind Barrier ~150 E MP 1.1		
	Photo Numbers	1	2	3	4	5	6		
Rock Material Information	Color	Gray	Gray	Gray	Red	Gray	Gray		
	Grainsize (in)	1/8	1/8	1/8	1/8	1/8	3/8		
	Compressive Strength (psi)	4 blows	4 blows	4 blows	20 blows	4 blows	13 blows		
	Compressive Strength Method								
	Rock Type	Quartzite	Quartzite	Quartzite	Sandstone	Quartzite	Congolmerate		
Fallen Rock Information	Length (ft)	2.9	2.1	4.0	5.0	4.5	5.3		
	Width (ft)	2.2	1.9	2.5	2.1	4.2	4.3		
	Height (ft)	2.9	2.0	3.9	2.3	3.7	3.0		
	Type								
	Time of Year								
	Weather								
	Injury Caused								
	Loss of Life Caused								
	Property Damage Caused								
	Impact to Traffic								
	Reported By								

Remarks:

1. ~ 470 pieces 6" to 1' and ~ 378 pieces 1' to 2' anything bigger is specified above
2.
3.
4.
5.
6.
7.
8.

Project:	Route 80 Rockfall Mitigation	Weather:	Sunny ~30°F		
Location:	MP 1.04 - 1.45 West, Hardwick and Knowlton Townships	Inspector:	Brian Felber and Pete Tomos		
Client:	New Jersey Department of Transportation	Date Inspected:	12/7/2010	Project No.:	44829

HNTB

ROCKFALL DESCRIPTION DATA SHEET FOR AREA B

CATEGORY	ITEM	PARAMETER							
General Information	Location	21' Behind Barrier ~20' E Outcrop	32' Behind Barrier ~103' E Outcrop	32' Behind Barrier ~100' E Outcrop	14' Behind Barrier ~150' E Outcrop	16' Behind Barrier ~160' E Outcrop	22' Behind Barrier 10' W End Wall	2' Behind Barrier 20' E End Wall	2' Behind Barrier 25' E End Wall
	Photo Numbers	7	8	9	10	11	12	13 & 14	15
Rock Material Information	Color	Gray	Gray	Gray	Gray	Gray Red	Gray	Gray Red	White
	Grainsize (in)	1/8	3/8	1/8	1/8	1/8	1/8	1/16	1/4
	Compressive Strength (psi)	20 blows	15 blows	11 blows	16 blows	> 30 blows	> 30 blows	6 blows	6 blows
	Compressive Strength Method								
	Rock Type	Quartzite	Conglomerate	Quartzite	Quartzite	Quartzite	Quartzite	Quartzite	Conglomerate
Fallen Rock Information	Length (ft)	2.6	5.2	4.3	3.2	3.4	3.0	4.4	3.0
	Width (ft)	2.1	3.8	1.2	2.7	2.1	2.7	3.8	3.0
	Height (ft)	0.4	1.7	1.3	3.0	1.6	0.7	1.7	2.9
	Type								
	Time of Year								
	Weather								
	Injury Caused								
	Loss of Life Caused								
	Property Damage Caused								
	Impact to Traffic								
	Reported By								

Remarks:

1. ~ 290 pieces 6" to 1' and ~ 189 pieces 1' to 2' anything bigger is specified above
2.
3.
4.
5.
6.
7.
8.

Project:	Route 80 Rockfall Mitigation	**Weather:**	Sunny ~30°F		
Location:	MP 1.04 - 1.45 West, Hardwick and Knowlton Townships	**Inspector:**	Brian Felber and Pete Tomos		
Client:	New Jersey Department of Transportation	**Date Inspected:**	12/7/2010	**Project No.:**	44829

HNTB

ROCKFALL DESCRIPTION DATA SHEET FOR AREA C

CATEGORY	ITEM	PARAMETER							
General Information	Location	1' Behind Barrier ~10' E MP 1.3	3' Behind Barrier ~20' E MP 1.3	4' Behind Barrier ~20' E MP 1.3	3' Behind Barrier ~75' E MP 1.3	On Top of Barrier ~100' E MP 1.3	13' Behind Barrier 100' E MP 1.3		
	Photo Numbers	16	17	18	19	20	21		
Rock Material Information	Color	Gray	Gray White	Gray	Gray	Gray Red	Gray		
	Grainsize (in)	1/8	3/8	3/8	1/8	1/4	1/8		
	Compressive Strength (psi)	15 blows	15 blows	4 blows	13 blows	16 blows	16 blows		
	Compressive Strength Method								
	Rock Type	Quartzite	Conglomerate	Conglomerate	Conglomerate	Quartzite	Quartzite		
Fallen Rock Information	Length (ft)	3.6	2.2	2.2	1.9	3.2	3.0		
	Width (ft)	1.1	1.8	1.1	1.6	1.6	1.6		
	Height (ft)	1.1	1.1	0.9	1.4	1.5	1.0		
	Type								
	Time of Year								
	Weather								
	Injury Caused								
	Loss of Life Caused								
	Property Damage Caused								
	Impact to Traffic								
	Reported By								

Remarks:

1. ~ 276 pieces 6" to 1' and ~ 107 pieces 1' to 2' anything bigger is specified above
2.
3.
4.
5.
6.
7.
8.

Project:	Route 80 Rockfall Mitigation	Weather:	Sunny ~30°F		
Location:	MP 1.04 - 1.45 West, Hardwick and Knowlton Townships	Inspector:	Brian Felber and Pete Tomos		
Client:	New Jersey Department of Transportation	DateInspected:	12/7/2010	Project No.:	44829

HNTB

ROCKFALL DESCRIPTION DATA SHEET FOR AREA D

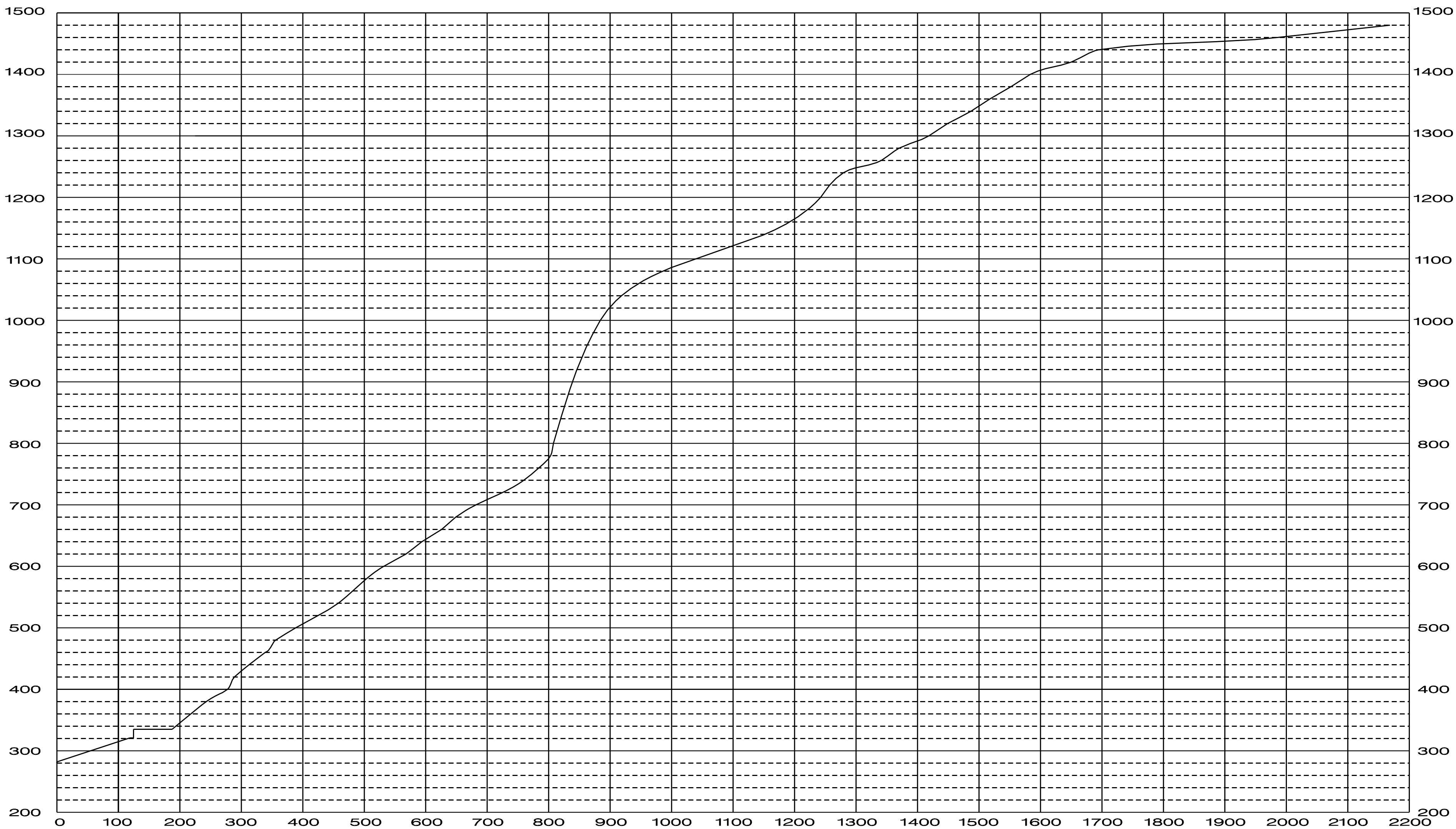
CATEGORY	ITEM	PARAMETER							
General Information	Location	16' Behind Barrier ~20' E Gabion							
	Photo Numbers	22							
Rock Material Information	Color	Gray							
	Grainsize (in)	1/8							
	Compressive Strength (psi)	15 blows							
	Compressive Strength Method								
	Rock Type	Quartzite							
Fallen Rock Information	Length (ft)	16.0							
	Width (ft)	12.0							
	Height (ft)	9.0							
	Type								
	Time of Year								
	Weather								
	Injury Caused								
	Loss of Life Caused								
	Property Damage Caused								
	Impact to Traffic								
	Reported By								

Remarks:

1. Estimated distrubution of talus size: 1" to 1' 5%
2. 1' to 2' 8%
3. 2' to 3' 8%
4. 3' to 4' 25%
5. 4' to 5' 20%
6. 5' to 6' 17%
7. > 6' 17%
8. The rock piece described above was the largest piece of talus visable.

ROUTE 80 ROCKFALL MITIGATION

PRELIMINARY ASSUMED CROSS SECTION OF AREA D



HNTB CORPORATION

NEW JERSEY DEPARTMENT OF TRANSPORATION

PROJECT NUMBER 44829

Chris Tzekin Leung

From: Scott Sheldon [Scott.Sheldon@dot.state.nj.us]
Sent: Monday, November 22, 2010 11:32 AM
To: Chris Tzekin Leung
Cc: Joseph Popelka
Subject: Fwd: Rock fall Notification

fyi-call Crew Supervisor Joe Popelka at # below for more details.

>>> Scott Sheldon 10/19/2010 7:53 AM >>>
Not sure if you we notified of this incident. If you need more information, you can call the C.S. at the Columbia Yard @ 908-496-4088. You may want to pass this along to the consultant. Thanks.

>>> Joseph Popelka 10/8/2010 7:32 AM >>>
Gentlemen
Last night I received a call from North Com. requesting safety,front end loader, and sand. Upon arrival there was a very large boulder laying in pieces from M.V. impact, in the slow lane route 80 westbound at mile post 1. The rock rolled down the mountain and was struck by a car and a tractor trailer causing extensive damage to both vehicles.

Joseph Popelka
Columbia Yard
phone 908-496-4088
fax 908 496-4853

"Safety is No Accident"

Chris Tzekin Leung

From: Brian Felber
Sent: Tuesday, February 08, 2011 10:25 AM
To: Chris Tzekin Leung
Subject: FW: Rt 80 Rockfall Phone Discussion with Maintenance

This may be helpful also.

From: Brian Felber
Sent: Tuesday, January 25, 2011 11:46 AM
To: Matthew Riegel
Subject: Rt 80 Rockfall Phone Discussion with Maintenance

Matt,

I took some notes during today's phone discussion and want to email them so we have them for our record.

John Gahwyler and Scott Sheldon (NJDOT)
Brian Felber, Matt Riegel, Steve Manera (HNTB)

- DPD did not give draft CD report to NJDOT Maintenance
- Stacked wall leaning as per John Gahwyler
- Stacked wall crushed or blocked pipe as per John Gahwyler
- Don't added on to barrier, install new barrier.
- Maintenance takes no exception to removing and replacing the barrier.
- Not much room will be gained behind the barrier, but HNTB will look into cleaning up behind the barrier and maybe replacing the drainage ditch with a buried pipe relying on infiltration such that a small excavator can easily get behind the barrier.
- Debris is being removed from behind the stacked stone wall once every year and one-half
- HNTB should include cleanout of pipes and maybe line pipes as part of final design.

Thanks,

Brian

Brian T. Felber, E.I.T.
Geotechnical Services

HNTB Corporation
Wayne Plaza I - Suite 400
145 Route 46 West
Wayne, NJ 07470-6830

Tel: 1-973-237-1650 (Main)
Tel: 1-973-435-3767 (Direct)
Fax: 1-973-237-9185
Cell: 1-973-800-5502
www.hntb.com

HNTB	RECORD OF TELEPHONE CALL	DATE 9/28/10 Job No. 44829

TO Robert Bird **of** NJDOT Environmental (609-530-4239)

FROM Anthony Velazquez **of** HNTB

BY Anthony Velazquez RE: Route 80 Rockfall Mitigation CD

DISCUSSIONS:

Mr. Velazquez phoned Mr. Bird to discuss the environmental screening to be performed by NJDOT and coordinate any environmental aspects that should be taken into consideration during the concept development efforts. The various environmental constraints within the project area were discussed including:

Wetlands and water resources: A drainage feature, which may be regulated under the Freshwater Wetlands Protection Act rules and/or the Flood Hazard Area Rules, is located within Area A and Area B. Further evaluation will be necessary during subsequent phases to determine permit requirements. NJDOT to check available floodplain mapping as part of environmental screening effort.

Cultural resources: Research has yet to be conducted to identify whether the project area contains documented or potential historic structures or archaeological resources, however rockfall mitigation projects are included on list of undertakings which have limited or No Effect on Cultural Resources in New Jersey.

Parkland/Section 4(f): Route 80 runs through Delaware Water Gap National Recreation Area and right-of-way abuts lands of National Recreation Area as well as Worthington State Forest. Coordination with Federal/State agencies to be defined in subsequent phases.

Air/Noise: Not considerations for this type of project.

Delaware River Wild and Scenic Designation: Coordination may be required during subsequent design phases.

Threatened/Endangered Species: Numerous species identified in NJ Landscape Project Mapping. Also, possible Indiana Bat habitat. Coordination with NJDEP ENSP and US Fish and Wildlife Service to be included as part of permit process.

ACTION TO BE TAKEN

Rob Bird to perform environmental screening. Timing of screening to be determined in coordination with DPD.

Copy to:
File

NOTE: THIS RECORD TO BE RETAINED IN THE MASTER FILE

HNTB	MEMORANDUM TO RECORD	DATE 10/26/10 Job No. 44829

Mr. Velazquez discussed I-80 Rockfall mitigation project with Robert Bird following a meeting for another project. Inquired as to status of Environmental Screening for project.

Mr. Bird indicated that he would discuss timing of environmental screening effort with DPD and would advise if screening would be available for inclusion in Concept Development study.

ACTION TO BE TAKEN

Rob Bird to perform environmental screening based on appropriate timing to be determined in coordination with DPD.

Copy to
File

NOTE: THIS RECORD TO BE RETAINED IN THE MASTER FILE

Chris Tzekin Leung

From: John Jamerson [John.Jamerson@dot.state.nj.us]
Sent: Thursday, September 30, 2010 11:21 AM
To: Steven Manera
Cc: Kamlesh Shah; Brian Felber; Matthew Riegel
Subject: RE: Project Limits

Steve-
As I indicated to you yesterday, this morning I spoke with Kamlesh Shah of DPD regarding the situation. He advised that we go to the Department's CPC & request that the project limits be extended for the addition 0.10 mile. I'll prepare a memo to that end and, hopefully, it will end up being a matter of bookkeeping.

-John

>>> Steven Manera <smanera@HNTB.com> 9/28/2010 3:52 PM >>>

John,

Just to clarify; the limits in our SOW were based on the original Problem Statement which indicates 1.04 to 1.35.

Steve

From: Brian Felber
Sent: Tuesday, September 28, 2010 3:29 PM
To: 'john.jamerson@dot.state.nj.us'
Cc: Steven Manera; Matthew Riegel; Laura Wolfe; Chris Tzekin Leung
Subject: Project Limits

John,

It was just brought to my attention that the project limits in our scope of work are from MP 1.04 to MP 1.35. In the meeting minutes from our site visit 5-5-10 you describe the project limits as MP 1.04 to MP 1.45. MP 1.35 is roughly halfway into the talus slope. Please let us know how we should continue defining the project limits and any implications which may be associated with this.

Thanks,

Brian

Brian T. Felber, E.I.T.
Geotechnical Services

HNTB Corporation
Wayne Plaza I - Suite 400
145 Route 46 West
Wayne, NJ 07470-6830

Tel: 1-973-237-1650 (Main)
Tel: 1-973-435-3767 (Direct)
Fax: 1-973-237-9185
Cell: 1-973-800-5502
www.hntb.com

APPENDIX J

PUBLIC COMMUNICATIONS

HNTB *The HNTB Companies*	**RECORD OF TELEPHONE CALL**	Job No. 44829 Rt 80 Rockfall DATE November 3, 2010

CALL TO Chip Stracciolini & Chris Rood of DRJBTC

CALL FROM TL of

BY TL

SUBJECT DISCUSSED	ACTION TO BE TAKEN
Information about the Open Road Tolling (ORT) project and the bearing replacement and superstructure painting project.. Chip said the project had a long-term closure of 3 out of 8 lanes in the toll plaza and the queue was about 1 to 3 miles long during the peak hours. In another instance, 4 out of 8 lanes were closed (long term) in the toll. The queue extended to about 7 miles. Chris Rood at 267-790-1084 is the person overseeing the project the project "Bearing Replacement and Superstructure Painting for the Route I-80 / Delaware River Bridge'. The construction of this project has not started. **Call to Chris Rood on 11/4/10** Chris was familiar with both projects. He said that the ORT project had installed cantilever sign structure foundation an MP 0.6 and 1.5 of Route 80 WB roadway. During the construction of these sign structures, right shoulder was permanently closed with a construction barrier and right lane was closed between 11 pm and 5 am. The queue was minimal, less than 0.5 mile. He also remarked that the queue was up to 12 miles on a Friday evening when 4 lanes in the toll plaza was closed. Open road toll lane will be open on November 22, 2010 while the construction will continue thru June 2011. After 11/22, one lane in the toll plaza will be closed at any given time until the end of the project. For the bearing replacement and superstructure painting project, it is anticipated to start shortly and be complete by November 2011. Complete closure of the bridge for 15 minute intervals will be implemented starting January 2011.	Further coordination with DRJBTC is needed to avoid impacting the traffic both by the rockfall project and the ORT project.

COPY TO:

NOTE: THIS RECORD TO BE RETAINED IN THE MASTER FILE

HNTB *The HNTB Companies*	**RECORD OF TELEPHONE CALL**	Job No. 44829 Rt 80 Rockfall DATE January 31, 2011

CALL TO Chris Rood of DRJBTC

CALL FROM TL of HNTB

BY TL

SUBJECT DISCUSSED	ACTION TO BE TAKEN
Open toll lanes have been open since November 22, 2010. There will still be various toll lane closures on the bridge as mentioned before. The overhead sign structures on Route 80 WB roadway are 90% finished. Some electrical work and median work have yet to be done. They are scheduled in late March for 1 to 2 weeks time. Single lane closures will be implemented during off peak hours (mostly daytime). The toll bridge rehabilitation project is underway and is currently implementing single lane closure between MP 1.6 on Route 80 WB roadway and the bridge. This lane closure will last until November 2011 and the schedule is as follow: • 7:00 am to 3:30 pm Monday thru Thursday • 7:00 am to 12:00 pm Friday • 6:00 am to 6:00 pm Saturday and Sunday From April to November, night time closures will be added to the above schedule and it involves single lane closure between 9 pm and 5 am and 15-minute shut down of Route 80 between 11 pm and 4 am.	

COPY TO:

NOTE: THIS RECORD TO BE RETAINED IN THE MASTER FILE

State of New Jersey

DEPARTMENT OF TRANSPORTATION
P.O. Box 600
Trenton, New Jersey 08625-0600

CHRIS CHRISTIE
Governor

JAMES S. SIMPSON
Commissioner

KIM GUADAGNO
Lt. Governor

May 6, 2011

Ms. Judith Fisher
Clerk, Hardwick Township
40 Spring Valley Road
Hardwick, New Jersey 07825

Dear Ms. Fisher,

In our continuing effort to improve safety and traffic flow along the I-80 Corridor, the New Jersey Department of Transportation (NJDOT) would like to announce the "start up" of its I-80 Westbound Rockfall Mitigation project in the Township of Hardwick, Warren County. This project falls between MP 1.04 and MP 1.35 and involves four (4) distinct rock cut sections.

This project was initiated by the Department's Bureau of Geotechnical Engineering in 2009 through a Problem Statement and was approved by the Capital Program Committee to begin Concept Development (CD) and the Department has almost completed the CD phase.

Based on initial reviews performed by the Bureau of Geotechnical Engineering, it is anticipated that large scale rock removal will not be feasible at this location due to numerous constraints including: the project location is within the Delaware Water Gap National Recreation Area, the existing terrain, and the lack of suitable long term detour routes. This section of I-80 consists of two travel lanes in each direction and currently operates in a constrained manner during daily and weekend peak periods and further impacted by seasonal peaks. During the CD phase, various rockfall mitigation measures will be evaluated such as scaling, rock bolting, installation of wire mesh and rock catch fences. It is anticipated there will be no Right of Way impacts and no major utility impacts. The project is not due to go to construction for at least two years.

Because there are no direct impacts to property owners or businesses, public outreach will be minimal; however, the Office of Community Relations will keep the local officials of Hardwick Township appraised as the project moves forward during the design phases. Once the project is ready to enter the construction phase, information will be sent to the Township that will include the name and phone number of the Department's Resident Engineer, and the name of the contractor who will be doing the work.

If you have any further questions or concerns regarding this matter or if I can be of any further assistance, please feel free to contact me at (609) 530-2110, or via e-mail at

Sincerely yours,

Debbie Hirt

Debbie Hirt
Community Relations Manager
Office of Community Relations

Cc: Communications
Bhavesh Shah, NJDOT

State of New Jersey
DEPARTMENT OF TRANSPORTATION
P.O. Box 600
Trenton, New Jersey 08625-0600

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

JAMES S. SIMPSON
Commissioner

May 6, 2011

Ms. Lisa K. Patton
Clerk, Knowlton Township
628 Route 94
Columbia, New Jersey 07832

Dear Ms. Patton,

In our continuing effort to improve safety and traffic flow along the I-80 Corridor, the New Jersey Department of Transportation (NJDOT) would like to announce the "start up" of its I-80 Westbound Rockfall Mitigation project in the Township of Hardwick, Warren County. This project falls between MP 1.04 and MP 1.35 and involves four (4) distinct rock cut sections.

This project was initiated by the Department's Bureau of Geotechnical Engineering in 2009 through a Problem Statement and was approved by the Capital Program Committee to begin Concept Development (CD) and the Department has almost completed the CD phase.

Based on initial reviews performed by the Bureau of Geotechnical Engineering, it is anticipated that large scale rock removal will not be feasible at this location due to numerous constraints including: the project location is within the Delaware Water Gap National Recreation Area, the existing terrain, and the lack of suitable long term detour routes. This section of I-80 consists of two travel lanes in each direction and currently operates in a constrained manner during daily and weekend peak periods and further impacted by seasonal peaks. During the CD phase, various rockfall mitigation measures will be evaluated such as scaling, rock bolting, installation of wire mesh and rock catch fences. It is anticipated there will be no Right of Way impacts and no major utility impacts. The project is not due to go to construction for at least two years.

Because there are no direct impacts to property owners or businesses, public outreach will be minimal; however, the Office of Community Relations will keep the local officials of Hardwick Township appraised as the project moves forward during the design phases. Once the project is ready to enter the construction phase, information will be sent to the Township that will include the name and phone number of the Department's Resident Engineer, and the name of the contractor who will be doing the work.

If you have any further questions or concerns regarding this matter or if I can be of any further assistance, please feel free to contact me at (609) 530-2110, or via e-mail at

Sincerely yours,

Debbie Hirt

Debbie Hirt
Community Relations Manager
Office of Community Relations

Cc: Communications
Bhavesh Shah, NJDOT

MEETING MINUTES

HNTB

Camden Ferry Terminal Building
2 Aquarium Drive, Suite 310
Camden, NJ 08103

Date: July 20, 2011

Subject: I-80 Rockfall Mitigation, Milepost 1.04 to 1.45
Concept Development Phase
Hardwick Township, Warren County

Locations: Kittatinny Point Visitors Center
Delaware Water Gap National Recreation Area

Purpose: Meet with National Park Service Officials to share with them the purpose of the project, concepts for mitigation and, solicit their feedback and concerns.

Attending: Bill Leonard, NPS
Kathy Commisso, NPS
Brinnen Carter, NPS
Andrew Farrar, NPS
Cody Yeakel, NPS
Kamlesh, Shah, NJDOT
Bhavesh Shah, NJDOT
George Worth, NJDOT
John Jamerson, NJDOT
Debbie Hirt, NJDOT
Matthew Riegel, HNTB
Steve Manera, HNTB

A meeting was held on Wednesday July 6, 2011 at the Kittitinny Point Visitors Center with National Park Service (NPS) officials, NJDOT staff and the Design consultant, HNTB Corp. The following notes were made during the meeting;

1. Ms. Hirt made a brief introduction and then invited all attendees to introduce themselves.
2. Mr. B. Shah gave a brief overview of the project purpose and the current phase of work being undertaken by the NJDOT, noting the Problem Statement submitted for the project as initiated by NJDOT's Geotechnical Engineering unit.
3. Mr. Jamerson provided a geological assessment of the conditions in the project area indicating four (4) areas of concern where rockfalls are sliding down onto I-80 between mileposts 1.04 and 1.45, thus creating the need for the project. He further stated that there are three (3) rock cut areas in the northern part of the state with this location being considered by NJDOT as the highest priority. There are numerous accidents that happen because of rockfalls. So far there have been no fatalities at the subject location. Mr. Jamerson stated that no rock blasting is planned for this location but instead NJDOT is contemplating improvements that will address the safety need and be aesthetically pleasing within the beauty of the park.
4. A question was raised by the NPS representatives regarding the 'rating process' for rockfalls. Mr. Jamerson responded by explaining the Rockfall Hazard Rating System created in the 1980's and used by NJDOT to evaluate rockfall locations.

5. A question was raised by the NPS representatives about the level of funding available for the project. The NJDOT replied that the preliminary cost estimate for the project is approximately $6M. D. Hirt also explained the path that a project travels and that this project is currently in the Concept Development phase.
6. Mr. Jamerson added that even though this project may go through the normal path for design, that NJDOT will be looking to potentially compress the schedule because each winter there is the possibility of another incident happening.
7. Ms. Hirt noted that she contacted Hardwick and Knowlton Township officials to see if they wanted to hold a public officials meeting with NJDOT representatives or if they felt a letter explaining the proposed project would be sufficient. Both towns felt that a letter would be sufficient.
8. Mr. Riegel provided and explanation of the concepts and alternatives that HNTB considered during the concept development phase. The four areas are divided into 1/10th mile increments along the westbound side of I-80 and are based on the geologic conditions present. A display board was used to illustrate the four areas. Area A is the furthest west.
    a. Areas A & B (milepost 1.04 to 1.25)
        i. Rock catchment fence placed behind the existing barrier curb to contain rockfalls
        ii. Heightened concrete barrier curb (42”-72” tall)
            - Mr. Riegel noted that environmentally sensitive areas, including an adjacent swale and the park setting, are primary considerations in choosing the best option.
            - Form liners could be used to construct the heightened barrier curb casting an impression into the concrete to mimic the look of natural boulders.
            - The recommended alternative is the heightened barrier curb.
    b. Area C(milepost 1.25 to 1.35)
        i. Anchored or draped mesh on the lower slope
        ii. Rock bolts and anchored mesh on the upper slope
        iii. Rock catchment fence
        iv. Hybrid protection system; includes an energy barrier at the crest of the lower slope to catch and funnel rock. The bottom of the energy barrier will be connected to draped mesh extending down the lower slope.
            - Mr. Riegel noted that this is the most difficult area because it has a large vertical rock face that is very close to the highway. He indicated concern for rock material falling from the upper slope and noted that rock bolting could pose problems with causing fractures and eventual rockfalls. A rock catchment fence would have to be as tall as the rock face (100’) to be effective.
            - The draped mesh will be made of steel with relatively small openings and can be vinyl coated to color match the rock.
            - The bottom of the mesh will be bolted to allow NJDOT Maintenance to gain access to clean out rock debris.
            - The recommended alternative is the Hybrid protection system.
            - NPS officials asked how the mesh would be constructed at the top of the slope. Mr. Jamerson indicated that the contractor will use cranes to elevate equipment and people to the top and workers will use ropes to repel down the slope to do the installation.
            - NPS officials asked if NJDOT had considered a rock shed for the entire length of the project. NJDOT replied that there are too many issues with that idea including cost, environmental impacts and maintenance.

c. Area D
    i. Removal and reinforcement including scaling, trim blasting and rock bolting
    ii. Protection; excavating and reinforcing the toe of the talus slope with rock bolts and shotcrete to create an enlarged catchment area
    iii. Rockfall control fences
    iv. Combination of ii and iii.
        - There were questions and discussion on how the excavation would be done and how deep it would need to be. Mr. Worth replied that since borings have not yet been taken, the exact depth is unknown at this time.
        - Mr. Riegel described the excavation process as working from the top down in small sections by excavating then stabilizing with rock bolts and continuing down to the next section.
        - The recommended alternative is a combination of ii and iii. It was also noted that the heightened concrete barrier would be continued in Areas C and D to maintain the visual continuity throughout the project.

9. NPS representatives asked if the NJDOT has done any 'visualizations' of the proposed concepts. Mr. Worth replied that NJDOT has not yet done them but will as the design process moves further along.
10. Mr. Manera provided a handout package that included a project briefing paper and two (2) sketches. One sketch showed a cross section of the proposed heightened concrete barrier curb with sacrificial timber attached to the slope side of barrier curb. The other sketch showed an elevation view of the barrier curb depicting the form liner (boulder) finish along the upper portion of the barrier curb.
11. Mr. Leonard requested an electronic copy of the handout package which Mr. Manera will send via e-mail.
12. NPS representatives inquired about how much of the proposed work would be in the parkland. NJDOT indicated that it appears the work can be done within the existing I-80 ROW. Mr. Jamerson stated that maybe a temporary construction easement would be needed however it is not anticipated at this time.
13. Ms. Hirt asked about the time frame for construction given where the project stands now. NJDOT representatives indicated construction would start in approximately 2-3 years and last approximately 7-9 months.
14. NPS representatives asked about the NEPA process. Mr. Worth stated that work on the NEPA process will commence once NJDOT agrees on the preferred alternative and that at this point in the project development, it appears that a Categorical Exclusion document is anticipated for this project.
15. Mr. Leonard noted that there are some endangered species such as the copperhead snake, timber rattlesnake and peregrine falcon. Ms. Commisso indicated that she believes they are on the south side of the highway. Ms. Hirt asked about the presence of bald eagles. Ms. Commisso said she would check on the presence of nests in the area.
16. Mr. Carter asked if NJDOT has checked on the presence of petrographs in the area. NJDOT replied that they have not. Mr. Carter recommended that NJDOT do so.
17. Mr. Carter noted that there was a rockfall mitigation project along Route 248 in Pennsylvania where a rockfall mitigation report (prepared by Westin Environmental) was made available to NPS and he is hoping to get a similar report for this project. Mr. B. Shah and Mr. Worth stated that NJDOT would supply the Park Service with a copy of the Concept Development report once the document has been finalized. Mr. Jamerson indicated that this report would also include information on the rockfall rating system.

18. Mr. Leonard indicated the need to check on the ROW lines to determine where Park property begins. Mr. Worth agreed to contact NJDOT ROW unit to obtain the deeds for the property. Mr. Manera will supply the ROW maps obtained from NJDOT which show the specific parcels acquired when I-80 was constructed. Mr. Leonard agreed to send NPS ROW maps to Mr. Manera.
19. Mr. Manera asked NPS officials about ideas for reaching park users to make them aware of a Public Information Center (tentatively planned for March/April 2012) for the project. The following ideas are noted;
    a. Regional newspaper ads in PA and NJ
    b. Trail Head notices
    c. NPS maintains a mailing list of hiking, environmental clubs, etc. (about 150 on the list). Ms. Hirt will send the PIC notice to Mr. Leonard and he will send to the mailing list.
    d. Mr. Leonard also indicated that they could post a notice on their website
    e. NPS can post a sign or notice at the Kittatinny Point Visitors Center.
    f. NPS can notify their PennDOT liaison of the PIC advertisement.
20. Mr. Manera inquired about NPS sending NJDOT a letter of support for the project. Mr. Leonard indicated that he would need some time to review the project with NPS staff and the Park Superintendent. The NPS would then provide a letter to NJDOT indicating their position on the project.

Action Item No.	Action Item Description	Responsible Party
1	Provide electronic copy of handout	Mr. Manera
2	Check on presence of bald eagle habitat	Ms. Commisso
3	Provide Final Concept Development report to NPS	Mr. B. Shah
4	Provide NJDOT deeds to NPS	Mr. Worth
5	Provide NPS ROW maps to HNTB	Mr. Leonard
6	Provide letter to NJDOT regarding NPS position on project	Mr. Leonard

cc. Nunzio Merla, FHWA
Zack Asadpour, NJDOT
Attendees

NJDOT ATTENDANCE RECORD
PLEASE PRINT
OFFICIALS BRIEFING

PROJECT: I 80 Rock Slope Stabilization **DATE:** 7/6/11

MEETING LOCATION: Kittatinny ~~Pt~~ Points Visitor Center

Name	Phone Number	Mailing Address/Affiliation	Email Address
1. Debbie Hirt	609-530-2110	Deborah.Hirt@DOT.state.nj.us	NJDOT Community Relations
2. George Worth	(609) 530-3800	NJDOT - Project Manager george.worth@dot.state.nj.us	NJDOT PO Box 600 TRENTON NJ 08625
3. STEVEN MANERA	(856) 536 5341	HNTB CORP 2 AQUARIUM DR. CAMDEN, NJ	SMANERA@HNTB.COM
4. MATT RIEGEL	973-632-7541	HNTB : WAYNE PLAZA I, STE 400 145 RT 46 WEST WAYNE NJ 07470	MDRIEGEL@HNTB.COM
5. Brinnen Carter	570 588 3840	Brinnen_Carter@nps.gov	1 River Rd Bushkill, PA 18324
6. Andrew Farrar	(703) 881-8719	farra3al@jmu.edu	
7. Cody Yeakel	610-841-6966	cody_yeakel@nps.gov	
8. Kathy Commisso	570-296-6952	Kathy_commisso@nps.gov	
9. Kamlesh R. Shah	609-530-5539	NJDOT - 1035 Parkway Ave. Trenton, NJ 08625	Kamlesh.Shah@dot.state.nj.us
10. Bhavesh N. Shah	609-530-5078	"	bhavesh.shah@ "
11. BILL LEONARD	570-426-2416	Bill_Leonard@nps.gov	1 River Road Bushkill PA 18324
12. JOHN JAMERSON	609-530-3733	John.Jamerson@dot.state.nj.us	1035 PARKWAY AVE TRENTON, NJ 08625

APPENDIX K

ENVIRONMENTAL SCREENING REPORT

NEW JERSEY DEPARTMENT OF TRANSPORTATION

ENVIRONMENTAL SCREENING

Revised April 27, 2006

Date:	February 7, 2011
Request for this screening made by:	Kamlesh Shah
Project Name:	Rockfall Mitigation Route 80 Milepost 1.04-1.45
Project Description:	Rockfall Mitigation
County and Municipality:	Warren/Townships of Hardwick and Knowlton

ENVIRONMENTAL CONSTRAINTS/OPPORTUNITIES:

Cultural Resources	**Yes / No**
Are there any 50+ year old structures in the project study area?	Y
Are there known buildings or structures on or eligible for the State and /or National Register of Historic Places in the project study area?	N
Is there involvement with a historic bridge or culvert?	N
Is the project located in a known or potential Historic District?	N
Are there any undisturbed areas, old foundations or building rubble in the project study area?	Y
Are there any known archaeological sites or potential underground cultural resources within the project study area?	Y
Enhancement Opportunities:	
Comments: Undisturbed areas along with potential underground cultural resources may exist in the project area, but SHPO review/ coordination may not be needed since the proposed project activities are included within the current *List of Undertakings Which Have Limited or No Effect on Cultural Resources in New Jersey*, number 53 rockfall mitigation. There is rock wall, located through most of Area A and B (See Concept Dev. Report November 2010). Disturbance to this wall (if considered historic) may require coordination with SHPO, since removing this wall is beyond normal rockfall mitigation measures which are on the no effects list.	

Section 4(f) Properties	**Yes / No**
Are there any recreational facilities within the project study area?	Y
Is there publicly owned open space in the project study area?	Y
Is there a Wildlife Refuge or Wildlife Management Area in the project study area?	N
Is there a school or school athletic fields in the project study area?	N
Is there a community park or parkland within the project study area?	Y
Enhancement Opportunities: Choosing treatments that blend in or compliment the natural surroundings of the water gap area.	
Comments: The project lies within and adjacent to both the Delaware National Recreation Area and Worthington State Forest. The project area also lies East of a portion of the Appalachian trail but should be far enough away to avoid any direct impacts. At this time it is unknown if ROW would be required from any of these resources.	

Air/Noise	**Yes / No**
Are there any sensitive receptors (i.e. residences, schools, hospitals, and churches) within 300 feet of the project?	N
Will the project change the vertical or horizontal alignment of the roadway?	N
Does the project provide for a significant increase in vehicle operating speeds of roadway capacity?	N
Is the project in a non-attainment area for Carbon Monoxide?	N
Is an intersection Carbon monoxide analysis required?	N
Is the project in a non-attainment area for PM2.5?	N
Is a PM2.5 hot-spot analysis required?	N
Is the project in a non-attainment area for PM10?	N
Is a PM10 hot-spot analysis required?	N
Mitigation Opportunities:	
Comments: This project will not have a significant effect on traffic noise levels in the area. The project qualifies as a Table 2, therefore no air quality analysis is required. The project is not listed on the current STIP and TIP.	

Ecology	Yes / No
Are there any wetlands, floodplains, sole source aquifer, stream crossings or wildlife habitat in the project study area?	Y
Are there any Category 1 waters or Wild and Scenic rivers in the project study area?	Y
Are there any potential or know vernal pool habitats with the project study area?	N
Are there any trout maintenance or trout production streams within the project study area?	N
Is there any potential for rare, threatened or endangered species or their habitats within the project study area?	Y
Are there any environmentally-sensitive areas that are possible project design constraints?	Y
Are there any potential stormwater management mitigation areas in project area or upstream of project area?	N

Describe ecology in the project study area: (heavily forested, project adjacent to State Forest, National Recreation Area and Delaware River)

The following ecological issues may be of concern, depending on the form and extent of rockfall mitigation chosen.

1) Riparian Area disturbances due to close proximity to the Delaware River. Mitigation may be needed if threshold is exceeded. Buffers may be 150 feet due to Threatened and Endangered Species habitat.
2) Wetland disturbance Area A and B (See Concept Dev. Report November 2010). Wetland Transition Areas may be 150 feet due to Endangered Species habitat.
3) Threatened and endangered species impacts. It is unlikely that impacts to most species listed would occur since the project will take place mainly along the curb and existing disturbed areas along I-80. Impacts to Indiana Bat may be of concern and timing restrictions and or additional coordination may be needed if tree clearing is proposed. (see attached list of species)
4) Reforestation most likely would not be required since this type of work is considered a linear safety project. Once tree clearing totals are known this can be verified with the landscape unit.

The following environmental permits and interagency coordination may be necessary:

U.S. Coast Guard (Bridge)		NJDEP Freshwater Wetlands	Y
USACOE Section 404		P.L. 2001 Chapter 10 Reforestation	
USACOE Section 10 (Navigable Waters)		NJDEP Waterfront Development	
CAFRA		NJDEP Flood Hazard	Y
NJPDES Construction Stormwater		NJDEP Riparian	
NJDEP Coastal Wetlands		USEPA-Sole Source Aquifer	
NJDEP Water Quality Certificate		Essential Fish Habitat	
Pinelands Commission		Category One waters	
D & R Canal Commission		NJDEP Stormwater Management Rules	
Meadowlands Commission		Delaware River Bridge Commission	

Comments: The following permits may be required depending on extent of impacts.

1) Flood Hazard Area permit possible if project lies within the associated Riparian area along the Delaware River.
2) Wild and Scenic River coordination (Delaware River adjacent to the project has been designated as a Wild And Scenic River).
3) Freshwater Wetland impacts one or more GP's again in area A & B.
4) Threatened and endangered species coordination, letter to USFWS and possible tree survey if tree clearing is proposed.

Socioeconomics	**Yes / No**
Will the project affect farmland or community facilities?	N
Based on the proposed improvements for this project, will there be possible displacement of businesses or residences?	N
Will the project affect access to community facilities, bus stop shelters, playgrounds or parks or gardens?	Y
Are there any observable safety issues or concerns in the project study area?	N
Does project have potential for Environmental Justice involvement?	N
It is possible that minor impacts to parkland may occur but there should be no impact to access or use of any properties. The proposed work will not isolate or require the acquisition/relocation of any residential properties. Community cohesion will not be adversely impacted in the project area. No residences, community facilities, or existing land use patterns will be adversely impacted by the proposed project.	

Hazardous Waste	**Yes / No**
Are there any known or suspected hazardous waste sites (UST, landfills, known NJDEP Case, ECRA Case), within the project study area?	unknown
Are there active or abandoned industries, service stations or repair shops within the project study area?	N
Is there evidence of potential contamination (monitoring wells, stained soils, etc.)?	N
Are railroad or railyards located in the project study area?	N
Enhancement Opportunities:	
Comments: A hazardous screening has not been performed for this project, but it is unlikely that hazardous waste issues will be an environmental constraint for this project due to the type of disturbance planned.	

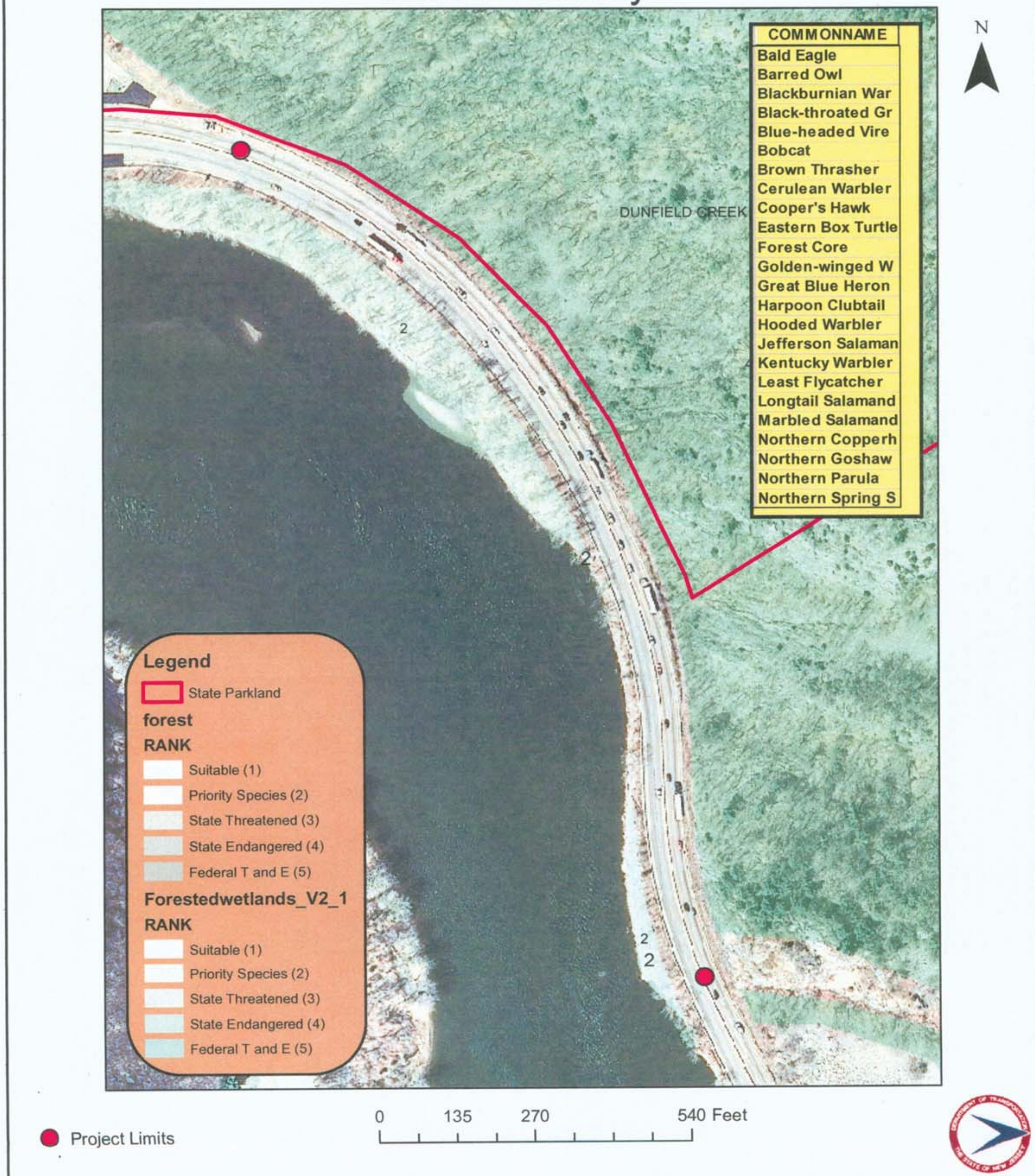
Environmental Screening Summary:

Several environmental constraints exist within the project area. Section 4(f) and Green Acres coordination will be required if any of the parks mentioned are disturbed. Several permits including freshwater wetlands and flood hazard may be required depending on what forms of rockfall mitigation are used and where disturbance is planned in the project area. Threatened and Endangered Species coordination will be required including letters to Natural Heritage program and USFWS specifically for Indiana Bat.

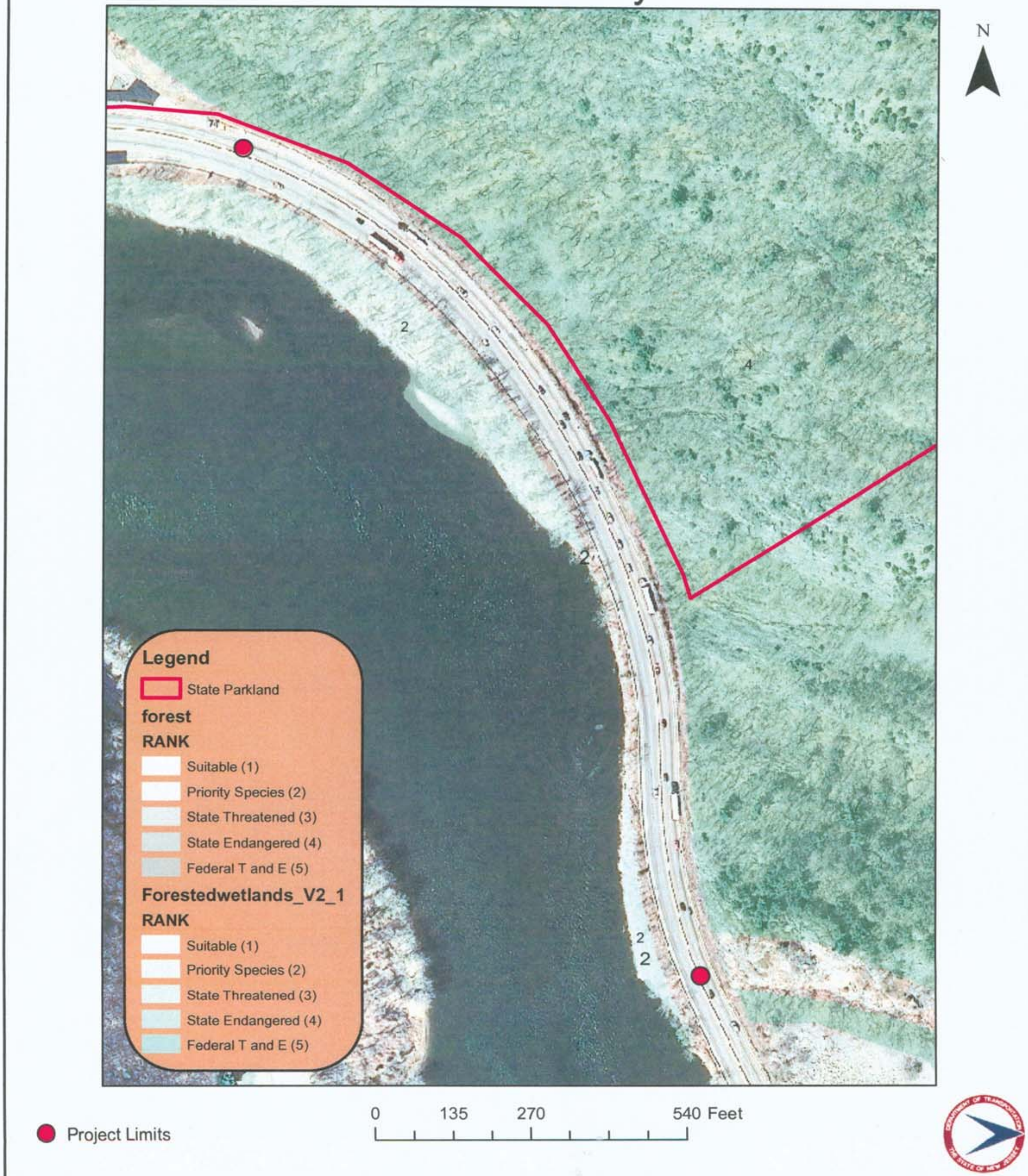
Prepared & Recommended By:

Robert Rein	2/15/11	609-530-4239
E-Team Screening Coordinator	Date	Phone
Pamela Garrett	2/15/11	609-530-2721
Environmental Team Leader	Date	Phone

Rockfall Mitigation Route 80 M.P 1.04-1.45
Townships of Hardwick and Knowlton
Warren County



Rockfall Mitigation Route 80 M.P 1.04-1.45
Townships of Hardwick and Knowlton
Warren County

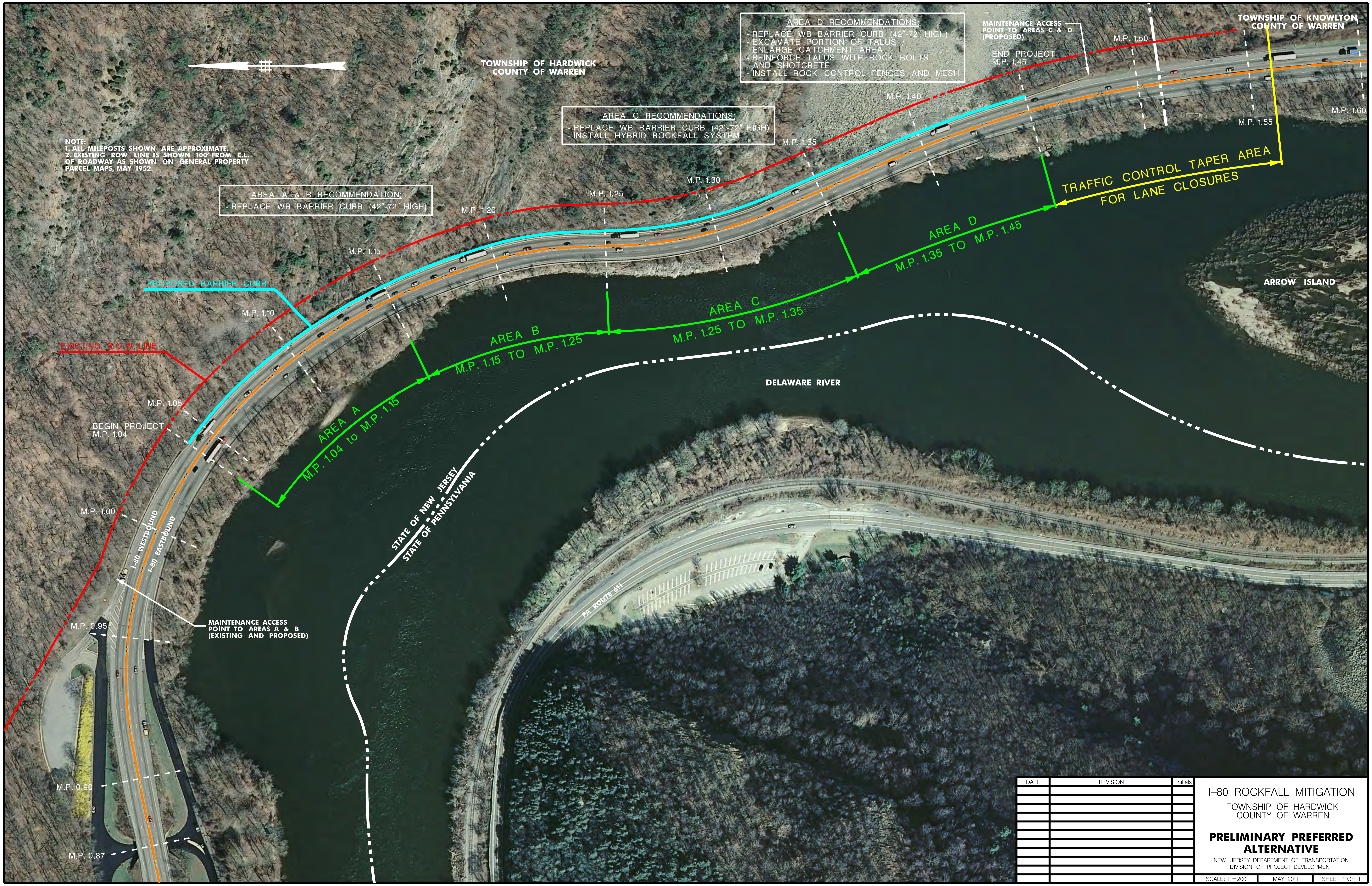


Threatened and Endangered Species In project Area Route 80 Rockfall Milepost 1.04-1.45

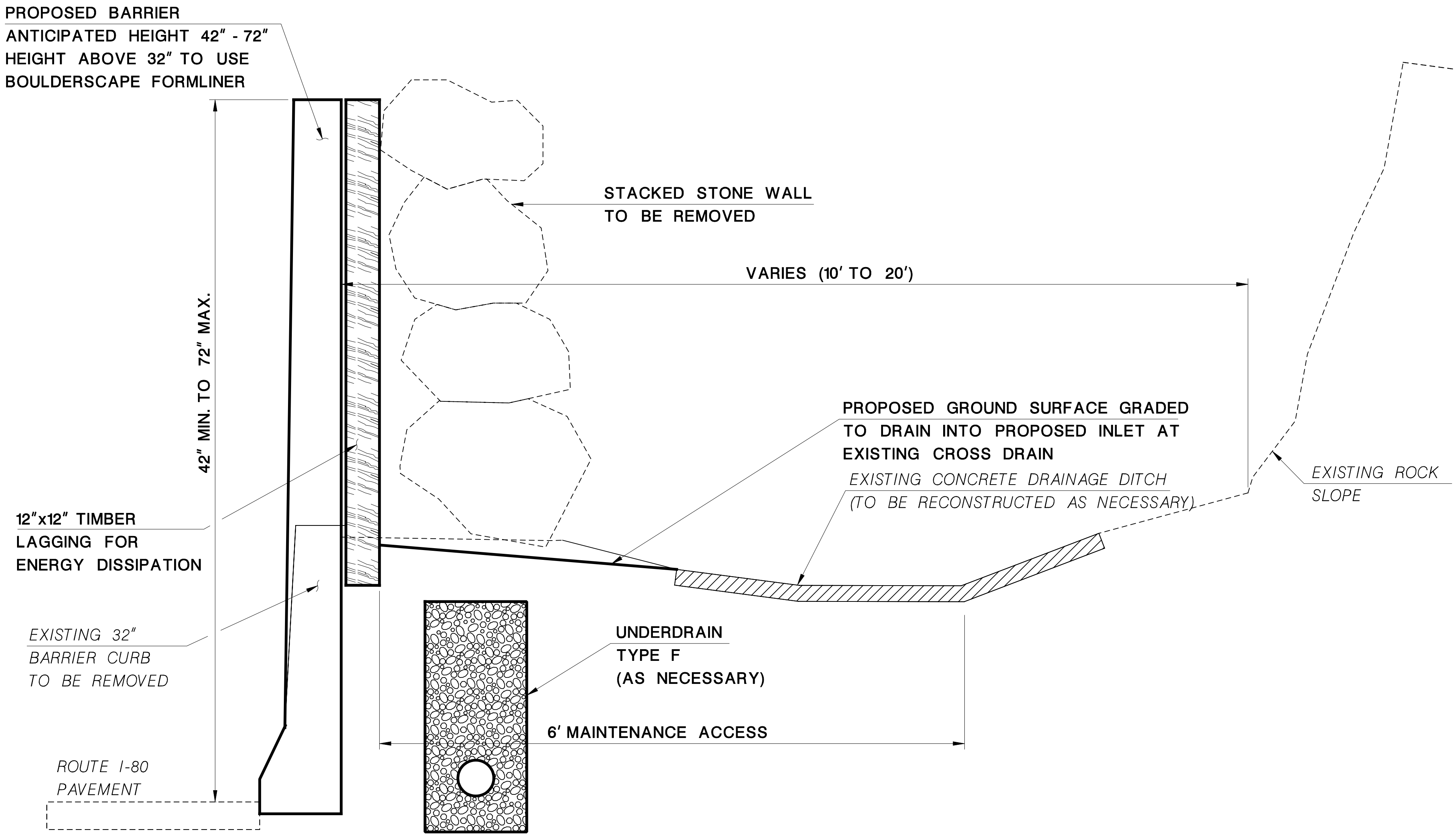
COMMONNAME
Bald Eagle
Barred Owl
Blackburnian Warbler
Black-throated Green Warble
Blue-headed Vireo
Bobcat
Brown Thrasher
Cerulean Warbler
Cooper's Hawk
Eastern Box Turtle
Forest Core
Golden-winged Warbler
Great Blue Heron
Harpoon Clubtail
Hooded Warbler
Jefferson Salamander
Kentucky Warbler
Least Flycatcher
Longtail Salamander
Marbled Salamander
Northern Copperhead Snake
Northern Goshawk
Northern Parula
Northern Spring Salamander
Red-headed Woodpecker
Red-shouldered Hawk
Timber Rattlesnake
Veery
Wood Thrush
Worm-eating Warbler

APPENDIX L

PRELIMINARY PREFERRED ALTERNATIVE,
CONCEPTUAL SKETCHES – PROPOSED ROCKFALL MITIGATION,
CONSTRUCTION STAGING, LANE CLOSURE HOURS,
AND DETOUR PLAN



TOWNSHIP OF HARDWICK
COUNTY OF WARREN
NOTE:
1. ALL MILEPOSTS SHOWN ARE APPROXIMATE.
2. EXISTING ROW LINE IS SHOWN 100' FROM C.L. OF ROADWAY AS SHOWN ON GENERAL PROPERTY PARCEL MAPS, MAY 1952.
AREA A & B RECOMMENDATION:
- REPLACE WB BARRIER CURB (42"-72" HIGH)
AREA C RECOMMENDATIONS:
- REPLACE WB BARRIER CURB (42"-72" HIGH)
- INSTALL HYBRID ROCKFALL SYSTEM
AREA D RECOMMENDATIONS:
- REPLACE WB BARRIER CURB (42"-72" HIGH)
- EXCAVATE PORTION OF TALUS / ENLARGE CATCHMENT AREA
- REINFORCE TALUS WITH ROCK BOLTS AND SHOTCRETE
- INSTALL ROCK CONTROL FENCES AND MESH
MAINTENANCE ACCESS POINT TO AREAS C & D (PROPOSED)
END PROJECT M.P. 1.45
TOWNSHIP OF KNOWLTON
COUNTY OF WARREN
M.P. 1.50
M.P. 1.55
M.P. 1.60
M.P. 1.40
M.P. 1.35
M.P. 1.30
M.P. 1.25
M.P. 1.20
M.P. 1.15
M.P. 1.10
M.P. 1.05
BEGIN PROJECT M.P. 1.04
M.P. 1.00
M.P. 0.95
M.P. 0.90
M.P. 0.87
PROPOSED BARRIER CURB
EXISTING R.O.W. LINE
TRAFFIC CONTROL TAPER AREA FOR LANE CLOSURES
AREA D M.P. 1.35 TO M.P. 1.45
AREA C M.P. 1.25 TO M.P. 1.35
AREA B M.P. 1.15 TO M.P. 1.25
AREA A M.P. 1.04 to M.P. 1.15
ARROW ISLAND
DELAWARE RIVER
STATE OF NEW JERSEY
STATE OF PENNSYLVANIA
I-80 WESTBOUND
I-80 EASTBOUND
MAINTENANCE ACCESS POINT TO AREAS A & B (EXISTING AND PROPOSED)
PA ROUTE 611
DATE
REVISION
Initials
I–80 ROCKFALL MITIGATION
TOWNSHIP OF HARDWICK
COUNTY OF WARREN
PRELIMINARY PREFERRED ALTERNATIVE
NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF PROJECT DEVELOPMENT
SCALE: 1" = 200'
MAY 2011
SHEET 1 OF 1



ROUTE 1-80 WESTBOUND
AREAS A & B SECTION VIEW

NOT TO SCALE (N.T.S.)

CONCEPT DEVELOPMENT STUDY
ROUTE I-80 ROCKFALL MITIGATION
MP 1.04 TO MP 1.45

PROPOSED ROCKFALL MITIGATION - SECTION VIEW

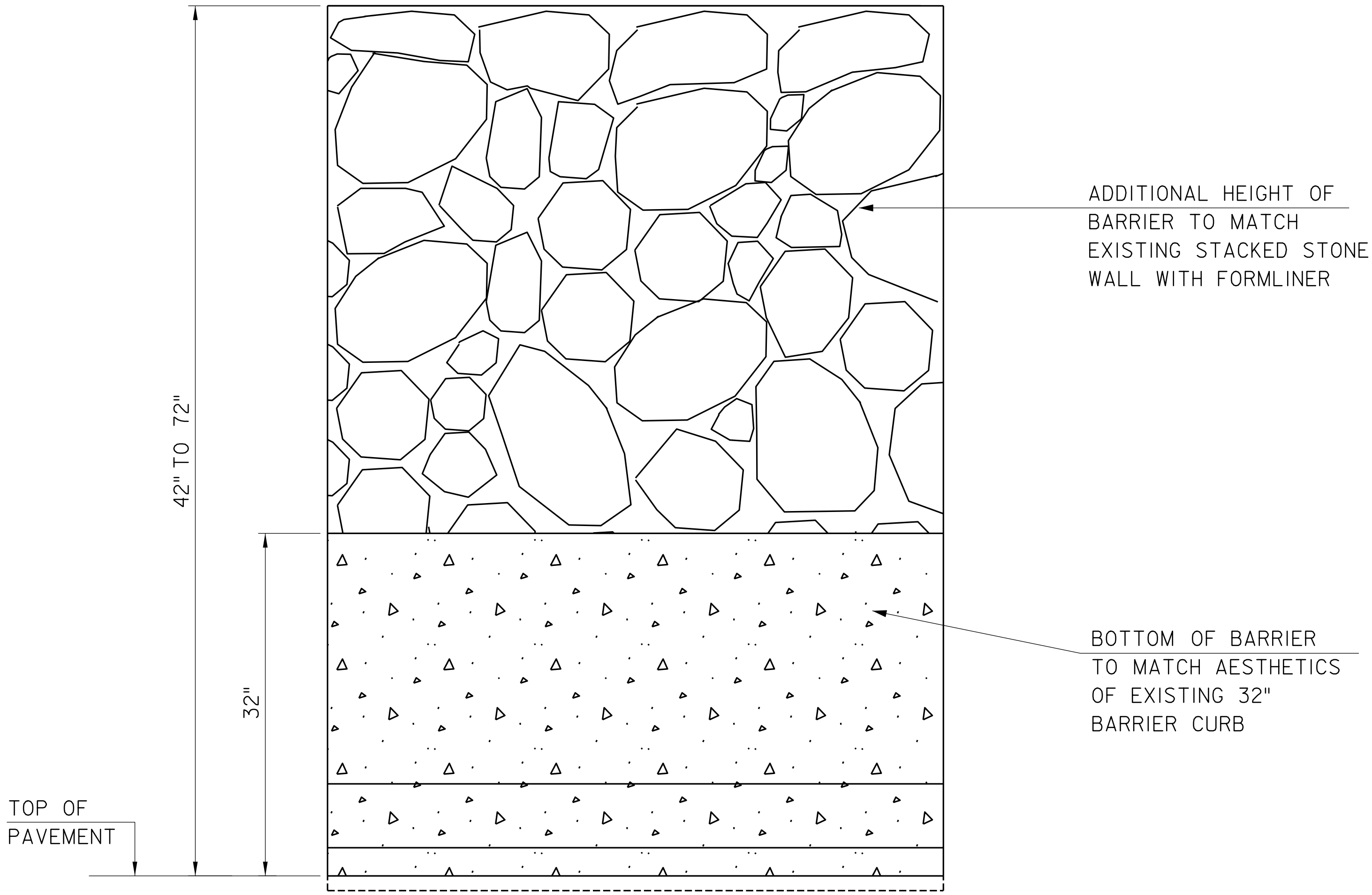
CLIENT:

NEW JERSEY
DEPARTMENT OF TRANSPORTATION
DIVISION OF PROJECT DEVELOPMENT

PREPARED BY:

HNTB

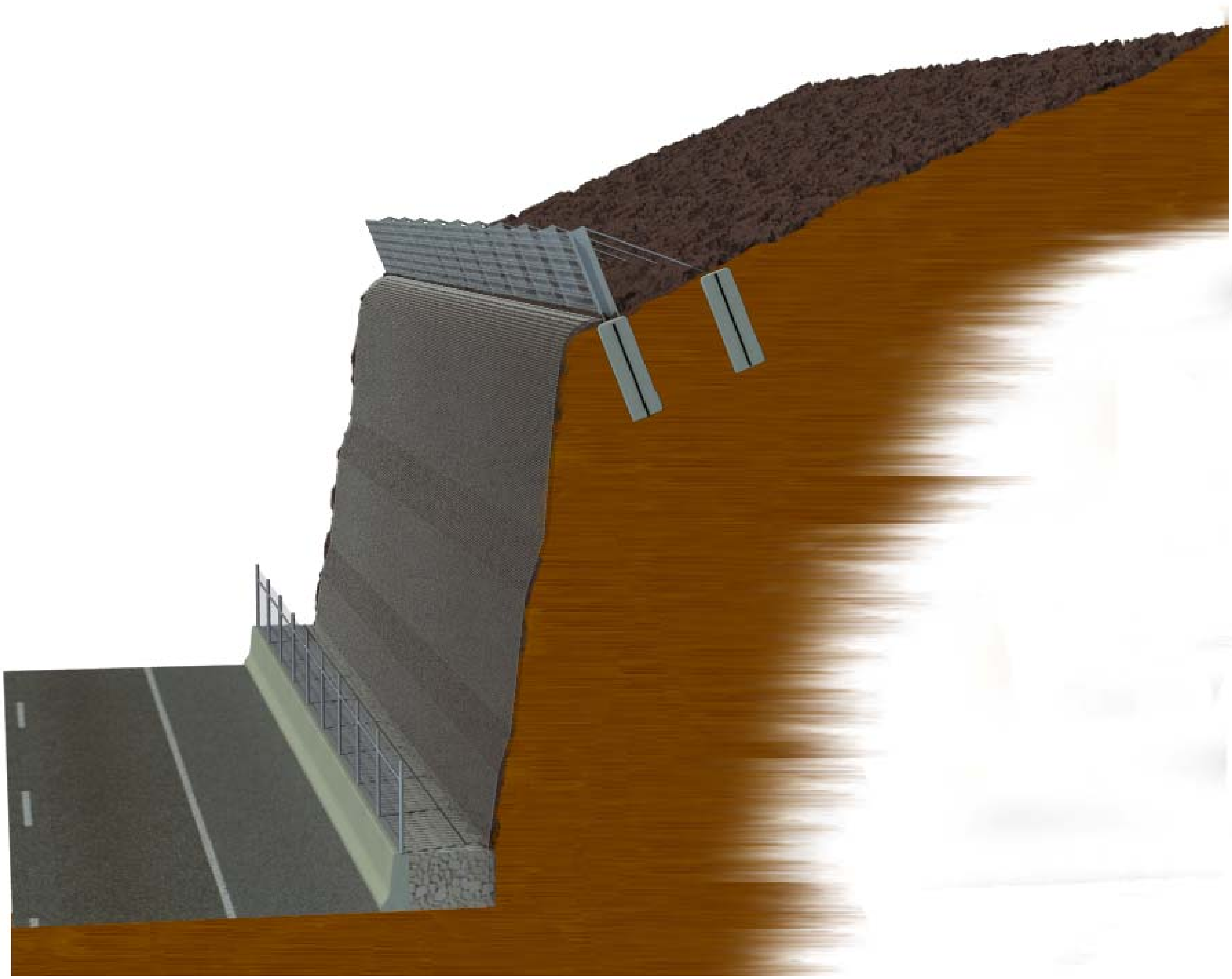
145 Route 46 West
Wayne, NJ 07470-6830
TEL (973) 237-1650



ROUTE I-80 WESTBOUND
AREAS A & B ELEVATION VIEW

NOT TO SCALE (N.T.S.)

CONCEPT DEVELOPMENT STUDY ROUTE I-80 ROCKFALL MITIGATION MP 1.04 TO MP 1.45	CLIENT: NEW JERSEY DEPARTMENT OF TRANSPORTATION DIVISION OF PROJECT DEVELOPMENT	PREPARED BY: HNTB 145 Route 46 West Wayne, NJ 07470-6830 TEL (973) 237-1650 FAX (973) 237-9185
PROPOSED ROCKFALL MITIGATION - ELEVATION VIEW		

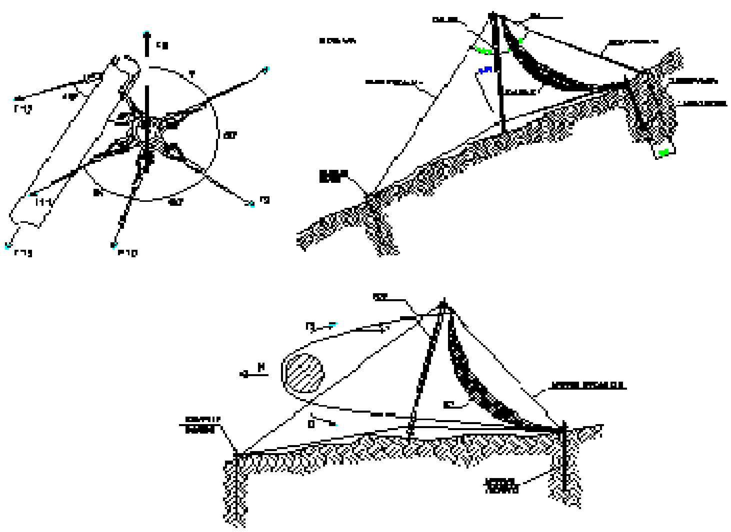


AREA C (MP 1.25 – 1.35)
CONCEPTUAL SKETCH SHOWING PROPOSED HYBRID ROCKFALL PROTECTION SYSTEM AND CATCHMENT FENCE

FIGURE 1

TUBOSIDER (Mountain Management)

Mountain Management is the North American dealer for TUBOSIDER.



TUBOSIDER manufacture rock fall barriers designed in every detail according to the following criteria:

- Level of kinetic energy to dissipate
- Dimension and optimization of the deformation
- Simplified assembly
- Simplified maintenance
- Protection against corrosion

We have determined that the value of kinetic energy ranging from 150 to 1500 KJ corresponds respectively to 0,5 and 5 ton rocks moving with a speed of 25 m/s.

FIGURE 2 - MANUFACTURES DATA FOR IGOR HYBRID SYSTEM (www.mountainmanagement.biz)

A company of the BRUGG Group

Hybrid rockfall protection barriers and catch fences

Hybrid rockfall protection barriers (attenuators) are a combination of rockfall protection drapes and flexible rockfall protection barriers without bottom supporting ropes. They are used as passive protection measures: The barrier brakes the falling rocks and the drape enables them to roll under control into the catch zone. Several hybrid barriers can be installed in succession.

Wide-ranging tests in collaboration with the Federal Research Institute WSL have confirmed the protection effect of hybrid rockfall protection barriers.

FIGURE 3 - MANUFACTURES DATA FOR GEOBRUGG HYBRID SYSTEM (www.geobrugg.com)

DATE	REVISION	Initials

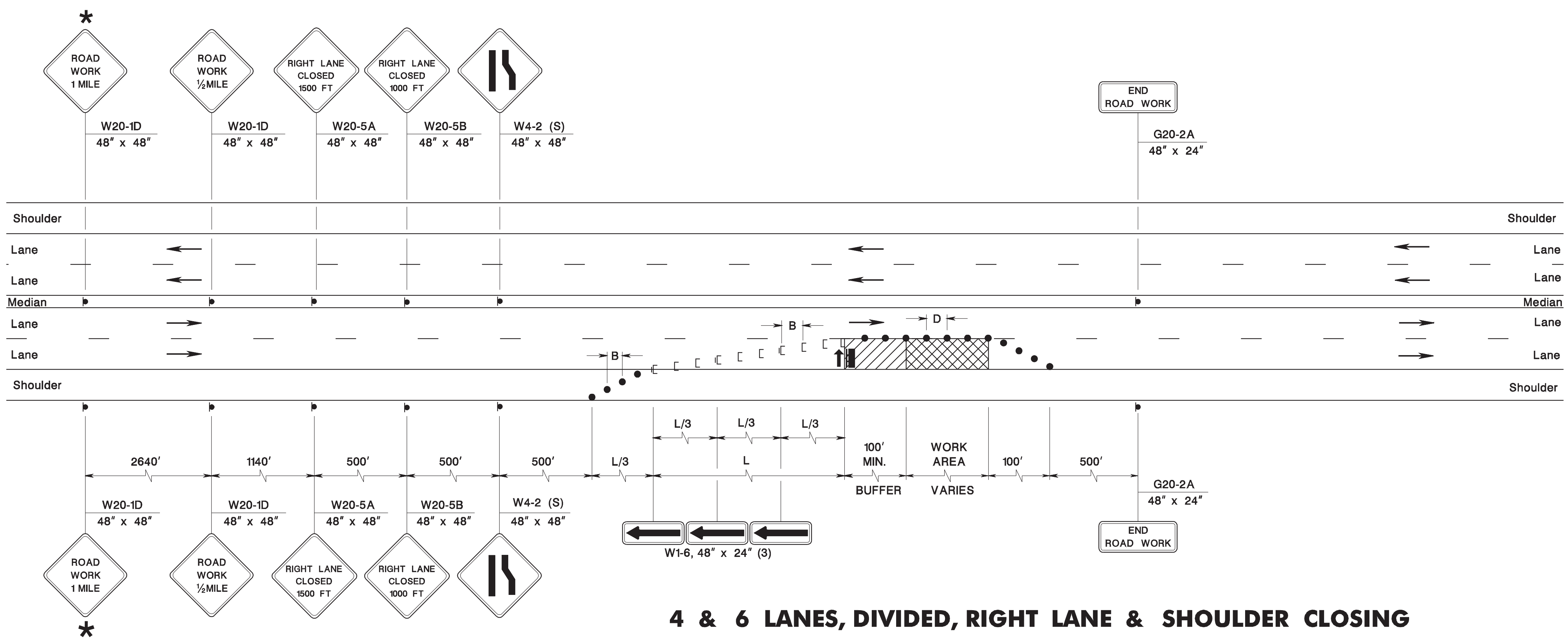
I–80 ROCKFALL MITIGATION

TOWNSHIP OF HARDWICK
COUNTY OF WARREN

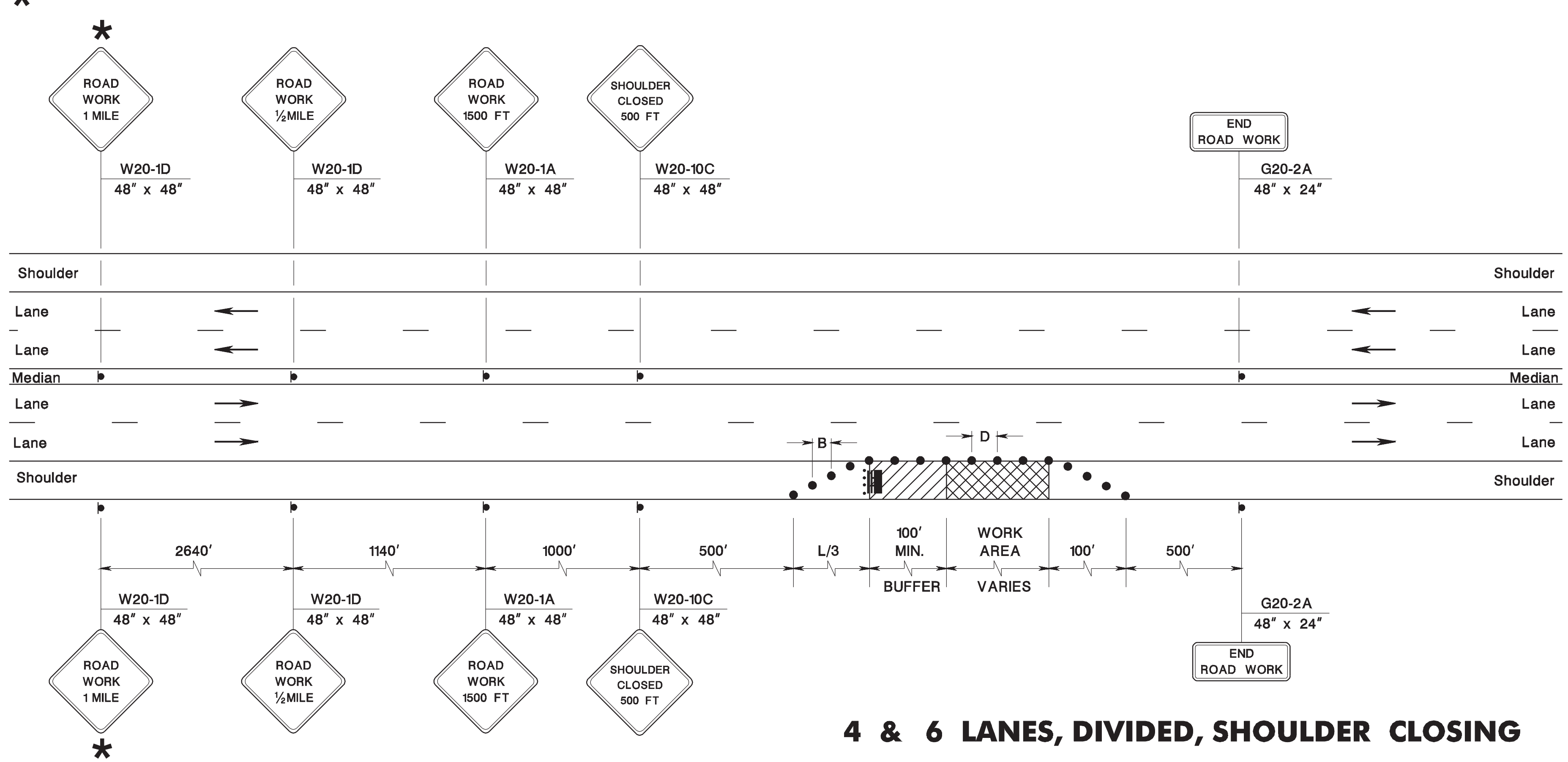
IMPROVEMENT PLAN
AREA D

NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF PROJECT DEVELOPMENT

SCALE: 1" = 100'	MARCH 2011	SHEET 1 OF 1



4 & 6 LANES, DIVIDED, RIGHT LANE & SHOULDER CLOSING



4 & 6 LANES, DIVIDED, SHOULDER CLOSING

* THIS SIGN SHALL BE INSTALLED FOR ROADS WITH A SPEED LIMIT OF 45 M.P.H. OR GREATER UNLESS OTHERWISE DIRECTED BY THE RE.
FOR ROADS WITH A SPEED LIMIT GREATER THAN 55 M.P.H., A "ROAD WORK 2 MILES" SIGN SHALL ALSO BE INSTALLED 2 MILES IN ADVANCE OF LANE CLOSING UNLESS OTHERWISE DIRECTED BY THE RE.

NOTES:

1. IF MEDIAN IS NARROWER THAN WIDTH OF SIGN PLUS 2 FEET, OMIT MEDIAN SIGNING.
2. SEE RECOMMENDED TAPER LENGTH AND SPACING TABLE ON SHEET TCD-2 FOR VALUES OF L, B AND D.

N.T.S.

TCD-14

NEW JERSEY DEPARTMENT OF TRANSPORTATION

TRAFFIC CONTROL DETAILS

New Jersey Department of Transportation
Traffic Operations North
Memorandum

TO:	Bhavesh Shah Principal Engineer Project Development
FROM:	Michael Pilsbury Supervising Engineer Traffic Operations North
DATE:	July 02, 2010
PHONE:	732-293-1211 FAX NUMBER: 201-797-8123
SUBJECT:	**Route I-80 Rockfall Mitigation, Westbound, Milepost 1.04-1.35** Townships of Hardwick and Knowlton, Warren County Mileposts 3.35 SB

As per your Memorandum Traffic Operations North personnel have completed a review of the above reference project and offer the following comments and recommendations:

1. Please use the following lane closure hours for this project:

LANE CLOSURE HOURS

Route 80 Westbound (Two Travel Lanes with Minimal to no Shoulders)

All Lanes Maintained

Monday to Thursday	6:00 AM to 8:00 PM
Friday	6:00 AM to 9:00 PM
Saturday	8:00 AM to 9:00 PM
Sunday	9:00 AM to 9:00 PM

One Lane Maintained

Monday through Thursday	8:00 PM to 6:00 AM (Next Day)
Friday	9:00 PM to 8:00 AM (Saturday)
Saturday	9:00 PM to 9:00 AM (Sunday)
Sunday	9:00 PM to 6:00 AM (Monday)

Route I-80 Full Closure and Diversion

Monday through Thursday	11:00 PM to 5:00 AM (Next Day)
Friday	11:00 PM to 6:00 AM (Saturday)
Saturday	11:00 PM to 6:00 AM (Sunday)
Sunday	11:00 PM to 5:00 AM (Monday)

2. No lane or ramp closures will be permitted on the following holidays:

   - Easter Sunday (including 6:00 AM Saturday until Noon Monday)
   - Memorial Day (See Note Below)
   - July 4th (See Note Below)
   - Labor Day (See Note Below)
   - Election Day (6:00 AM until 8:00 PM the day of)
   - Thanksgiving Day (See Note Below)
   - Christmas Day (See Note Below)
   - New Years Day (See Note Below)

   NOTE:

If Holiday Falls On	No Lane Closures Permitted
Sunday or Monday	6:00 AM Friday until Noon Tuesday
Tuesday	6:00 AM Friday until Noon Wednesday
Wednesday	6:00 AM Tuesday until Noon Thursday
Thursday	6:00 AM Wednesday until Noon Monday
Friday or Saturday	6:00 AM Thursday until Noon Monday

3. The proposed work must be coordinated with any other projects that may be underway at the same time in the project area.

4. Shoulders may be closed at any time during the day but should be open from 6:00 AM to 9:00 AM and 3:00 PM to 7:00 PM for morning and evening rush hours.

5. Please provide four variable message boards that are both cell phone capable and have compatible software that can be integrated into the Statewide Traffic Management Centers current communication software to be used for traffic mitigation.

6. The Detour for this route would be Diversion Route 80W-7 in the Warren County Diversion Book. This would be as follows:

   - Exit traffic right onto ramp to Route 46 / Route 94 (Exit 4)
   - Left onto Route 46 East
   - Right onto County Route 611 (Portland Bridge to Pennsylvania)
   - Go through toll plaza
   - Left onto County Route 611 North
   - Turn Right onto Broad Street
   - Take Ramp back onto Route I-80 Westbound

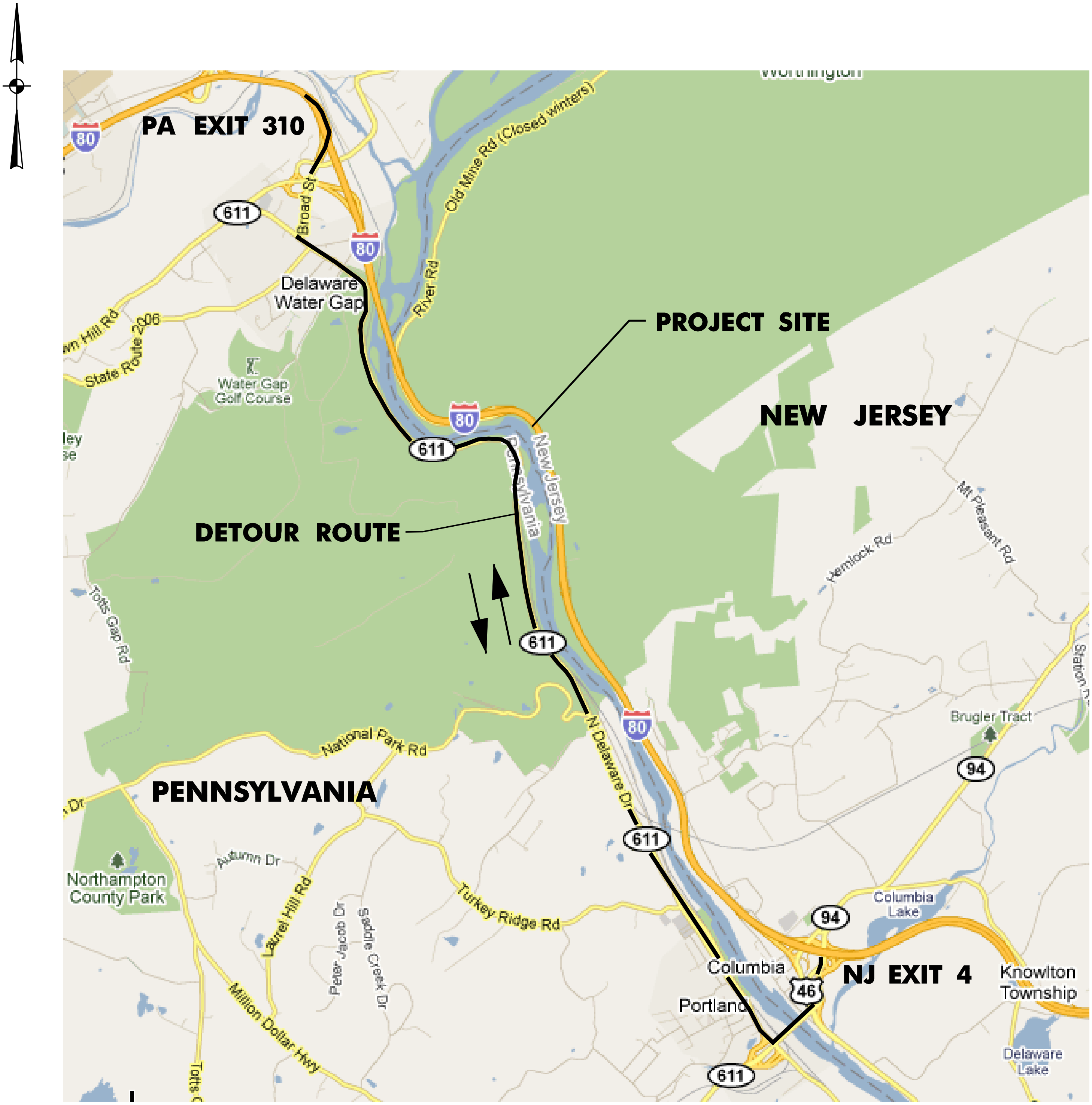
7. For the full Route I-80 Westbound closure to be used approval will be needed by the Delaware River Joint Toll Bridge Commission and an extensive out reach program enacted prior to any full closure taking place.

8. For a full weekend closure Traffic Operations will require additional review and traffic analyses. This would be required of the designer and as per the final rule requirements under the Federal Highway Administration.

Should you have any questions or comments please feel free to contact Paul Hartle of my staff at (201) 797-9023.

HNTB

Filename: \\FFLw00\CADD\44829\I-80 Rockfall\T1\Plans\Project Location Packages$ Username: $user$ Date: 19-NOV-2010



NOTE:
1. IMAGES OBTAINED FROM GOOGLE.COM
2. DETOUR ROUTE IS DIVERSION ROUTE 80W-7 IN THE WARREN COUNTY DIVERSION BOOK.

NOT TO SCALE (N.T.S.)

CONCEPT DEVELOPMENT STUDY ROUTE I-80 ROCKFALL MITIGATION MP 1.04 TO MP 1.45	CLIENT: NEW JERSEY DEPARTMENT OF TRANSPORTATION	PREPARED BY: HNTB 145 Route 46 West Wayne, NJ 07470-6830 TEL (973) 237-1650 FAX (973) 237-9185
DETOUR PLAN		

APPENDIX M

CONSTRUCTION COST ESTIMATES BACKUP

For:	Rt. 80 Rockfall	Job Number:	44829	Sheet No.	
By:	BTF	Check By:		Check by:	
Date:	1/5/2011	Date:		Date:	

HNTB

COST ESTIMATE

Item	QUANTITY		UNIT	UNIT COST	COST	REFERENCE
Area A and B						
Alternative I - No Action		0	LS	$0.00	**$0.00**	
Alternative II - Rock Catch Fence					**$327,200.00**	
Rock Catch Fence	MP 1.25 - MP 1.04 =	1,109	LF	$250.00	$277,200.00	
Debris Removal	Cleanup rockfall at toe of slope	100	CY	$500.00	$50,000.00	
Alternative III - Heightened Barrier					**$463,345.56**	
Concrete Barrier (Including Timber)	MP 1.25 - MP 1.04 =	1,109	LF	$275.00	$304,920.00	
Debris Removal	Cleanup rockfall at toe of slope	100	CY	$500.00	$50,000.00	
Existing Barrier and Wall Removal	MP 1.25 - MP 1.04 =	1,109	LF	$50.00	$55,440.00	
Excavation, Unclassified	(1,109' x 1.5' x 3' + 1,109' x 1' x 6') / 27cf/CY) =	431	CY	$20.00	$8,625.56	1
Underdrain Type F	MP 1.25 - MP 1.04 =	1,109	LF	$40.00	$44,360.00	1
Area C						
Alternative I - No Action		0	LS	$0.00	**$0.00**	
Alternative II - Mesh on Lower Slope					**$424,280.00**	
Rock Scaling and Disposal		50	CY	$500.00	$25,000.00	2,3,4
Rock Bolts	[MP 1.35-1.25=528'],370'/ 20'spacing x 8' Bolts =	211	LF	$150.00	$31,680.00	2,3,4
Rock Bolt Testing		2	EA	$3,800.00	$7,600.00	
Wire Mesh	200' x 120' (Not to be paced in Gabion Area) =	24,000	SF	$15.00	$360,000.00	
Alternative III - Mesh on Both Slopes					**$1,336,200.00**	
Rock Scaling and Disposal		50	CY	$500.00	$25,000.00	2,3,4
Rock Bolts	48,000 sf / 10' spacing / 10' spacing x 8' bolts	3,840	LF	$150.00	$576,000.00	2,3,4
Rock Bolt Testing		4	EA	$3,800.00	$15,200.00	
Wire Mesh	Twice area of lower slope assumed	48,000	SF	$15.00	$720,000.00	2,3,4
Alternative IV - Rock Catch Fence					**$132,000.00**	
Rock Catch Fence		528	LF	$250.00	$132,000.00	
Alternative V - Hybrid System					**$2,156,126.67**	
Rock Scaling and Disposal		50	CY	$500.00	$25,000.00	2,3,4
Hybrid System Anchors (Inc. Barrier)	(2 rows x 528ft / 10ft spacing) x 15ft =	1,584	LF	$600.00	$950,400.00	3
Hybrid System Mesh (Lower Slope)	528' x 120' =	63,360	SF	$15.00	$950,400.00	3
Rock Bolts for Spot Bolting		70	LF	$150.00	$10,500.00	2,3,4
Rock Bolt Testing		4	EA	$3,800.00	$15,200.00	
Shotcrete (Contingency)		6	SY	$1,300.00	$7,800.00	1
Concrete Barrier (Including Timber)	MP 1.55 - MP 1.25 =	528	LF	$275.00	$145,200.00	
Existing Barrier and Wall Removal	MP 1.25 - MP 1.04 =	528	LF	$50.00	$26,400.00	
Excavation, Unclassified	(528' x 1.5' x 3' + 528' x 1' x 6') / 27cf/CY) =	205	CY	$20.00	$4,106.67	1
Underdrain Type F	MP 1.25 - MP 1.04 =	528	LF	$40.00	$21,120.00	1

References:

1) NJDOT 2008, 2009, and 2010 Bid Price Report Referenced and Unit Cost Selected Based on Findings
2) Engineer's Estimate for HNTB Project 45493 - SEPTA Gwynedd Cut and confirmed by similar Bid Price on 5/26/09
3) Email from Joe Bigger (Geobrugg) to Brian Felber (HNTB) dated 9/30/2010
4) Discussion with Andrew Salmaso (Janod) 11-19-10

Lumps Sum Items Cost Estimate Backup

Item	Unit Price	Source
Performance and Payment Bond	$15,000	Table H-1 of Construction Cost Estimating Guide
Liability Insrance	$10,000	Table H-4 of Construction Cost Estimating Guide
Progress Schedule	$6,000	Table H-5 of Construction Cost Estimating Guide
Construction Layout	$25,000	Table H-3 of Construction Cost Estimating Guide
Final Cleanup	$7,500	Table H-2 of Construction Cost Estimating Guide
Clearing Site	$15,000	Table H-7 of Construction Cost Estimating Guide
Field Office	$40,000	Price from past project including setup and maintenance
Mobilization	$150,000	Table H-2 of Construction Cost Estimating Guide. Assume construction costs of all rockfall mitigation items to be $1.5 million

Traffic Control Items	Quantity	Unit Price		Cost
Drums	30	$80		$2,400
Barricades	15	$120		$1,800
Construction Barrier	2200	$75		$165,000
Construction Signs	500	$30		$15,000
Crash Cushion	1	$20,000		$20,000
TMA	1	$15,000		$15,000
VMS	2	$20,000		$40,000
Flashing Arrow Board	1	$3,500		$3,500
			Total =	$262,700
			Say	$270,000

APPENDIX N

RISK ASSESSMENT REPORT FOR AREA D

RISK ASSESSMENT REPORT

WESTBOUND I-80 ROCKFALL MITIGATION
Concept Development Phase

Area D Milepost 1.35 to 1.45, Warren County, New Jersey

Prepared for: HNTB Corporation, Wayne, NJ

Prepared by: Wyllie & Norrish Rock Engineers Inc., Redmond, WA

Norman I. Norrish, P.E.

Date: March 23, 2011

Project No. 102-2003

Table of Contents

List of Tables

List of Figures

Appendices

1.0 INTRODUCTION

By way of a professional services agreement dated November 11, 2010, Wyllie & Norrish Rock Engineers Inc. (W&N) was retained by HNTB Corporation (HNTB) to assist with an assessment of rock slopes adjacent to Westbound Route 80 between Mileposts 1.04 and 1.45, Warren County, New Jersey. Of the four designated milepost intervals for the HNTB project, the W&N scope related primarily to Area "D" between Mileposts 1.35 and 1.45. The contractual scope included the following tasks:

A. Review existing information
B. Perform Site Visit
C. Perform rockfall simulation
D. Perform risk analysis
E. Conceptual barrier Design
F. Review Overall Rockfall Remediation Plan (Areas "A", "B", and "C")
G. Reporting

The site visit was performed by Norman I. Norrish, P.E. on November 30, 2010 accompanied by Mr. J. Jamerson of NJDOT and Messrs. M. Riegel, J. Szturo and B. Felber of HNTB. A resume for Mr. Norrish is attached as Appendix A.

2.0 BACKGROUND

2.1 Terminology

It is useful to clarify the terms "*hazard*" and "*risk*" that will be used through the balance of this report. A rock fall or soil slope failure is one of a number of geologic processes categorized as natural hazards. These natural processes include landslides, debris avalanches, slope creep movement, soil piping, snow avalanches and so on. These events occur in nature and have done so since the geologic evolution of landforms began. In some cases, the activities of humans can influence the occurrence of natural hazard events. When there is a reference to a high hazard, the meaning is that there is a high likelihood an event will occur.

Risk refers to the consequences of a natural hazard event if it occurs. It is easy to envision an event that has absolutely no consequence in terms of humans, for example a snow avalanche in the remote mountains. The same natural hazard perched above a ski resort would represent a significant risk.

The hazards that engineers are most interested in are those that have both a high likelihood of occurrence and a high likelihood of causing damage, injuries, death or severe economic impacts. Applied to highway slopes, it is necessary to assess both the degree of **hazard** in terms of the rock or soil becoming dislodged from the slope and the potential damage **(risk)** it could inflict based on its energy, probable trajectory and the likelihood of something being in its path.

In the discussions that follow, hazard ratings are the subjective assessments of the writer with ***"low"*** indicating an estimated event frequency of multiple years; ***"moderate"*** indicating an estimated event frequency of one to two years; and ***"high"*** indicating an estimated event frequency of less than a year. The event frequencies could be altered under adverse climatic conditions such as atypical freeze-thaw cycles with the presence of surface water.

2.2 Rockfall Management Systems

In the mid 1980's, Mr. D. Wyllie developed a prototype rock slope hazard rating system for highways (Wyllie, 1987). This system was adopted and refined by the Oregon Department of Transportation and the Federal Highway Administration leading eventually to the publication *"The Rockfall Hazard Rating System Implementation Manual"* (FHWA, 1993), referred to by acronym as the RHRS.

Appendix B illustrates the categories that comprise the RHRS scoring protocol. Scores are assigned based on experienced judgment and simple calculations rather than by extensive quantitative analysis or testing. Within any one rating category, the benchmark examples increase exponentially, that is, 3, 9, 27, and 81 points, and represent a continuum of points from 1 to 100. This is intended to amplify the occurrence of high hazard characteristics in the cumulative rating applied to the slope. The RHRS rating for a given slope has a maximum value of 1000 points (10 categories x 100 maximum points per category).

Rockfall ratings are intended to be relative to enable comparison of the slopes within a common transportation network. Thus, it is important that procedures be implemented to make sure that the ratings are internally consistent, for example through training of the personnel doing the fieldwork. The absolute rating of a slope does not, of itself, indicate the need or the urgency to carry out remedial measures. Rather, the rating in comparison to all other ratings for the network is a filtering mechanism through which the highest priority sites can be identified for follow up investigation, design and stabilization. It should also be noted that a low rated slope is not a "zero risk" slope in terms of rockfall occurrence.

3.0 SITE DESCRIPTION

The I-80 alignment at the project site is generally north-south as it passes through the Delaware Water Gap National Park between Mt. Tammany to the east and Mt. Minsi to the west. The Appalachian Mountains in this area consist of sedimentary beds including siltstones, sandstones, shales and quartzites that dip to the northwest at intermediate inclinations.

For the four areas under consideration for the HNTB concept design project, the most recent 2009 hazard ratings prepared by NJDOT are as follows:

MP 1.04 to 1.15 Area “A”: 406
MP 1.15 to 1.25 Area “B”: 630
MP 1.25 to 1.35 Area “C”: 662
MP 1.35 to 1.45 Area “D”: 422

These ratings compare to the theoretical maximum RHRS rating of 1000 points as described above. It is understood that Area “C” is the highest rated rock cut in the State and that the four sites collectively are amongst the highest in the State.

Area “D” consists of an extensive 450-foot high talus slope bounded by an oblique trending cliff-forming outcrop that is some 200 feet high. Talus blocks are angular and consist of strong quartzite and conglomerate with little fine material between the blocks.

Figure 1 shows the existing catchment conditions along Westbound I-80 within Area “D”. The natural talus slope below the cliff rests at an angle of 35° to 37°, typical for deposits comprised of strong, angular rock blocks. During construction, it appears that the toe of the talus was excavated at some locations to create the footprint for the highway. Consequently, at such locations the lower portion of the talus is steepened from 37° to 45° using placed rock, below which stacked and locally-grouted rock boulders are present to act as a rockfall barrier (see Figure 1).

4.0 GENERAL APPROACH TO RISK ASSESSMENT for AREA “D”

As described above, risk is the consequence of a hazardous event. As applied to Area “D” the hazardous event is the dislodging of rock blocks from the cliff and their traversing the talus slope to arrive on the travel lanes of I-80. Thus a risk assessment must consider three components:

1. The probability that rockfall will be generated at the cliff source area.
2. The probability that rockfalls so generated will land on the highway.

3. The consequences to the highway infrastructure and to the traveling public should the rockfalls reach the highway.

Each of these components is discussed in the following sections.

4.1 Probability of Rock fall Occurrence from Source Area.

The occurrence of rockfall from a rock slope is dependent on the structural fabric of the rock mass, that is, the presence, orientation and shear strength of geologic discontinuities that define unstable blocks. Figure 2 indicates that the outcrops above the talus slope contain moderately spaced joint and bedding planes that define potentially unstable blocks. Limited structural mapping by HNTB confirmed the visual assessment. (Figure 2) .

Adverse structural conditions must be accompanied by triggering mechanism(s) to dislodge the blocks. In the case of Area “D” the primary agent is probably freeze-thaw cycles acting on near-surface water-filled joints and bedding planes. A secondary agent could be the wedging action of tree roots or the leverage supplied by the wind loading of trees.

The rate of rockfall is very difficult to estimate in the absence of subsurface drilling information concerning talus thickness. In all probability the rate of talus development was the highest immediately after deglaciation and has progressively slowed over the past 20,000 years. In the opinion of the writer tens of rockfalls probably occur per year in Area “D” but these are typically less than 3 feet in diameter (1 ton). Larger rockfalls, in the size range of 20 tons and larger, probably occur with a frequency of perhaps ten years or more. These subjective assertions are based on the presence of tree growth on talus slope immediately beneath steep outcrop and on the lack of fresh scars on the rock face, both of which suggest limited rockfall activity (Figure 2). These estimated rockfall frequencies were corroborated by Mr. John Jamerson of NJDOT Geotechnical Engineering (personal communication).

4.2 Probability that Rockfall will Reach I-80

The probability that a rockfall event will reach the highway in Area “D” can be evaluated in several ways. The best approach is to review the rockfall history as documented by state maintenance forces. Based upon an interview that HNTB performed with Mr. Joe Popeka of NJDOT Maintenance, **there are no documented rockfall events nor any recollections of significant rockfall events within Area “D” over the past 5 to 10 years**. In contrast, rockfalls have been recorded in Areas “A” and “B” as recently as October 2010.

A second approach to evaluate rockfall runout potential is to examine the slope geometry (Figure 3). As a rule-of-thumb, the potential runout zone beyond the toe of a talus slope is defined by a line at 25° that extends from the base of the source area. In this case, the rockfall shadow extends well beyond I-80 indicating the potential for "large" boulders to reach the highway (Figure 3).

The third approach to estimate the probability of rockfalls reaching I-80 is through the use of rockfall simulations. Although these analytical methods have been in engineering use for about 20 years, the complex interaction of the controlling variables dictates that caution be exercised when interpreting the model results. Many of the required input variables cannot be directly measured through field or laboratory tests with the result that precedent case histories in similar materials are used to assign reasonable values. Ideally, rockfall simulation should not be applied without site specific calibration developed from either documented rockfall trajectories or by means of rolling rock field tests. Unfortunately, neither of these approaches is available for the I-80 Area "D" site and hence engineering judgment was used to assign reasonable values from the software supplier (Rocscience Inc., Toronto, Ontario) and from published records**. It is emphasized that the rockfall simulations herein are intended to verify concept feasibility and are not suitable for final mitigation design.**

The simulations used software "RocFall" Version 4.054 dated Aug 16, 2010. An idealized cross section through the center of Area "D" was provided by HNTB (Figure 4). The section extended from downslope of I-80 to above the cliff-forming outcrops between elevations 800 and 1000 feet. The steep outcrops were assumed to be the source area with uniform probability that rockfalls could originate from anywhere on the face. The distribution of materials comprising the slope is shown in Figure 4. An analysis point was defined at the westbound shoulder of I-80.

Based on field measurements by HNTB, a mean boulder size of 4-foot diameter (2 ½ tons) was selected as the design boulder. Further, an extreme boulder size of 8-foot diameter (20 tons) was also included in the simulations. As a point of reference, the 2010 Area "A" / "B" rockfalls were estimated to be 1 ½ tons and 7 tons. Also, note that the RocFall software does not explicitly consider the boulder shape.

The remaining input variables relate to the material properties present on the slope. These include the normal and tangential coefficients of restitution, friction angle and roughness. Figure 4 shows the assigned values for these variables. In most cases the software adopts distributions and hence mean and standard deviation values are required. As previously described, default values provided by the software supplier were utilized. The roughness and friction angle values are dependent on the size of the boulder under consideration. A smaller diameter boulder will experience greater roughness on a bedrock or talus slope than will a larger boulder and hence the assigned roughness values are greater. Conversely, a small boulder will be less likely to roll or slide on a rough surface and therefore the assigned friction angle is higher (somewhat analogous to static and rolling angles of friction).

For each simulation, 1000 rockfall trajectories were modeled. The bounce heights and energy at the analysis point were tabulated for comparative purposes. As shown in Figure 5, the salient results are as follows:

Mean rock: 4 ft diameter (2 ½ tons)

- ~ 3% probability of reaching I-80, rolling or sliding at arrival
- Average total energy ~ 35 ft-tons
- Maximum total energy ~ 85 ft-tons

Extreme rock: 8 ft diameter (20 tons)

- ~ 30% probability of reaching I-80, rolling or sliding at arrival
- Average total energy ~ 300 ft-tons
- Maximum total energy ~ 550 ft-tons

(Note: Total energy = translational + rotational kinetic energy)

The important results of the simulations are the muted trajectories of the boulders at the analysis point and the total kinetic energy values compared to the potential energy at the source. Assuming an average vertical separation of 500 feet between the source and the I-80 grade, the potential energies of the mean and extreme boulders are 1250 ft-tons and 10,000 ft-tons respectively. This means that the model predicts more than 90% of the energy is dissipated during the slope impacts. With regard to the predicted probabilities of 3% and 30%, these values are consistent with the recent rockfall history and the rockfall shadow analysis above.

4.3 Probability that Rockfall will Impact Traveling Public.

Due to the very high ADT on I-80, it is assumed that any rock that reaches the highway will have a very high probability of causing damage or injury. On a very subjective basis, these probabilities are estimated to be 75% for the mean boulder size and 90% for the extreme boulder.

5.0 RISK ASSESSMENT for AREA "D"

5.1 Subjective Risk Assessment

As discussed in Section 2, Area "D" received a hazard rating of 422 by NJDOT in 2009 using the Rockfall Hazard Rating System (RHRS) developed by the Federal Highway Administration (FHWA, 1993). This value can be benchmarked against the ratings of 406, 630 and 662 for Areas "A", "B", and "C", respectively, and against a maximum rating of 1000 (10 categories at 100 maximum). Thus, on a simple comparative basis, the latter two areas should be considered as higher priorities for mitigation than Area "D".

Design guidance for rockfall catchment areas is provided by the 2001 joint publication of the Oregon Department of Transportation Research Group and the Federal Highway Administration (ODOT, 2001). This document synthesizes the data collected from over 10,000 rock rolling measurements to develop performance criteria for various catchment and rock slope geometries. Catchment (i.e. "ditch") geometries include slopes of 4H:1V, 6H:1V and flat with rock slopes inclinations ranging from 1H:1V to vertical and with slope heights between 40 and 80 feet. The design guidance is presented in the form of expected rockfall retention percentage assuming the rockfall originates from the top of the slope under consideration. Most agencies target 90 to 95% retention as a reasonable design criterion. Figure 6 shows the application of the ODOT design guidance to an 80-foot high, 1H:1V slope. The chart indicates that for 90% retention a catchment width of between 23 and 60 feet is required, depending on catchment slope. For the Area "D" situation, the comparable slope is more than 400 feet high at an inclination 37° indicating that greater catchment widths would be required. The current geometry is clearly substandard with respect to current design practice.

A final aspect of the subjective risk assessment relates to the use of concrete barriers and stacked rocks as rockfall mitigation. Figure 7 shows the results of rockfall impacts on concrete barriers. Concrete with a compressive strength of 3000 to 4000 psi is not capable of withstanding impacts from intact rock blocks with compressive strengths 3 to 5 times greater. The results of such collateral damage can be just as hazardous as the rockfall itself. As applied to Area "D", a rockfall that impacts either the stacked rock barrier or the shoulder barrier could potentially propel fragments onto the highway. Optimal barriers make provision to absorb energy rather than being rigid to impacts. A side observation with respect to the stacked rock barrier on the lower photograph in Figure 1 is that it could serve as a launch point to exaggerate the trajectory of a rolling rock, thereby increasing its probability of reaching the travel lanes.

5.2 Semi-Quantitative Risk Assessment

As previously described, the risk to highway is a function of three variables:

1. The probability that rockfall will be generated at the cliff source area.
2. The probability that rockfalls so generated will land on the highway.
3. The consequences to the highway infrastructure and to the traveling public should the rockfalls reach the highway.

Based on the evaluations herein, these factors can be combined as follows:

For 4-foot diameter boulder: (2½ foot tons):

Annual probability of rockfall occurrence: say 10 per year
Probability of reaching highway: 3%
<u>Probability of causing damage of injuries: 75%</u>

Annual probability of damage or injuries: 10 x 0.03 x 0.75 = 23%

For 8-foot diameter boulder: (20 foot tons):

Annual probability of rockfall occurrence: say 1 every 10 years
Probability of reaching highway: 30%
<u>Probability of causing damage of injuries: 90%</u>

Annual probability of damage or injuries: 0.1 x 0.3 x 0.9 = 3%

Thus a 4-foot diameter boulder can be expected to cause injuries or damage about once every 4 to 5 years while the larger extreme boulder would do so about every 30 to 35 years. These values are somewhat pessimistic (conservative) compared to the documented rockfall history for Area "D" summarized in Section 4.2 wherein no rockfalls have been documented in Area "D" for the past 5 to 10 years. This measurement period is too short to reach conclusions concerning validity of the risk assessment. Notwithstanding the differences, the prudent course of action is to assume the more conservative risk assessment estimate that incorporates a greater frequency of rockfalls causing damage or injuries than currently documented for Area "D".

5.3 Risk Assessment Conclusion

1. A relatively large rockfall volume is required to reach the highway.
2. Such events have low probability but with high potential consequence.

6.0 MITIGATION

In order of preference, rockfall mitigation is subdivided into ***removal, reinforcement*** and ***protection*** methods. Removal refers to scaling and trim blasting techniques; reinforcement to rock bolts or dowels; and protection to fences, slope drape and sheds.

6.1 I-80 Mitigation Constraints

1. Construction to be performed under live traffic – one lane closure part time (eliminates alignment / grade changes)
2. Shoulder barrier height may be limited by snow removal operations.
3. Aesthetic issues have not been identified at this stage of project development and hence aesthetic considerations were not used to restrict viable rockfall mitigation alternatives. Potential aesthetic impacts and the potential for aesthetic enhancements are identified for each alternative. These can be utilized in future stakeholder negotiations at the project design phase.

6.2 Area "D" Mitigation Alternatives

The following mitigations alternatives were evaluated at a concept level:

I. No action – accept the risk and allocate available funds to higher priority areas.
II. Removal/reinforcement – scale and reinforce source area for rockfalls.
III. Protection – modify catchment geometry to improve effectiveness.
IV. Protection – rockfall control fences.
V. Protection – improve catchment geometry in combination with rockfall control fence.

Alternative I requires no additional explanation.

Alternative II includes scaling, trim blasting and rock bolting (tensioned steel bars) of the cliff-forming outcrop above the talus slope. In order to execute the work under live traffic, temporary rockfall control fences will be required at or above the highway grade. Work plan items for the design phase will include:

- Digital terrain model (DTM) with maximum 2-foot contour interval.
- Helicopter reconnaissance of cliff to confirm that no major potential instabilities are present and to record high quality oblique photographs.
- Sirovision or LiDAR techniques for remote structural mapping of the cliff face combined with conventional structural mapping to design stabilization requirements. LiDAR is a laser-based technique while Sirovision utilizes digital photographs for structural mapping of inaccessible locations (see Haneberg, et. al., 2006).
- Development of construction plans using high quality oblique photographs as a base.

Alternative III consists of incrementally excavating and reinforcing the toe of the talus slope to create an enlarged catchment area. As shown in Figure 8 the general sequence will include grouting of the talus behind the design cut line, followed by staged, top-down excavation with rock bolt reinforcement and shotcrete face treatment on successive lifts. An enhanced barrier (+42 inches tall) with a granular backfill is recommended to absorb the impact energy of rockfall impacts. The interim stability of the talus slope will be paramount and for this reason only short station intervals would be open at any given time. Work plan items for the design phase will include:

- Digital terrain model (DTM) with maximum 2-foot contour interval.
- Probe drilling to determine thickness of talus deposits for entire length of Area “D”. Assume two holes on sections every 50 feet.
- Laboratory testing for intact compressive strength of shale beneath the talus and for talus fragments.
- Detailed rockfall simulation analyses to optimize size of catchment area.
- Helicopter reconnaissance and ground reconnaissance of cliff to confirm that no major potential instabilities are present.
- Slope stability analyses to evaluate interim and final stability factors.
- Development of specifications for grout and shotcrete that are matched to site conditions.

Alternative IV is shown in Figure 9 and consists of one or more rockfall control fences located upslope of the existing barrier. Work plan items for the design phase will include:

- Digital terrain model (DTM) with maximum 2-foot contour interval.
- Probe drilling to determine typical thickness of talus deposits and the feasibility of drilling and grouting. Assume ten probe holes total.
- Detailed rockfall simulation analyses to optimize height, location and impact capacity of the fence(s).
- Helicopter reconnaissance and ground reconnaissance of cliff to confirm that no major potential instabilities are present.
- Development of specifications for grout and anchor posts that are matched to site conditions.

Alternative V is a hybrid alternative that combines elements of Alternatives III and IV. Referring to Figure 10, the catchment geometry would be modified as for Alternative III, but the size would be reduced thereby decreasing the required excavation. The anticipated cut height for Alternative V is 6 to 8 feet. To augment the performance of the catchment zone, a modified fence would be placed above the cut to act as an energy attenuator for rolling rocks such that they fall into the enlarged catchment below. Work plan items for the design phase will include:

- Digital terrain model (DTM) with maximum 2-foot contour interval.
- Probe drilling to determine thickness of talus deposits for entire length of Area "D". Assume two holes on sections every 50 feet.
- Laboratory testing for intact compressive strength of shale beneath the talus and for talus fragments.
- Detailed rockfall simulation analyses to optimize size of catchment area and the height of the modified fence.
- Helicopter reconnaissance and ground reconnaissance of cliff to confirm that no major potential instabilities are present.
- Slope stability analyses to evaluate interim and final stability factors.
- Development of specifications for grout and shotcrete that are matched to site conditions.

7.0 CLOSURE

7.1 Alternative Comparison

Table 1 below presents a comparison matrix for the five alternatives using multiple criteria, some of which are subjective and some of which are quantitative. The narrative below briefly summarizes the rationale for the ratings:

Risk Reduction

Alternative V was judged to offer the ***highest*** risk reduction by virtue of the energy dissipation function and the favorable location adjacent to the highway that will afford the greatest opportunity for ongoing maintenance. With suitably placed and sized fences, Alternative IV could achieve a similar ***high*** level of risk reduction. Alternative III, relies solely on intercepting the rockfall trajectory with no opportunity for energy dissipation, and was therefore rated as ***moderate*** risk reduction. Alternative II was judged to offer ***low*** level of risk reduction because the destabilizing agents (frost action, root wedging, etc.) will continue to act on the rock face, eventually destabilizing more blocks. This long term action is difficult to visually monitor from the highway vantage point.

Outside Right-of-Way

Alternatives II (Removal/Reinforce) and IV (Fences) will require construction activities and the installation of permanent structures beyond the current right-of-way. This will require appropriate construction and maintenance ***easements*** and approvals from other jurisdictions, thereby complicating the design process. Alternatives III and V can be constructed within NJDOT right-of-way.

Required Ongoing Maintenance

Alternative II was rated as ***low*** because once the scaling and bolting is complete, no further action is required. Alternatives III and V were rated as ***moderate*** because the primary maintenance activity will be routine cleaning of the catchment area using small excavation equipment. Alternative IV with fences located on the talus slope was rated as ***high*** because the fences would be designed to arrest the rock movement and therefore would have to be occasionally purged of rock at a relatively inaccessible location. In addition, damage to the posts or fence mesh would require that specialized repairs be undertaken some distance from the nearest staging area for compressed air, electricity, etc.

Construction Impact

Construction impact is a subjective rating of the extent to which traffic on I-80 will be impacted by the construction activity. In this regard, the Alternative IV fences were rated ***low*** because the construction will be distant from the highway. However, some form of moveable barrier may be required as protection against accidentally dislodged rocks. Alternative II was rated as ***moderate*** because of the potential requirement to remove larger volumes of rock than could reasonably be retained by a temporary barrier, thereby necessitating temporary closures. Alternatives III and V were also rated ***moderate*** using the rationale that the contractor could use material excavated from the toe of the talus to develop an elevated temporary workbench perhaps partially encroaching on the westbound outboard lane. This should serve to segregate the construction activities from the live traffic.

Construction Difficulty

This rating refers to the ease or difficulty of construction posed by site conditions such as topography, access, and rock/soil characteristics. Alternative II was rated as ***moderate*** because the work will be executed by contractors experienced with scaling, drilling and installing rock bolts using rope access. Such work is routine for specialty stabilization contractors and the site poses no extraordinary challenges other than establishing access to the top of the rock face. Alternatives III and V were also rated as ***moderate*** because the work is close to I-80 thereby facilitating the use of larger equipment to drill and grout the coarse talus. In contrast, Alternative IV was rated as ***high*** because the talus will have to be drilled to provide foundations for the fence posts and anchorage for the support cables. This drilling will be carried out on steep hillsides without the benefit of temporary benches and may necessitate helicopter support.

Construction Duration

Low and high estimates for the construction duration (measured in 10-hour work days) for each alternative are developed in Appendix C. In some cases the duration is based on productivity rates while in other cases it is simply a subjective estimate.

Cost

An estimated cost range for each mitigation alternative is derived in Appendix C. The cost range is reflective of both quantity variation and unit rate variation. The total estimates are built up from line items for construction cost, traffic control, mobilization and engineering. The latter includes engineering for site characterization, design and construction monitoring. Note that traffic control and mobilization costs may duplicate costs accounted for elsewhere in the Area "A", "B", and "C" estimates.

Aesthetic Impact

Alternative II involves rock slope scaling and the installation of rock reinforcement using tensioned steel bars referred to as rock bolts. The permanent evidence of this mitigation will be the presence of small (8in x 8in) steel plates with a protruding bar and nut. These can be painted to blend with the natural color of the rock face, or with more effort, be camouflaged with pieces of rock epoxied over the plates. In either case the aesthetic impact from the distant vantage point of I-80 will be ***negligible*** and for a recreational hiker in the area the impact would be ***low***. Alternative III was rated as ***moderate*** impact for both the travelling public and for hikers because of the proximity and geometric shape of the enhanced barrier and the shotcrete facing. These features could be constructed to reduce visual impact by sculpting the shotcrete and forming the barrier face to simulate rock cuts, stacked rock or stone masonry. Alternatives IV and V that involve steel posts with intervening cable mesh were assigned ***high*** aesthetic impact for either proximal or distant viewers. Colored PVC coatings could be used to match the structural elements to the background rock and soil but this would provide minimal improvement to the aesthetic footprint of the fences.

7.2 Preferred Alternative

The "No Action" Alternative I is a valid alternative for consideration given the historical lack of rockfalls documented for Area "D". However, the risk assessment herein indicates that the area is prone to infrequent, but potentially high consequence, rockfall events. The selection of Alternative I by NJDOT is a matter of policy and risk tolerance and the need to allocate funds to higher priority sites within the State.

Of the four proactive remedies (II though V), cost does not appear to be an over-riding factor and the ultimate selection will be based on risk reduction, traffic considerations during construction, compatibility of the final mitigation product with highway maintenance operations and on outside stakeholder interests.

From the limited perspectives of cost and risk reduction, W&N recommends that Alternative V (Modified Catchment / Fence) be positioned for Area “D” as the preferred alternative in the stakeholder consultative process. This recommendation is qualified by the assertion that NJDOT recognizes and accepts that Alternative V provides *risk reduction* and does not provide *risk elimination*. Furthermore, site and corridor constraints preclude the achievement of contemporary design standards for rockfall mitigation in Area “D” of the I-80 project within a reasonable capital cost allocation.

Table 1 Comparison Matrix for Area "D" Mitigation Alternatives

Alt.	Description	Risk Reduction	Outside Right-of-Way	Required Ongoing Maintenance	Construction Impact	Construction Difficulty	Construction Duration (days)		Cost ($1,000)		Aesthetic Impact
							Low	High	Low	High	
I	No action	Zero	N	Status Quo	None	None	0	0	$0	$0	None
II	Removal / Reinforce	Low	Y	Low	Moderate	Moderate	67	87	$562	$966	Low
III	Modify Catchment	Moderate	N	Moderate	Moderate	Moderate	90	120	$751	$1,336	Moderate
IV	Fence(s)	High	Y	High	Low	High	54	91	$649	$1,104	High
V	Mod. Catchment/Fence	Highest	N	Moderate	Moderate	Moderate	120	150	$740	$1,307	High

Color Key:

Desirable	Neutral	Undesirable

Notes:

1. **Risk Reduction** refers to subjective comparison with current risk. Low = 10 to 30% reduction, Moderate = 20 to 40% reduction, High = 30 to 50% reduction.
2. **Right-of-Way** - Options II and IV are judged to be outside NJDOT right-of-way and would require access easements for construction.
3. **Required Maintenance** is a subjective assessment of the degree to which the proposed mitigation requires ongoing periodic maintenance by highway operations personnel.
4. **Construction Impact** relates to the degree to which traffic will be impacted by the specific construction option.
5. **Construction Difficulty** refers to site conditions that are unusual, for example the requirement to drill and grout anchors in the coarse talus for the fence option.
6. **Construction Duration** is an estimate of the days required for actual work assuming 10-hour days.
7. **Costs** were developed from recent unit prices modified to suit site conditions.
8. **Aesthetic Impact** is a subjective assessment of the degree to which the mitigation measures will be noticeable by park users and by the traveling public.

7.0 REFERENCES CITED

Federal Highway Administration, 1993. Rockfall Hazard Rating System, Participant's Manual, Publication No. FHWA SA-93-057, 102pp.

Haneberg, W.C., Norrish, N.I., and Findley, D.P., 2006. Digital outcrop characterization for 3-D structural mapping and rock slope design along Interstate 90 near Snoqualmie Pass, Washington: 57th Annual Highway Geology Symposium, Breckenridge, Colorado, September 27-29, 2006, p. 146-160.

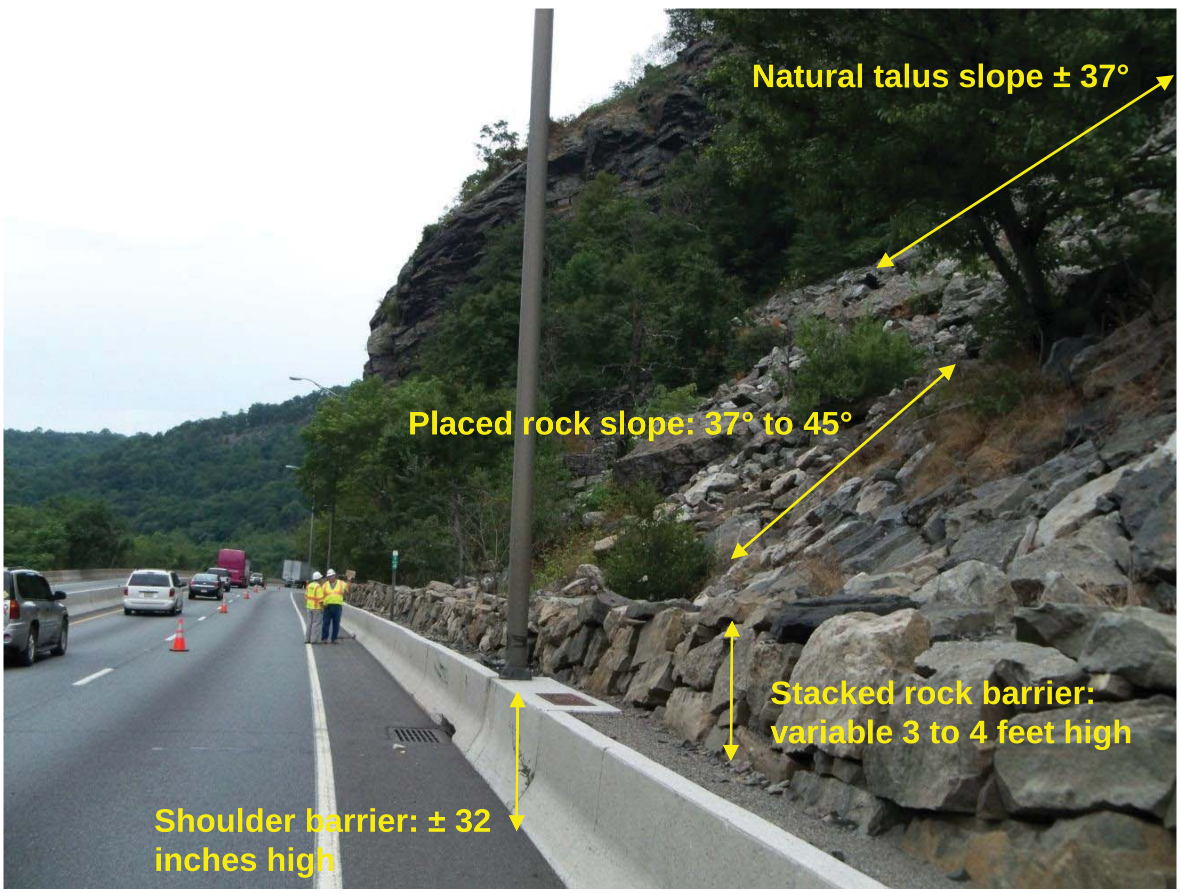
Oregon Department of Transportation, 2001. Rockfall Catchment Area Design Guide, ODOT Research Group Report SPR-3 (032), Salem, OR, 77 pp with appendices.

Rocscience, 2010, RocFall Version 4.054. Rocscience Inc., Toronto, Ontario.

Wyllie, D.C., 1987. Rock Slope Inventory System; Proceedings of the Federal Highway Administration Rockfall Mitigation Seminar, F.H.W.A. Region 10, Portland, OR.

FIGURES

View eastbound, November 30, 2010



View westbound, July 20, 2010

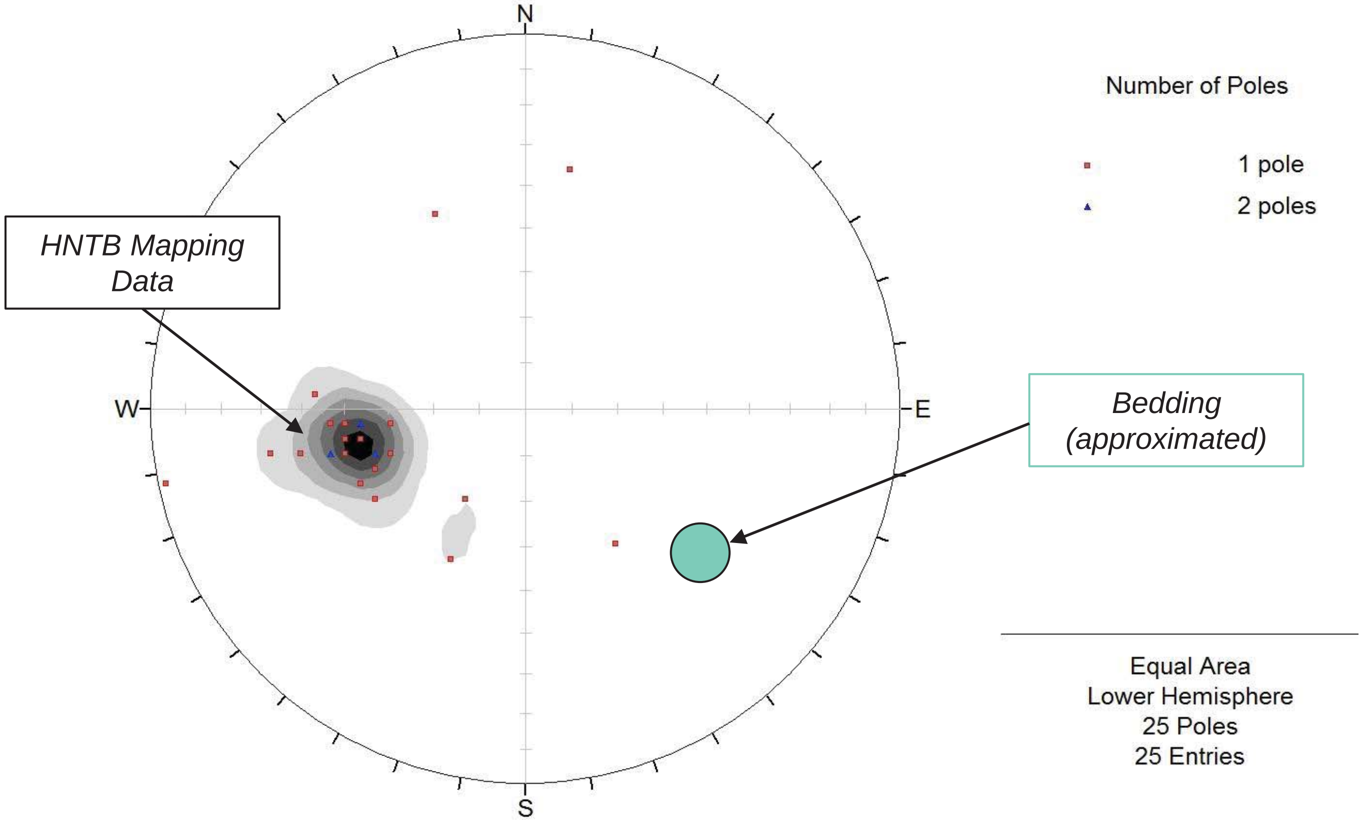
Figure 1

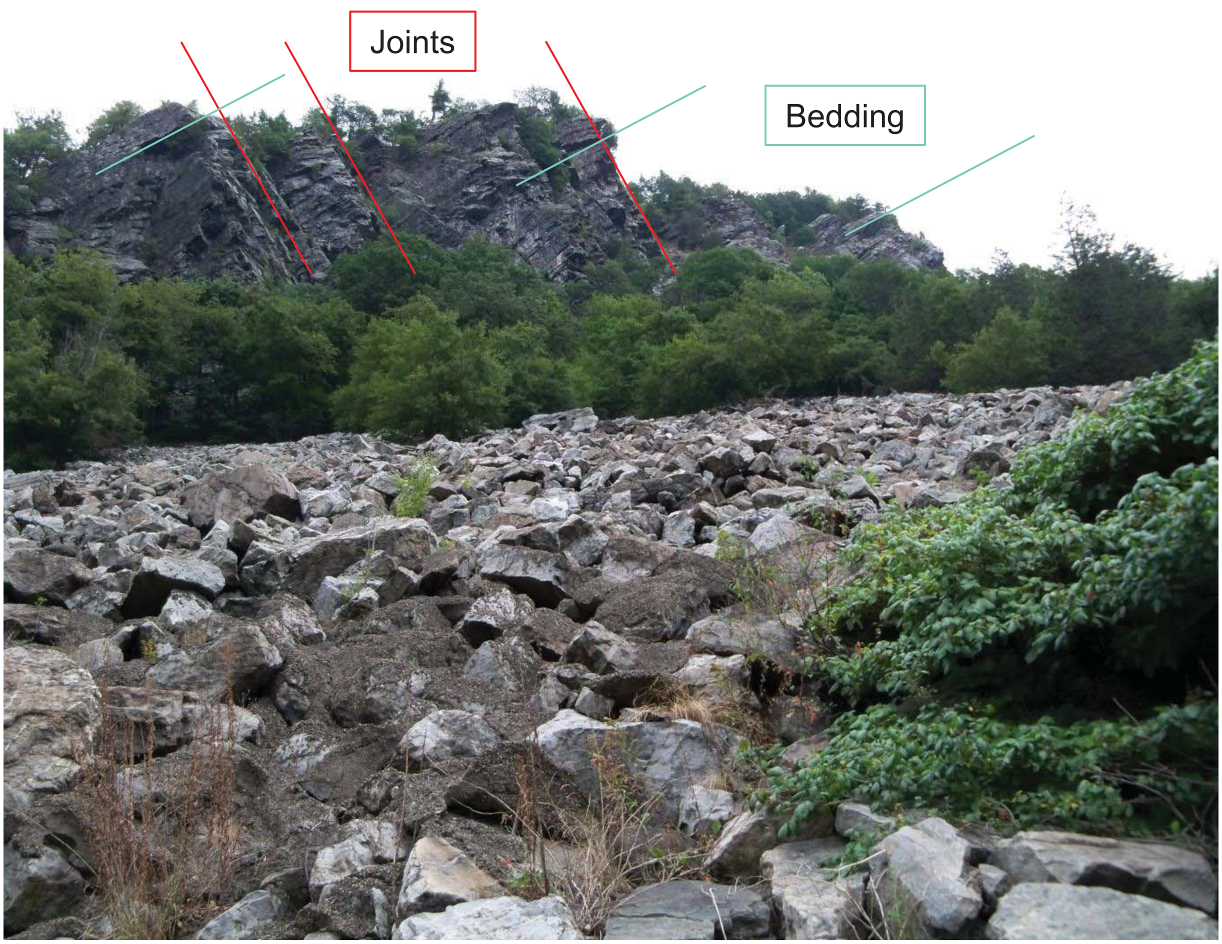
Area "D" – Existing Ditch Catchment

Project No. 010-2004 Date: March, 2011

wyllie & norrish ROCK ENGINEERS

HNTB Corporation
I-80 Rockfall Mitigation Concept Development





View upslope vicinity M.P. 1.42

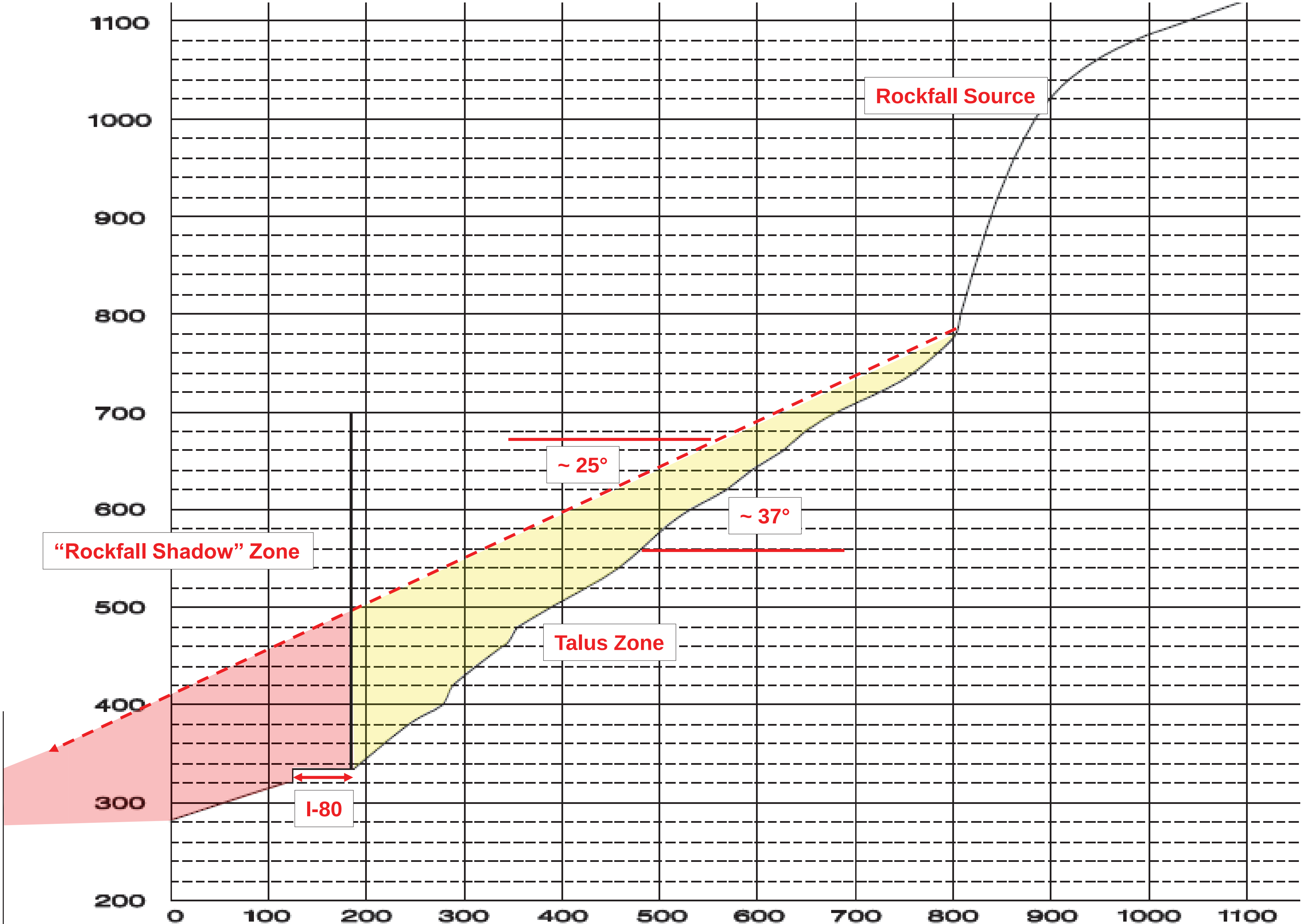
Figure 2

Area "D" Structural Geology

Project No. 010-2004 Date: March, 2011

HNTB Corporation
I-80 Rockfall Mitigation Concept Development

wyllie & norrish ROCK ENGINEERS



Project No. 010-2004 Date: March, 2011

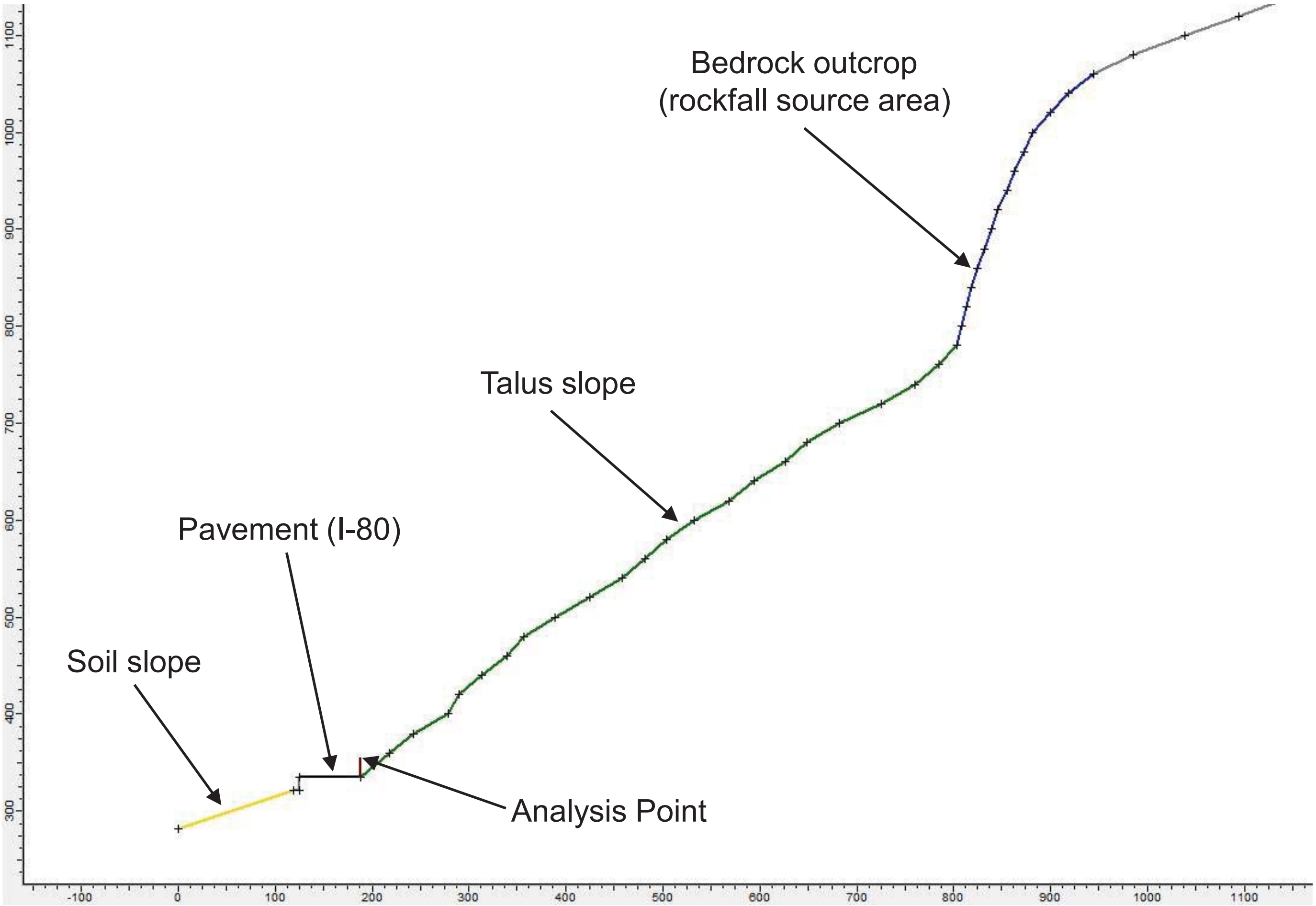
Cross section looking westbound, provided by HNTB Corp

Figure 3

Potential Rockfall Runout Distance

wyllie & norrish ROCK ENGINEERS

HNTB Corporation
I-80 Rockfall Mitigation Concept Development



MATERIAL PROPERTIES (Design boulder = 4-foot diameter, 2½ tons)

Material	R_n Mean	R_n Std Dev	R_t Mean	R_t Std Dev	ϕ Mean	ϕ Std Dev	Rough
Bedrock outcrop	0.35	0.04	0.85	0.04	35	3	5
Talus slope	0.32	0.04	0.82	0.04	35	2	4
Soil slope	0.3	0.04	0.8	0.04	30	2	0
Pavement	0.4	0.04	0.9	0.04	30	2	0

MATERIAL PROPERTIES (Extreme boulder = 8-foot diameter, 20 tons)

Material	R_n Mean	R_n Std Dev	R_t Mean	R_t Std Dev	ϕ Mean	ϕ Std Dev	Rough
Bedrock outcrop	0.35	0.04	0.85	0.04	30	3	3
Talus slope	0.32	0.04	0.82	0.04	30	2	2
Soil slope	0.3	0.04	0.8	0.04	30	2	0
Pavement	0.4	0.04	0.9	0.04	30	2	0

Explanation:

R_n = Coefficient of Normal Restitution

R_t = Coefficient of Tangential Restitution

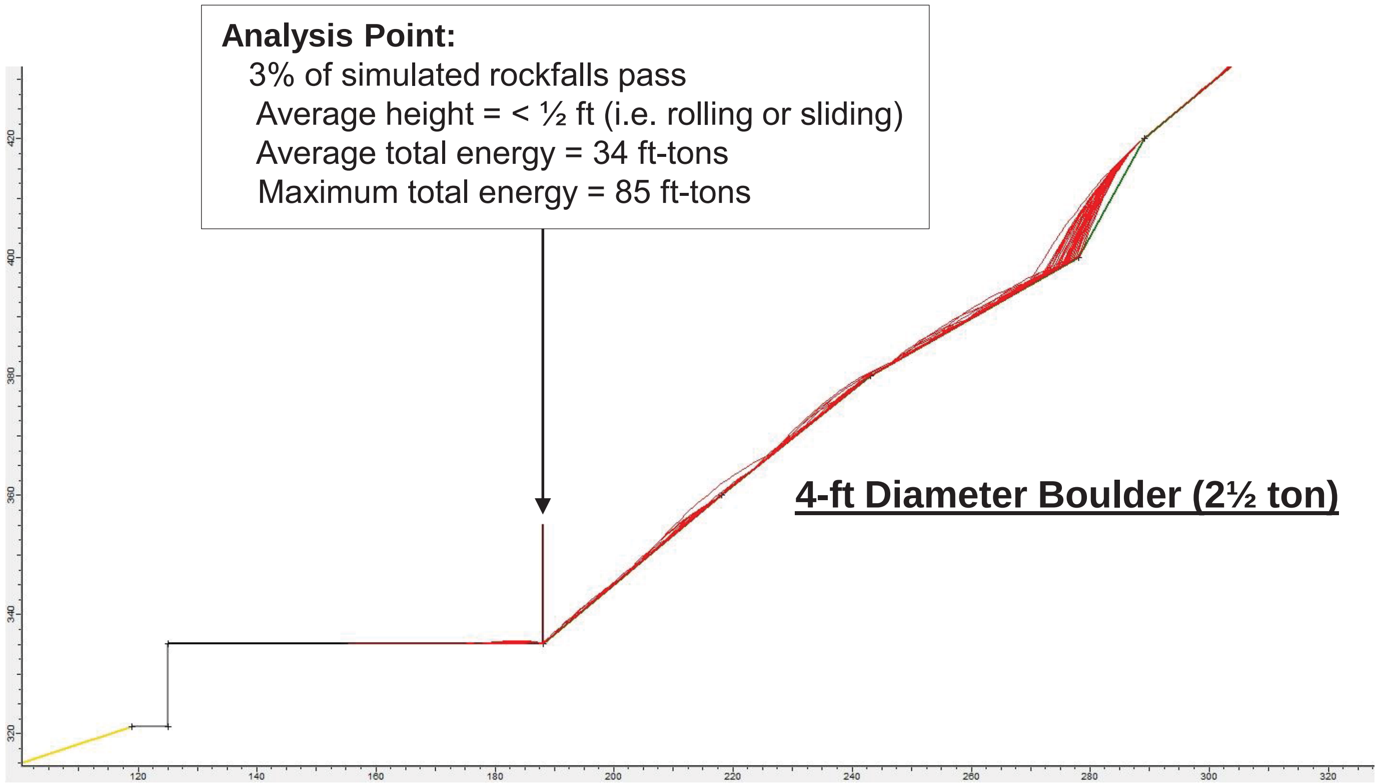
ϕ = Friction angle (degrees)

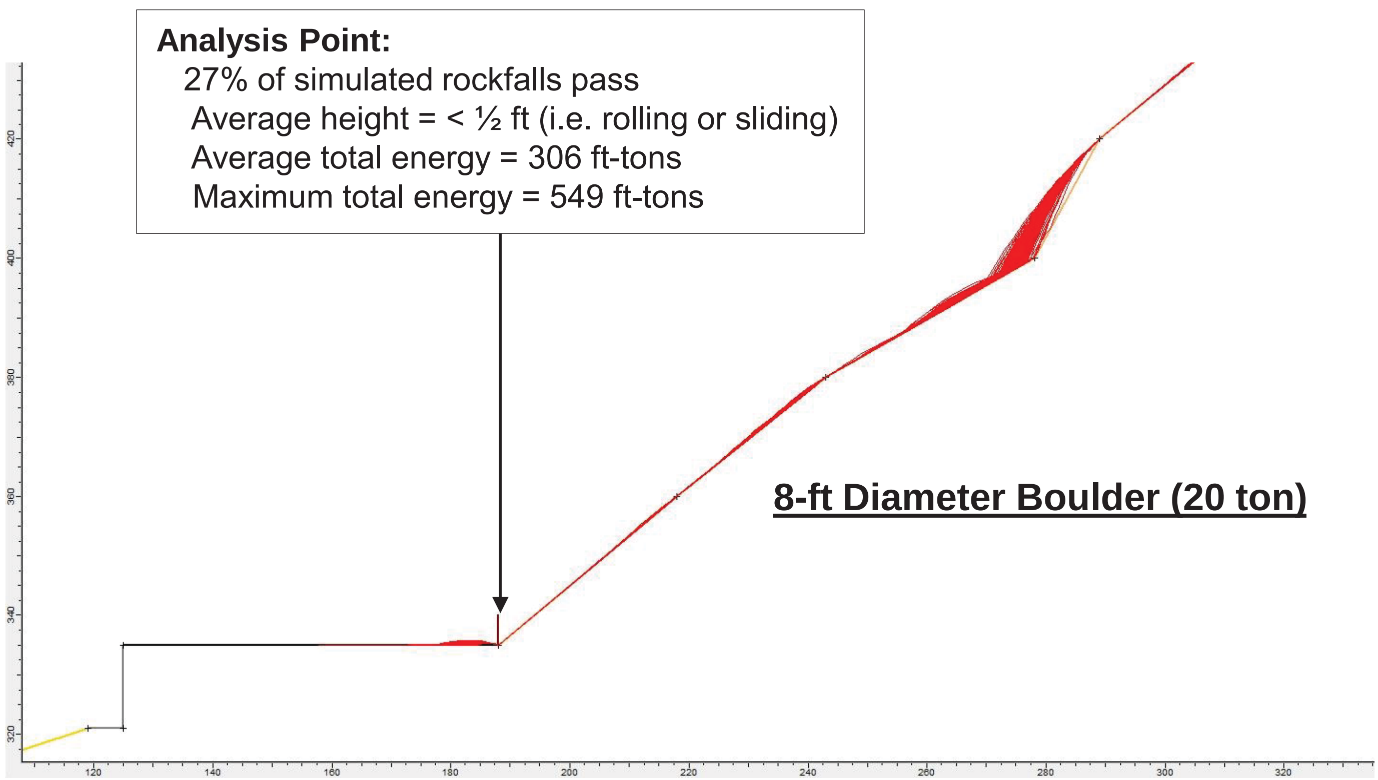
Rough = Deviation of surface from mean plane (degrees)

Project No. 010-2004 Date: March, 2011

Figure 4

Material Properties for Rockfall Simulations





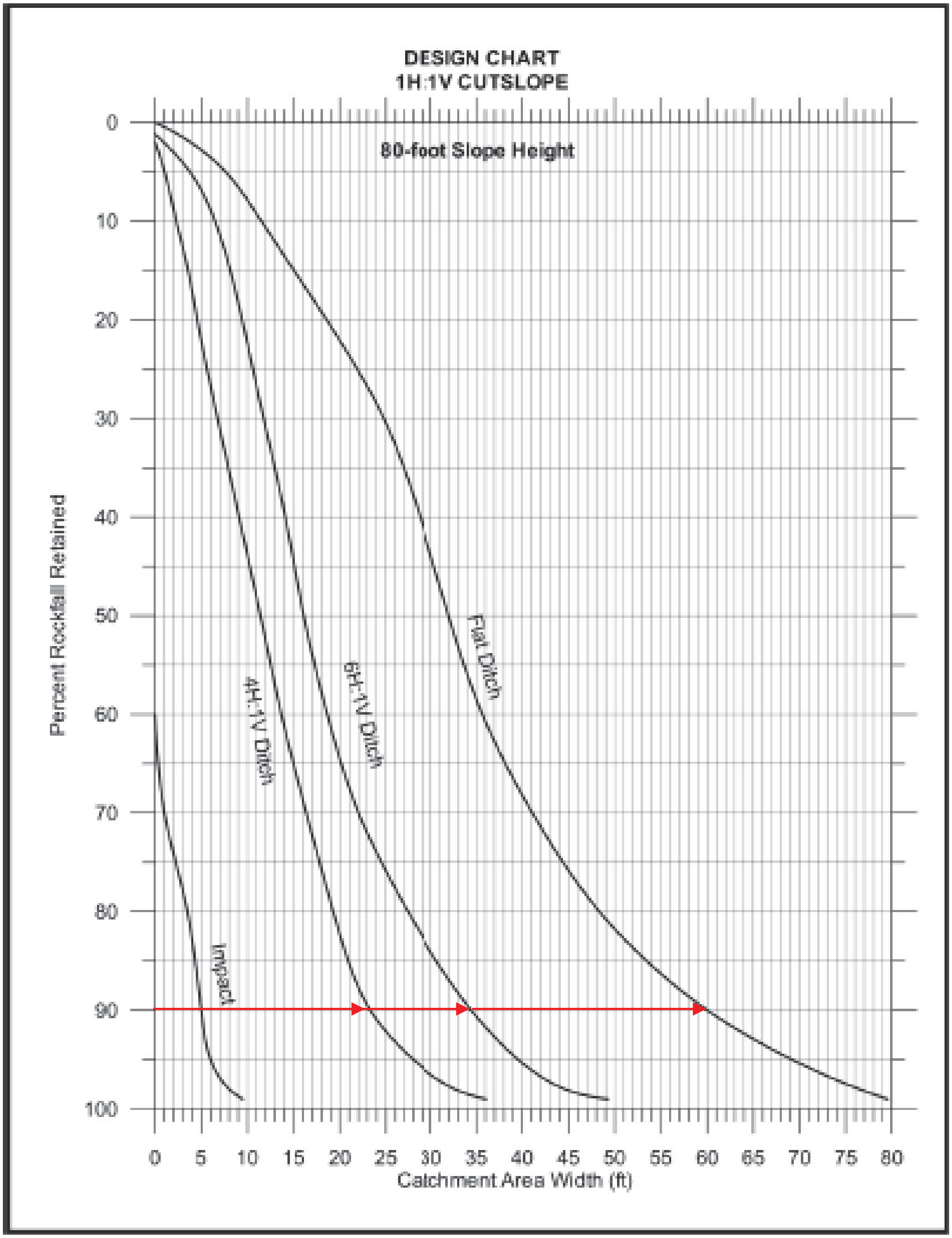
Notes:

1. Rockfall simulations performed using Rocscience software "RocFall" Ver 4.054

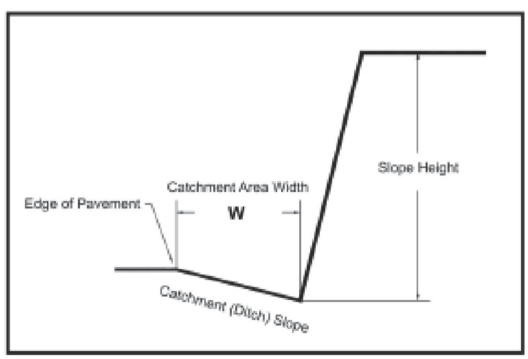
2. Simulations for concept development only; not suitable for design.

Figure 5

Rockfall Simulation Results



Quick Reference - 80-Ft Slope Catchment Area Width - **W**				
Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	**W** (ft)	**W** (ft)	**W** (ft)
50%	0	11	16	32
75%	2	18	25	44
80%	4	19	27	48
85%	4	21	31	53
90%	5	23	34	60
95%	6	28	40	69
99%	10	36	49	80



Ref: ODOT (2001)

Figure 6

Catchment ("Ditch") Design

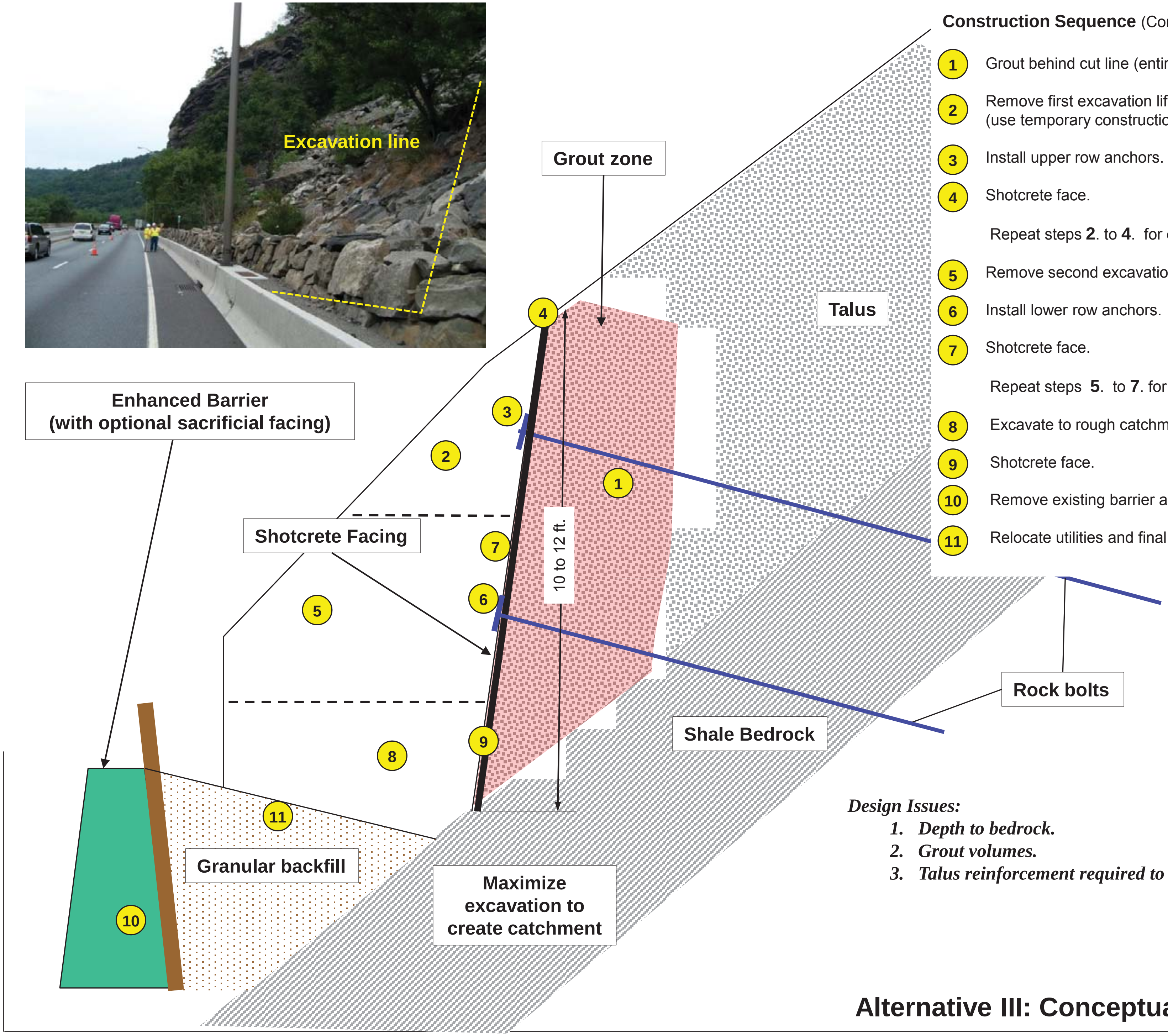
Denali Highway, AK

Chuckanut Drive, WA 2004

Figure 7

Examples of Collateral Rockfall Damage

Project No. 010-2004 Date: March, 2011



Construction Sequence (Conceptual)**:**

1. Grout behind cut line (entire length Area "D").
2. Remove first excavation lift for 50 to 100-ft station length (use temporary construction berm for access).
3. Install upper row anchors.
4. Shotcrete face.

Repeat steps **2**. to **4**. for entire length Area "D".

5. Remove second excavation lift for 50 to 100-ft station length.
6. Install lower row anchors.
7. Shotcrete face.

Repeat steps **5**. to **7**. for entire length Area "D".

8. Excavate to rough catchment grade or top of bedrock.
9. Shotcrete face.
10. Remove existing barrier and install enhanced barrier / facing.
11. Relocate utilities and final grade catchment zone.

Design Issues:

1. ***Depth to bedrock.***
2. ***Grout volumes.***
3. ***Talus reinforcement required to achieve design Factor of Safety.***

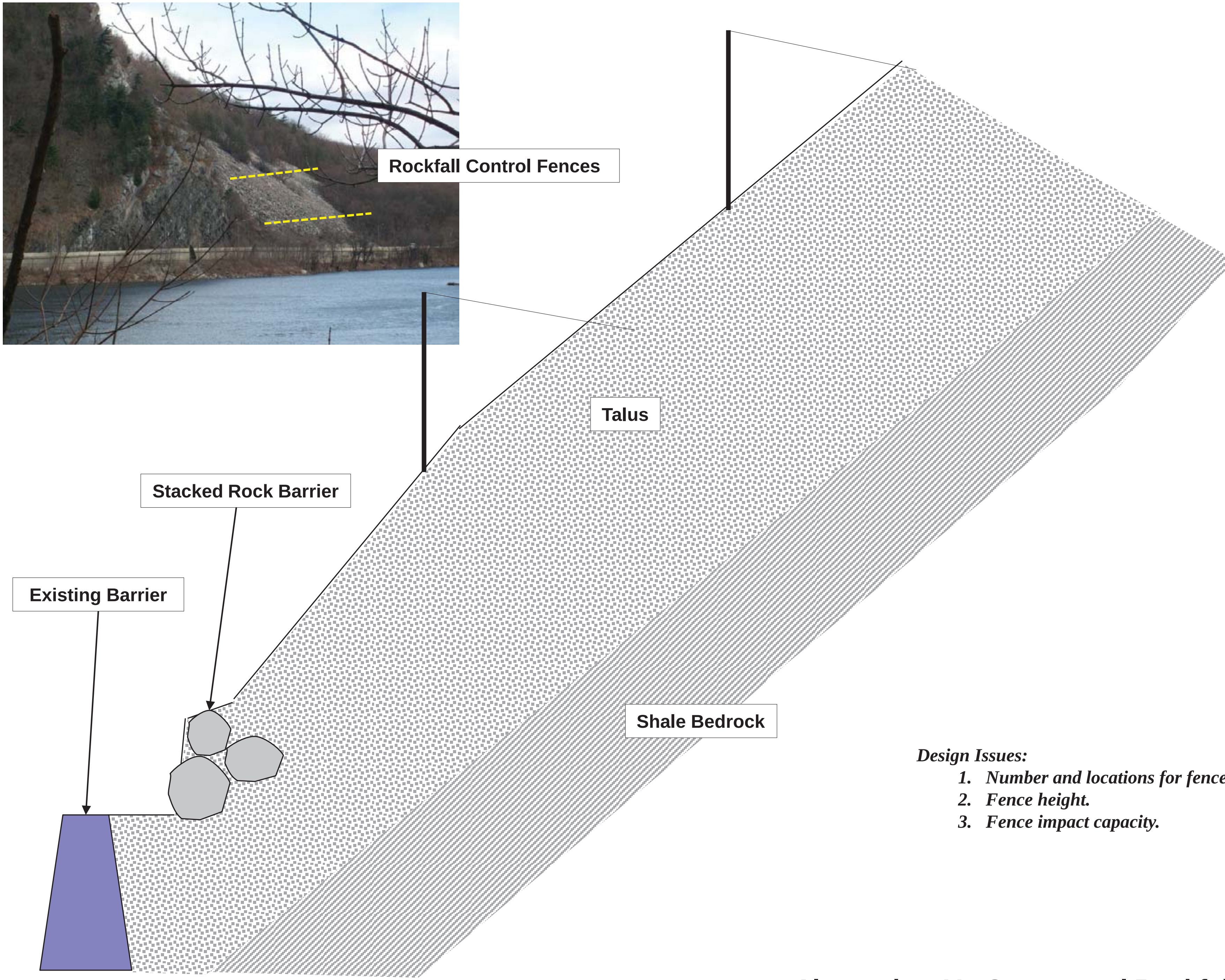
Figure 8

Alternative III: Conceptual Rockfall Mitigation

Project No. 010-2004 **Date:** March, 2011

wyllie&norrish ROCK ENGINEERS

HNTB Corporation
I-80 Rockfall Mitigation Concept Development



Design Issues:

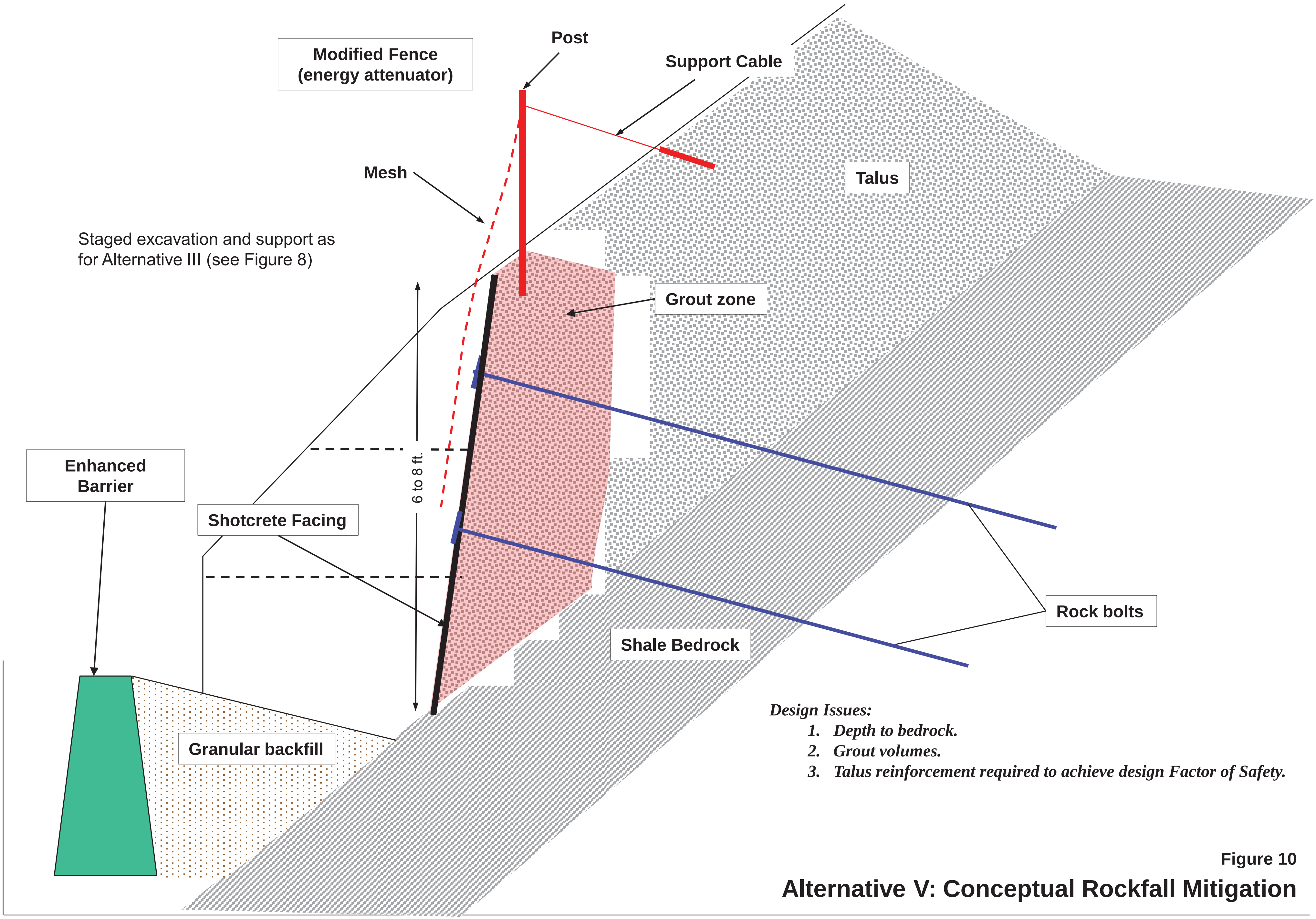
1. *Number and locations for fences.*
2. *Fence height.*
3. *Fence impact capacity.*

Project No. 010-2004 **Date:** March, 2011

Figure 9

Alternative IV - Conceptual Rockfall Mitigation

HNTB Corporation
I-80 Rockfall Mitigation Concept Development



Design Issues:

1. *Depth to bedrock.*
2. *Grout volumes.*
3. *Talus reinforcement required to achieve design Factor of Safety.*

Figure 10

Alternative V: Conceptual Rockfall Mitigation

Appendices

Appendix A:

Resume for Norman I. Norrish, P.E.

NORMAN I. NORRISH, P. ENG., P.E.
Principal and Co-Founder of Wyllie & Norrish Rock Engineers Inc.

Technical Specialist, Rock Engineering

B.A.Sc./1971/Geological Engineering (Geotechnical Option)
M.A.Sc./1974/Mining Engineering (Rock Mechanics)

Registered Professional Engineer:
British Columbia, Washington, Wyoming and Oregon
Member, Canadian Institute of Mining, Metallurgy and Petroleum
Member, American Society of Civil Engineers

Norman I. ("Norm") Norrish has 35 years of experience in the application of rock mechanics to mining, transportation, and civil construction projects including senior level project responsibility for the investigation, design and construction management of transportation projects in mountainous terrain throughout Western North America. He has worked internationally in Peru, Chile, Columbia, Panama, the Philippines, the former Soviet Union and the Peoples Republic of China. Mr. Norrish contributed significantly to Transportation Research Board Special Report 247, *Landslides: Investigation and Mitigation*. Over the past ten years he has made 40 presentations of NHI training course #132035 "Rock Slopes" to state DOTs throughout the US. Some of the Pacific Northwest transportation projects that Norm has been closely involved with include:

- *State Route 504, access to Mount St. Helens, WSDOT*
- *Rocky Point Viaduct replacement, US101, ODOT*
- *State Route 97, Ruby Creek rock slope stabilization for WSDOT*
- *State Route 2, Stevens Pass rock slope stabilization for WSDOT*
- *State Route 28, Rock Island rock slope design for WSDOT*
- *Airport Beach Road & South Channel Bridge, rock cuts for AKDOT&PF*
- *State Route 20, Rock avalanche and landslide mitigation for WSDOT*
- *Going to the Sun Road, Rockfall evaluation and tunnel repairs for WFLHD, MT*
- *I84, Rockfall mitigation assessment following 2000 cy failure, ODOT*
- *Chuckanut Drive, State Route 11, Rock slope hazard rating, WSDOT*
- *Clackamus Highway, Highway 224, Emergency Rockfall Mitigation, ODOT*
- *I90, MP 58, Emergency Rockfall Design and Construction Support, WSDOT*
- *I90, MP 57 to 59, Rock Slope Design, WSDOT*
- *US 20 Pioneer Eddyville Design Build, ODOT*
- *US 95, Specialist input to Disputes Review Board, ITD*
- *USMS Independent Review, WSDOT*
- *I90, MP 66, Stabilization Design for PS&E, WSDOT*

Appendix B:

Rockfall Hazard Rating System (RHRS)

<table>
<tr><th colspan="3" rowspan="2">CATEGORY</th><th colspan="4">RATING CRITERIA AND SCORE</th></tr>
<tr><th>POINTS 3</th><th>POINTS 9</th><th>POINTS 27</th><th>POINTS 81</th></tr>
<tr><td colspan="3">SLOPE HEIGHT</td><td>25 FT</td><td>50 FT</td><td>75 FT</td><td>100 FT</td></tr>
<tr><td colspan="3">DITCH EFFECTIVENESS</td><td>Good catchment</td><td>Moderate catchment</td><td>Limited catchment</td><td>No catchment</td></tr>
<tr><td colspan="3">AVERAGE VEHICLE RISK</td><td>25% of the time</td><td>50% of the time</td><td>75% of the time</td><td>100% of the time</td></tr>
<tr><td colspan="3">PERCENT OF DECISION SITE DISTANCE</td><td>Adequate site distance, 100% of low design value</td><td>Moderate site distance, 80% of low design value</td><td>Limited site distance 60% of low design value</td><td>Very limited site distance 40% of low design value</td></tr>
<tr><td colspan="3">ROADWAY WIDTH INCLUDING PAVED SHOULDERS</td><td>44 feet</td><td>36 feet</td><td>28 feet</td><td>20 feet</td></tr>
<tr><td rowspan="5">GEOLOGIC CHARACTER</td><td rowspan="2">CASE 1</td><td>STRUCTURAL CONDITION</td><td>Discontinuous joints, favorable orientation</td><td>Discontinuous joints, random orientation</td><td>Discontinuous joints, adverse orientation</td><td>Continuous joints, adverse orientation</td></tr>
<tr><td>ROCK FRICTION</td><td>Rough, Irregular</td><td>Undulating</td><td>Planar</td><td>Clay infilling, or slickensided</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">CASE 2</td><td>STRUCTURAL CONDITION</td><td>Few differential erosion features</td><td>Occasional erosion features</td><td>Many erosion features</td><td>Major erosion features</td></tr>
<tr><td>DIFFERENCE IN EROSION RATES</td><td>Small difference</td><td>Moderate difference</td><td>Large difference</td><td>Extreme difference</td></tr>
<tr><td colspan="3">BLOCK SIZE
———
QUANTITY OF ROCKFALL/EVENT</td><td>1 FT
———
3 cubic yards</td><td>2 FT
———
6 cubic yards</td><td>3 FT
———
9 cubic yards</td><td>4 FT
———
12 cubic yards</td></tr>
<tr><td colspan="3">CLIMATE AND PRESENCE OF WATER ON SLOPE</td><td>Low to moderate precipitation; no freezing periods; no water on slope</td><td>Moderate precipitation or short freezing periods or intermittent water on slope</td><td>High precipitation or long freezing periods or continual water on slope</td><td>High precipitation and long freezing periods or continual water on slope and long freezing periods</td></tr>
<tr><td colspan="3">ROCKFALL HISTORY</td><td>Few falls</td><td>Occasional falls</td><td>Many falls</td><td>Constant falls</td></tr>
</table>

Appendix C:

Construction Schedule and Cost Estimates

Alternative II: Removal / Reinforce Cost Estimate

* Slope length is longer than highway length due to the oblique angle that the cliff-forming outcrop exhibits.

Scaling Quantity Estimates

	Low	High	
Total slope length**	700	800	ft
Slope length rope per set	25	25	ft
Total scaling sets	28	32	
Time per set	2.5	3	day
Scaling days	70	96	days
Setup time	4	8	days
Total scaling days	74	104	days
Crew days (3-man crew)	37	52	days

Rock Reinforcment Quantity Estimates

	Low	High	
Area to be bolted	120,000	140,000	sf
Area / bolt	1000	1000	sf
Equivalent pattern	32	32	ft
Number of bolts	120	140	
Average bolt length	25	30	ft
Total bolt length	3000	4200	
Bolts / day	4	4	
Bolting duration	30	35	days

COST ESTIMATE

Item	**Unit**	**Quantity**		**Unit Rate**		**Cost**	
		Low	High	Low	High	Low	High
Scaling	crew day	37	52	$4,000	$5,000	$148,000	$260,000
Bolting	ft	3000	4200	$80	$100	$240,000	$420,000
				Subtotal Construction:		$388,000	$680,000
Traffic control	day	67	87	$1,100	$1,300	$73,700	$113,100
Mob / Demob	LS	1	1	$30,000	$50,000	$30,000	$50,000
Engineering	LS	1	1	18%	18%	$69,840	$122,400
				TOTAL		**$561,540**	**$965,500**

** Engineering (design & construction) based on percentage of construction cost.

Alternative III: Modify Catchment

Qantity Estimates

	Low	High	
Total slope length	500	500	ft
New cut height	10	12	ft
New face area	5000	6000	sf
Excavate & remove	1111	1333	cy
Area / bolt	75	60	sf
Number of bolts	67	100	
Average bolt length	15	20	ft
Total bolt length	1000	2000	ft
Talus volume grouted	1111	1778	cy
Grout volume	367	587	cy
Construction duration	90	120	days

Bolting estimate assumes two rows with bolts at 10 to 12-foot centers.

Grout volume estimate assumes 6 to 8 feet behind neat line for cut for total slope face area. Talus porosity assumed at 33%.

COST ESTIMATE

Item	**Unit**	**Quantity**		**Unit Rate**		**Cost**	
		Low	High	Low	High	Low	High
Excavate and removal	cy	1111	1333	$80	$120	$88,889	$160,000
Enhanced Barrier	ft	500	500	$200	$250	$100,000	$125,000
Rock bolts	ft	1000	2000	$100	$120	$100,000	$240,000
Shotcrete (6in thick)	sy	556	667	$200	$250	$111,111	$166,667
Grout	cy	367	587	$300	$400	$110,000	$234,667
				Subtotal Construction:		$510,000	$926,333
Traffic control	day	90	120	$1,100	$1,300	$99,000	$156,000
Mob / Demob	LS	1	1	$30,000	$50,000	$30,000	$50,000
Engineering	LS	1	1	22%	22%	$112,200	$203,793
					TOTAL	**$751,200**	**$1,336,127**

** Engineering (design & construction) based on percentage of construction cost.

Alternative IV: Fence Estimate

Qantity Estimates

	Low	High	
Total slope length	500		ft
Number of fences	2		
Total fence length	1000	1250	ft
Installation rate	20	15	ft/day
Setup time	4	8	days
Construction duration	54	91	days

COST ESTIMATE

Item	**Unit**	**Quantity**		**Unit Rate**		**Cost**	
		Low	High	Low	High	Low	High
Fence cost	ft	1000	1250	$500	$700	$500,000	$875,000
				Subtotal Construction:		$500,000	$875,000
Traffic control	day	54	91	$1,100	$1,300	$59,400	$118,733
Mob / Demob	LS	1	1	$30,000	$5,000	$30,000	$5,000
Engineering	LS	1	1	12%	12%	$60,000	$105,000
					TOTAL	**$649,400**	**$1,103,733**

** Engineering (design & construction) based on percentage of construction cost.

Alternative V: Modified Catchment / Fence

Qantity Estimates

	Low	High	
Total slope length	500	500	ft
New cut height	6	8	ft
New face area	3000	4000	sf
Excavate & remove	667	889	cy
Area / bolt	75	60	sf
Number of bolts	40	67	
Average bolt length	15	20	ft
Total bolt length	600	1333	ft
Talus volume grouted	444	889	cy
Grout volume	147	293	cy
Total fence length	500	500	ft
Construction duration	120	150	days

Bolting estimate assumes two rows with bolts at 10 to 12-foot centers.

Grout volume estimate assumes 4 to 6 feet behind neat line for cut for total slope face area. Talus porosity assumed at 33%.

Energy barrier fence (posts & mesh)

COST ESTIMATE

Item	**Unit**	**Quantity**		**Unit Rate**		**Cost**	
		Low	High	Low	High	Low	High
Excavate and removal	cy	667	889	$80	$120	$53,333	$106,667
Enhanced Barrier	ft	500	500	$200	$250	$100,000	$125,000
Rock bolts	ft	600	1333	$100	$120	$60,000	$160,000
Shotcrete (6in thick)	sy	333	444	$200	$250	$66,667	$111,111
Grout	cy	147	293	$300	$400	$44,000	$117,333
Energy Barrier Fence	ft	500	500	$300	$500	$150,000	$250,000
				Subtotal Construction:		$474,000	$870,111
Traffic control	day	120	150	$1,100	$1,300	$132,000	$195,000
Mob / Demob	LS	1	1	$30,000	$50,000	$30,000	$50,000
Engineering	LS	1	1	22%	22%	$104,280	$191,424
					TOTAL	**$740,280**	**$1,306,536**

APPENDIX O

PRELIMINARY ENGINEERING SCOPE STATEMENT FORM

NJDOT Scope Statement

Preliminary Engineering

I-80 Rockfall Mitigation, Milepost 1.04 to 1.45

Purpose: The intent of the Preliminary Engineering (PE) Scope Statement is to provide useful project information to designers who are interested in becoming the designer of record for PE and possibly Final Design and Construction for this project. In addition, it will be used to solicit a man-hour estimate and cost proposal. The PE Scope Statement identifies the key elements of PE that are necessary to advance the proposed project to the Final Design (FD) phase.

The PE Scope Statement is developed by the Division of Project Development (DPD) Lead Engineer and the Concept Development (CD) designer near the conclusion of CD, prior to requesting the services of a designer to perform PE. The Scope of Work section is approved by the appropriate Subject Matter Experts (SME).

Section 1 of the document focuses on Proposed Project Identification Information and CD data including the location and description. Section 2 of the document specifies the Scope of Work for PE.

PROPOSED PROJECT IDENTIFICATION INFORMATION

PROPOSED PROJECT SPECIFICS

Proposed Project Name	Limits
I-80 Rockfall Mitigation, Milepost 1.04 to 1.45	Milepost 1.04 to 1.45
DPD Lead Engineer	**DPD Manager**
Bhavesh Shah	Laine Rankin
Designer	
_____	
Counties	**Municipalities**
Warren Select County 2 Select County 3	Hardwick _____ _____
UPC Number	095450
DB Number	_____
Legislative District(s)	23 _____ _____
Congressional District (s)	5 _____ _____
Route	I-80
Start Milepost	1.04
End Milepost	1.45
Alternate Route	_____
Alternate Start Milepost	_____
Alternate End Milepost	_____
STIP Information	_____
Structure Numbers	_____
Project Classification:	8 - Miscellaneous
MPO	NJTPA

PROPOSED PROJECT ESTIMATE

List the Proposed Project estimates for each category from Concept Development.

Project Item:	CD Phase Estimated Amount
Design	$460,000
R□W	$0
Utility Relocation	$0
Construction	$4,415,000
Construction Engineering	$40,000
Contingencies	$220,000
Total	$5,100,000

CONCEPT DEVELOPMENT INFORMATION

Date of Concept Development Report:	_____	**Date of CD Scope Summary Meeting:**	_____
Date of CPC decision to advance project to PE:	_____	**Date of Federal Approval of CD Report:**	_____
CD Designer:	HNTB		
PE to be Completed by (check one):	☐ In-House ☒ Consultant		

PRELIMINARY ENGINEERING INFORMATION (to be filled in upon selection of a designer)

PE Project Information

Designer's Name:			
FMIS Contract ID Number (i.e. 89 00766):		**Funding Source:**	
Agreement Number (i.e. 2001PM03):			

APPROVAL

Name	Title	Date Approved
Lead Engineer	Division of Project Development	mm/dd/yy
Laine Rankin	Manager, Division of Project Development	mm/dd/yy
Lynn Rich	Director, Division of Project Development	mm/dd/yy

Janet Fittipaldi	Manager, Bureau of Landscape Architecture and Environmental Services	mm/dd/yy 5.26.11

PRELIMINARY ENGINEERING SCOPE OF WORK

NOTE: The PE designer will perform the tasks associated with PE as so marked, in preparation for Final Design. The Lead Engineer of the DPD will review and negotiate the proposal, execute the Agreement and instruct the designer to begin work. The DPD Lead Engineer will direct the proposed project through PE.

Capital Program Management

Division of Project Development
Technical and Administrative Activities

Sign Off by Division of Project Development Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3005	Initiate Preliminary Engineering	☒ Yes ☐ No	☒ DPD ☒ Designer	
3160	Prepare Draft Preliminary Engineering Report	☒ Yes ☐ No	☐ DPD ☒ Designer	
3170	Prepare Final Design Scope Statement	☒ Yes ☐ No	☐ SME's ☐ DPD ☒ Designer	
3175	Complete Preliminary Engineering Quality Certification	☒ Yes ☐ No	☒ Designer	
3180	Update Project Management Plan	☐ Yes ☒ No	☐ DPD	
3195	Prepare Project Management Plan (**Major Projects**)	☐ Yes ☒ No	☐ DPD ☐ Designer	
3200	FHWA Approves Draft Project Management Plan (**Major Projects**)	☐ Yes ☒ No	☐ DPD ☐ Designer FHWA	
3205	NJDOT Reviews Draft Preliminary Engineering Report	☒ Yes ☐ No	☒ DPD ☒ DPM ☒ SME's ☐ Designer	

3210	FHWA Reviews and Approves Preliminary Engineering Report	☒ Yes ☐ No	☐ DPD ☐ Designer FHWA	
3215	Present to Capital Program Screening Committee	☒ Yes ☐ No	☒ DPD	
3220	Capital Program Committee Approves Advancement to Final Design	☒ Yes ☐ No	☐ DPD CPC	
3225	Assess Designer	☒ Yes ☐ No	☒ DPD ☐ DPM	
3280	Hold Project Briefing	☒ Yes ☐ No	☒ DPD ☐ DPM	
3285	Complete PE Closeout	☒ Yes ☐ No	☒ DPD	
3960	Obtain Traffic Loading Data	☐ Yes ☒ No	☐ DPD ☐ Designer	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Division of Right of Way and Access Management
ROW

Sign Off by Right of Way Supervisor/Manager	FOR FERIADOON HASMANI	Date:	6/16/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3110	Prepare ROW Report	☐ Yes ☒ No	☐ Designer	May Require right of entry at top of Rock Cut.
3115	Initiate ROW Impact Plan	☐ Yes ☒ No	☐ Designer	
3120	Hold ROW Kick-Off Meeting	☐ Yes ☒ No	☐ ROW ☐ DPD ☐ Designer ☐ DPM	
3125	Prepare Initial ROW Estimate	☐ Yes ☒ No	☐ DPD ☐ ROW	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes number and type of parcels, known environmental problems, riparian parcels, public commitments, etc.

Division of Right of Way and Access Management
Office of Access Design

Sign Off by Office of Access Management Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3105	Prepare Project Access Plan and Access Impact Summary	☐ Yes ☒ No	☐ Designer ☐ OAD ☐ DPD	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes number of driveways impacted, pending agreements or major access permit applications, driveway modifications causing circulation issues, alternative access issues, Access Impact Assistance issues, etc.

Division of Capital Program Support
Bureau of Landscape Architecture and Environmental Solutions
Drainage

Sign Off by Drainage Supervisor/Manager		**Date:**	5-27-2011

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3085	Prepare Preliminary Drainage Design	☒ Yes ☐ No	☐ DPD ☒ Designer	Minor effort to investigate ponding issue located near MP. 1.15

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes drainage deficiencies, new/improved outfalls, storm water management rules, permits, Best Management Practices (structural and non-structural), easements/right-of-way, etc.

NJDOT Scope Statement

Preliminary Engineering

Division of Capital Program Support
Bureau of Landscape Architecture and Environmental Solutions
Landscape Architecture

Sign Off by Landscape Architecture Supervisor/Manager	[signature]	Date:	5-26-11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3010	Determine & calculate deforested area	☒ Yes ☐ No	BLAES	

ADDITIONAL INPUT *This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.* *Examples of information for this section include screens or buffers, aesthetic plantings, non-veg surfaces, reforestation, etc.*

Division of Capital Program Support
Bureau of Landscape Architecture and Environmental Solutions
Environmental Solutions

Sign Off by Environmental Solutions Supervisor/Manager		Date:	5.26.11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3300	Initiate Cultural Resources (Section 106) Process	☒ Yes ☐ No	☒ BLAES ☒ ~~Designer~~	
3305	Conduct CR Survey	☒ Yes ☐ No	☒ BLAES ☒ ~~Designer~~	
3310	Prepare CR Survey Report	~~☒ Yes~~ ☒ No	☐ BLAES ☒ ~~Designer~~	
3315	Review CR Survey Report	~~☒ Yes~~ ☒ No	☒ BLAES	
3320	Address Comments on CR Report	~~☒ Yes~~ ☒ No	☐ BLAES ☒ ~~Designer~~	
3325	Approve CR Survey Report	~~☒ Yes~~ ☒ No	☒ BLAES	
3330	Obtain SHPO Concurrence (No Resources, No Effect, No Adverse Effect)	☒ Yes ☐ No	SHPO	Results of CR Survey may necessitate MOA/Section 4(f) involvement
3335	Prepare Draft MOA (Adverse Effect Only)	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3340	Obtain SHPO Concurrence (No Adverse Effect with Conditions or Adverse Effect)	☐ Yes ☒ No	☐ BLAES SHPO	
3345	Obtain FHWA Approval of CR Survey Report	☐ Yes ☒ No	☐ FHWA	
3350	Prepare Adverse Effect Documentation & Submit to	☐ Yes ☒ No	☐ BLAES	

	FHWA (Adverse Effect Only)			
3355	FHWA Sends Adverse Effect Documentation to ACHP	☐ Yes ☒ No	FHWA	
3360	ACHP Reviews and Accepts or Declines Participation	☐ Yes ☒ No	ACHP	
3365	Resolve Adverse Effects	☐ Yes ☒ No	☐ BLAES FHWA	
3370	Circulate MOA for Comment	☐ Yes ☒ No	☐ BLAES	
3375	Prepare Final MOA	☐ Yes ☒ No	☐ BLAES	
3380	Execute the MOA	☐ Yes ☒ No	☐ BLAES ☐ DPD FHWA, ACHP, SHPO	
3390	Submit Historic Sites Council Application	☐ Yes ☒ No	☐ BLAES ☐ Designer SHPO	
3395	Present to Historic Sites Council	☐ Yes ☒ No	☐ BLAES Historic Sites Council	
3400	Inform Jurisdictional Agency Regarding Programmatic Section 4(f) Impacts	☐ Yes ☒ No	☐ BLAES	
3405	Receive Concurrence Regarding Programmatic Section 4(f) Impacts	☐ Yes ☒ No	Jurisdictional Agencies	
3410	Prepare Programmatic Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3420	Prepare De Minimis Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3425	Prepare Programmatic Net Benefit Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3430	NJDOT Reviews Programmatic Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES	
3435	Revise Programmatic Section 4(f) Evaluation (NJDOT Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer	

3440	FHWA Reviews Programmatic Section 4(f) Evaluation	☐ Yes ☒ No	FHWA	
3445	Revise Programmatic Section 4(f) Evaluation (NJDOT Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3450	FHWA Approves Programmatic Section 4(f) Evaluation	☐ Yes ☒ No	FHWA	
3460	Inform Jurisdictional Agency Regarding Draft Individual Section 4 (f) Impacts	☐ Yes ☒ No	☐ BLAES	
3465	Receive Concurrence Regarding Draft Individual Section 4(f) Impacts	☐ Yes ☒ No	Jurisdictional Agencies	
3470	Prepare Draft Individual Section 4 (f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3475	NJDOT Reviews Draft Individual Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES	
3480	Revise Draft Individual Section 4(f) Evaluation (NJDOT Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3485	FHWA Reviews and Comments on Draft Individual Section 4(f) Evaluation	☐ Yes ☒ No	FHWA	
3490	Revise Draft Individual Section 4(f) Evaluation (FHWA Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3495	Conduct Draft Individual Section 4(f) Legal Sufficiency Review	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3500	Circulate Draft Individual Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3505	Prepare Final Individual Section 4(f) Evaluation	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3510	FHWA Approves Final Individual Section 4(f) Evaluation	☐ Yes ☒ No	FHWA	
3520	Inform Green Acres Program and Local Officials	☐ Yes ☒ No	☐ BLAES	
3525	Receive Concurrence on Green Acres Impacts	☐ Yes ☒ No	Green Acres Prog. Local Officials	

3530	Hold Green Acres Pre-Application Meeting	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3535	Negotiate Green Acres Compensation	☐ Yes ☒ No	☐ BLAES ☐ Designer Green Acres Prog. Local Officials	
3540	Identify Alternatives (EA Only)	☐ Yes ☒ No	☐ BLAES ☐ DPD ☐ Designer	
3545	Prepare EA or EA/4(f)	☐ Yes ☒ No	☐ Designer	
3550	NJDOT Reviews EA	☐ Yes ☒ No	☐ BLAES	
3555	Revise EA (NJDOT Comments)	☐ Yes ☒ No	☐ Designer	
3560	FHWA Reviews EA	☐ Yes ☒ No	FHWA	
3565	Revise EA (FHWA Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3570	FHWA Approves EA	☐ Yes ☒ No	FHWA	
3575	Conduct Draft Individual Section 4(f) Legal Sufficiency Review (EA)	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3580	Circulate EA	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3585	Hold EA Public Hearing and Comment Period	☐ Yes ☒ No	☐ BLAES ☐ Designer ☐ OCR	
3590	Address EA Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3595	Submit FONSI Request Package	☐ Yes ☒ No	☐ BLAES	
3600	FHWA Approves Final Individual Section 4(f) (EA)	☐ Yes ☒ No	FHWA	
3605	FHWA Reviews and Issues FONSI	☐ Yes ☒ No	FHWA	

3610	Publish Notice of FONSI Availability	☐ Yes ☒ No	☐ BLAES ☐ Designer ☐ OCR	
3620	Publish Notice of Intent in Federal Register (EIS Only)	☐ Yes ☒ No	☐ BLAES FHWA	
3625	Invite Cooperating Agencies (EIS Only)	☐ Yes ☒ No	FHWA	
3630	Hold NEPA Scope Meeting (EIS Only)	☐ Yes ☒ No	☐ BLAES ☐ DPD ☐ Designer FHWA	
3635	Prepare Alternatives Analysis Report	☐ Yes ☒ No	☐ BLAES ☐ DPD ☐ Designer	
3640	Prepare DEIS or DEIS/4(f)	☐ Yes ☒ No	☐ Designer	
3645	NJDOT Reviews DEIS	☐ Yes ☒ No	☐ BLAES	
3650	Revise DEIS (NJDOT Comments)	☐ Yes ☒ No	☐ Designer	
3655	FHWA Reviews DEIS	☐ Yes ☒ No	FHWA	
3660	Revise DEIS (FHWA Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3665	FHWA Approves DEIS to Circulate	☐ Yes ☒ No	FHWA	
3670	Publish Notice of Availability in Federal Register (DEIS)	☐ Yes ☒ No	☐ BLAES EPA	
3675	Circulate DEIS	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3680	Hold EIS Public Hearing and Comment Period	☐ Yes ☒ No	☐ BLAES ☐ OCR ☐ Designer	
3685	Address Public and Agency Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3690	Select Final Alternative	☐ Yes ☒ No	☐ DPD Scope Team	
3700	Prepare and Submit FEIS	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3705	FHWA Reviews and Comments on FEIS	☐ Yes ☒ No	FHWA	

3710	Address FEIS Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3715	FHWA Reviews FEIS for Legal Sufficiency and Approval	☐ Yes ☒ No	☐ BLAES ☐ Designer FHWA	
3720	Publish EIS Notice of Availability in Newspaper	☐ Yes ☒ No	☐ BLAES ☐ OCR	
3725	Publish FEIS Notice in Federal Register	☐ Yes ☒ No	☐ BLAES EPA	
3730	FHWA Publishes ROD in Federal Register	☐ Yes ☒ No	☐ BLAES ☐ DPD	
3735	Circulate FEIS	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3740	Conduct Air Quality Study	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3745	Prepare Air Quality TES	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3750	NJDOT Reviews Air Quality TES	☐ Yes ☒ No	☐ BLAES	
3755	Address Air Quality TES Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3760	Approve Air Quality TES	☐ Yes ☒ No	☐ FHWA ☐ BLAES	
3765	Conduct Ecology Study	☒ Yes ☒ No	☐ BLAES ☒ Designer	
3770	Prepare Ecology TES	☒ Yes ☐ No	☒ BLAES ☒ Designer	
3775	NJDOT Reviews Ecology TES	☒ Yes ☒ No	☒ BLAES	
3780	Address Ecology TES Comments	☒ Yes ☒ No	☐ BLAES ☒ Designer	
3785	Approve Ecology TES	☒ Yes ☒ No	☒ BLAES	
3790	Conduct Socio-Economic Study	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3795	Prepare Socio-Economic TES	☐ Yes ☒ No	☐ BLAES ☐ Designer	

3800	NJDOT Reviews Socio-Economic TES	☐ Yes ☒ No	☐ BLAES	
3805	Address Socio-Economic TES Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3810	Approve Socio-Economic TES	☐ Yes ☒ No	☐ BLAES	
3815	Conduct Noise Study	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3820	Prepare Noise TES	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3825	NJDOT Reviews Noise TES	☐ Yes ☒ No	☐ BLAES	
3830	Address Noise TES Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3835	Approve Noise TES	☐ Yes ☒ No	☐ BLAES	
3840	Conduct Hazardous Waste Study	☒ Yes ☐ No	☒ BLAES ☐ Designer	Document findings of Hazardous Waste screening in CED.
3845	Prepare Hazardous Waste TES	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3850	NJDOT Reviews Hazardous Waste TES	☐ Yes ☒ No	☐ BLAES	
3855	Address Hazardous Waste TES Comments	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3860	Approve Hazardous Waste TES	☐ Yes ☒ No	☐ BLAES	
3865	Hold Public Information Center	☒ Yes ☐ No	☒ BLAES ☒ OCR ☒ Designer ☒ DPD	
3870	Prepare CED	☒ Yes ☐ No	☒ BLAES ~~☒ Designer~~	
3875	NJDOT Reviews and Approves CED	☒ Yes ☐ No	☒ BLAES	
3880	Initiate Environmental Technical Studies	☒ Yes ☐ No	☒ BLAES	
3890	Prepare Certified Categorical Exclusion (CED)	☐ Yes ☒ No	☐ BLAES	

	Document			
3900	Review and Approve Certified Categorical Exclusion Document (CED)	☐ Yes ☒ No	☐ BLAES	
3910	Prepare Draft EO 215 Document	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3920	NJDOT Reviews Draft EO 215 Document	☐ Yes ☒ No	☐ BLAES	
3925	Revise Draft EO 215 Document (NJDOT Comments)	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3930	NJDEP Reviews EO 215 Document	☐ Yes ☒ No	NJDEP	
3940	Address NJDEP Comments and Prepare Final EO 215 Document	☐ Yes ☒ No	☐ BLAES ☐ Designer	
3945	NJDEP Approves EO 215 Document	☐ Yes ☒ No	☐ NJDEP	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes a list of the anticipated NEPA document, type of permits anticipated, anticipated environmental impacts and environmental commitments made in CD if any, etc.

Division of Capital Program Support
Value Management

Sign Off by Value Management Supervisor/Manager	Paul ? Schoenfeld	Date: 5/24/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
		☐ Yes ☐ No		

Value Engineering Reviewed:	☒ Yes ☐ No
Value Analysis to be Performed:	☐ Yes (if construction & ROW cost > $20 million) ☒ No
Combined Estimated Cost of Construction, ROW, and Utilities:	☐ < $3 million ☐ $3-5 million ☒ $5-15 million ☐ > $15 million
Lane Occupancy Charges and Road User Costs to be completed:	☒ Yes ☐ No

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes VE review, lane occupancy charges/road user cost information, etc.

Division of Capital Program Support
Utilities

Sign Off by Utilities Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3040	Establish Utility Engineering Funding	☐ Yes ☒ No	☐ DPD ☐ Designer ☐ Program Coordination	
3045	Send Letter #2 and Plans to Utility Companies	☐ Yes ☒ No	☐ DPD ☐ Designer Utility Cos.	
3050	Prepare Utility Agreement	☐ Yes ☒ No	☐ DPD ☐ Designer	
3055	Update Base Plans and Identify Conflicts	☐ Yes ☒ No	☐ DPD ☐ Designer Utility Cos.	
3060	Execute Utility Agreement	☐ Yes ☒ No	☐ DPD Utility Cos. DAG	
3080	Conduct Subsurface Utility Exploration	☐ Yes ☒ No	☐ DPD ☐ Designer SUE Contractor Utility Cos.	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section include location of cell towers, location/presence of fiber optic lines, etc.

Division of Capital Program Support
Jurisdiction

Sign Off by Jurisdiction Supervisor/Manager		Date:	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
		☐ Yes ☐ No		

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes the anticipated number of maps and agreements, presence of streetscape or aesthetic treatments, local approval of such, etc.

I-80 Rockfall Mitigation, Milepost 1.04 to 1.45

Division of Design Services
Civil Engineering
Geometrics & Safety

Sign Off by Civil Engineering Supervisor/Manager	Richard Jaffe	**Date:**	8/22/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3030	Prepare Horizontal & Vertical Geometry	☒ Yes ☐ No	☐ DPD ☒ Designer	Establish existing baseline to be used on roadway plans.
3035	Prepare Utility Base Plans	☐ Yes ☒ No	☐ Designer	
3070	Prepare Preliminary Roadway Plans	☒ Yes ☐ No	☐ DPD ☒ Designer SME's	
3130	Update Preliminary Detour and Construction Staging Plans	☒ Yes ☐ No	☒ DPD ☒ Designer SME's	
3135	Prepare Construction Cost Estimate	☒ Yes ☐ No	☐ DPD ☒ Designer	
3150	Prepare Design Exception Report	☐ Yes ☒ No	☐ DPD ☐ Designer ☐ Value Management State Trans. Engr. FHWA	
3165	Finalize Project Plan	☒ Yes ☐ No	☐ DPD ☒ Designer	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes a discussion of substandard design elements, design exceptions, and perhaps a quick description of the proposed geometry if it is unusual, commitments made to community, etc.

Division of Design Services
Civil Engineering
Pavement

Sign Off by Civil Engineering/Pavement Supervisor/Manager	Susan Gresavage	**Date:**	6/14/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3095	Prepare Preliminary Geotechnical Report	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	
3970	Collect Existing Pavement and Subgrade Soil Information	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	
3975	Conduct Pavement Testing Program	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	
3980	Prepare Pavement Recommendation	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes evidence of subsurface drainage issues, settlement problems, stability problems,etc.

Division of Design Services
Structural Engineering
Structures and Geotechnical

Sign Off by Structural Engineering Supervisor/Manager GEOTECHNICAL	PROJECT ENGINEER GEOTECH. ENG'RING	**Date:**	7/21/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3100	Prepare Structural Design Recommendation Summary	☒ Yes ☐ No	☐ Designer	Proposed heightened barrier curb with integrated lighting standards.

ADDITIONAL INPUT
This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes rock slope issues, soil borings, scour, unusual existing or proposed structural elements, clearances, substandard elements, design exceptions, etc.

SEE ATTACHED PAGE

Division of Design Services
Civil Engineering
Pavement

Sign Off by Civil Engineering/Pavement Supervisor/Manager		**Date:**	

7/21/11

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3095	Prepare Preliminary Geotechnical Report	☐ Yes ☒ No	GEOTECHNICAL ☐ ~~Pvmt. Design Unit~~ ☐ Designer	THIS ACTIVITY SHOULD BE SHOWN W/ "STRUCTURE & GEOTECHNICAL"
~~3970~~	~~Collect Existing Pavement and Subgrade Soil Information~~	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	
~~3975~~	~~Conduct Pavement Testing Program~~	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	
~~3980~~	~~Prepare Pavement Recommendation~~	☐ Yes ☒ No	☐ Pvmt. Design Unit ☐ Designer	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes evidence of subsurface drainage issues, settlement problems, stability problems,etc.

Division of Design Services
Regional Design and Survey Services
Geodetic Survey

Sign Off by Geodetic Survey Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3015	Prepare Control Survey Report	☒ Yes ☐ No	☐ DPD ☒ Designer ☐ Geodetic Survey	
3020	Conduct Topographic Survey	☒ Yes ☐ No	☐ DPD ☒ Designer ☐ Geodetic Survey	Recommend LIDAR surveying.
3025	Prepare Base Maps	☒ Yes ☐ No	☐ DPD ☒ Designer ☐ Geodetic Survey ☐ CADD Support	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes base mapping obtained in CD, tidal issues, compliance with MAP filing laws, geodetic control issues, etc.

Division of Design Services
Regional Design and Survey Services
Railroads

Sign Off by Railroads Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
		☐ Yes ☐ No		

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes presence of at-grade crossings, overhead structure clearances, diagnostic team meetings, etc.

Division of Construction Services and Materials
Construction Engineering

Sign Off by Construction Engineering Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3130	Update Preliminary Detour and Construction Staging Plans	☒ Yes ☐ No	☒ Designer	Coordinate with DRJTC for lane closure scheduled for the ongoing projects on the Delaware Water Gap Toll Bridge
3145	Conduct Constructability and Maintenance Review	☒ Yes ☐ No	☐ DPD ☐ Designer ☒ Const. Engineering	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes commitments made to local officials or other agencies, staging details, detour discussion, schedule constraints, utility conflicts, etc.

Operations

Division of Traffic Engineering and Safety
Traffic Signal and Safety Engineering

Sign Off by Traffic Signal and Safety Engineering Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3090	Determine Traffic Engineering Facility Locations	☐ Yes ☒ No	☐ TSSE ☐ Designer	State owned lighting standards integrated with the barrier curb.

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes discussion of need for temporary signals, right-of-way constraints (related to traffic signal equipment), utility conflicts, etc.

Division of Regional Operations
Roadway and Electrical

Sign Off by Regional Operations Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
		☐ Yes ☐ No		

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes elements of the design that will necessitate and increase in maintenance personnel or equipment, conflicting or overlapping projects with Operations, etc.

Statewide Traffic Operations

Statewide Traffic Operations
Traffic Operations and Intelligent Transportation System (ITS) Facilities

Sign Off by Traffic Operations Supervisor/Manager		**Date:**	
Sign Off by ITS Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
3065	Prepare Preliminary ITS Facility Design	☐ Yes ☒ No	☐ Designer ☐ ITS ☐ Traffic Ops	

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes compliance with latest ITS Investment Strategy and Architecture, consultation with Traffic Ops during CD, etc.

Capital Investment Planning and Grant Administration

Division of Statewide Planning
Commuter Mobility

Sign Off by Commuter Mobility Supervisor/Manager		**Date:**	

Activity No.	Activity Name	Execute	Responsible Unit	Comments
		☐ Yes ☐ No		

ADDITIONAL INPUT

This section has been provided for the CD designer and the functional units to state any assumptions, to clarify and customize standard activities, and to add important information. Please be clear and concise. Provide your unit's contact person and number.

Examples of information for this section includes bicycle and pedestrian compatibility, presence of bus stops, interruption of pedestrian accommodations during construction, ADA issues, etc.

APPENDIX P

CONSTRUCTION TIMELINE AND ASSUMPTIONS

Route 80 Rockfall Mitigation

Schedule Assumptions:

1. The production rate of removal of concrete barrier is 200 LF/day. Removal of vertical curb is 400 LF/day.
2. Lighting standards are 4 units/day, electrical conduit is 150 LF/day, electrical wire is 300 LF/day. Assume 24 lighting standard units for 6 days. 2000' of wiring would take 20 days for the wiring and conduits. Assume 5 weeks.

Area C

3. Drilling, Installing, and Grouting Anchors for Hybrid System: 3 6-day weeks working 10 hrs/day (Figuring 106 15' anchors, completing ~6 per shift)
4. Installing Hybrid Barrier: 2 6-day weeks working 10 hrs/day
5. Hanging and Connecting Draped Mesh portion of Hybrid System: 2 6-day weeks working 10 hrs/day (Figuring 1 week to hang and connect to barrier and 1 week to connect seams)
6. Installing Enhanced Barrier: 11 10-hr days (assuming 50' per day)

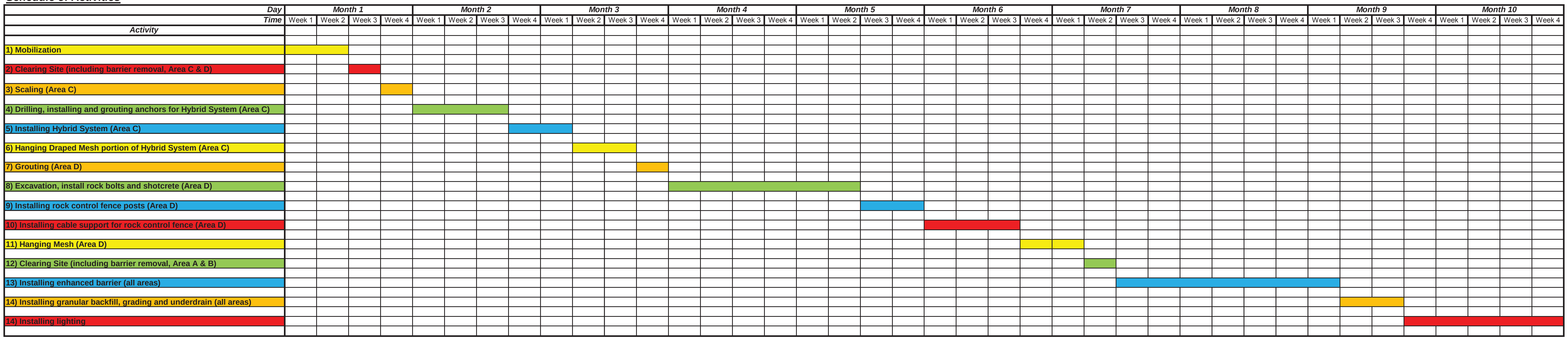
Area D

7. Grouting: 1 6-day week working 10 hrs/day
8. Incremental Top Down Excavation (Upper Level), Install Top Row of Rock Bolts, Shotcrete Face: 2 6-day weeks working 10 hrs/day (Figuring 50' length at a time, 5 bolts per row, 11 50' lengths at one per day)
9. Incremental Top Down Excavation (Middle Level), Install Lower Row of Rock Bolts, Shotcrete Face: 2 6-day weeks working 10 hrs/day (Figuring 50' length at a time, 5 bolts per row, 11 50' lengths at one per day)
10. Incremental Top Down Excavation (Bottom Level), Shotcrete Face: 2 6-day weeks working 10 hrs/day (Figuring 50' length at a time, 5 bolts per row, 11 50' lengths at one per day)
11. Installing Enhanced Barrier: 11 10-hr days (assuming 50' per day)
12. Installing Granular Backfill: 1 6-day week working 10 hrs/day
13. Drilling Post Holes, Installing Posts, and Grouting Posts: 9 10-hr days (Figuring 106 shallow post holes completing ~12 per shift)
14. Drilling Cable Support Holes, Installing Cable Supports, and Grouting Cable Supports: 18 10-hr days (Figuring 106 ~10' deep post holes completing ~6 per shift)
15. Hanging and Connecting Mesh: 2 6-day weeks working 10 hrs/day (Figuring 1 week to hang and connect to barrier and 1 week to connect seams)

Rt 80 WB Rockfall Mitigation

Single Crew Timeline

Schedule of Activities



Note: Assume 6 working days per week and 10 hours shift per working day. This assumption is based on the lane closure hours recommendation as shown on Table 9

Rt 80 WB Rockfall Mitigation *Multiple Crew Timeline*

Schedule of Activities

Day	Month 1				Month 2				Month 3				Month 4				Month 5				Month 6				Month 7			
Time	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4
Activity																												
1) Mobilization																												
2) Clearing Site (including barrier removal, Area C & D)																												
3) Scaling (Area C)																												
4) Drilling, installing and grouting anchors for Hybrid System (Area C)																												
5) Installing Hybrid System (Area C)																												
6) Hanging Draped Mesh portion of Hybrid System (Area C)																												
7) Grouting (Area D)																												
8) Excavation, install rock bolts and shotcrete (Area D)																												
9) Installing rock control fence posts (Area D)																												
10) Installing cable support for rock control fence (Area D)																												
11) Hanging Mesh (Area D)																												
12) Clearing Site (including barrier removal, Area A & B)																												
13) Installing enhanced barrier (all areas)																												
14) Installing granular backfill, grading and underdrain (all areas)																												
14) Installing lighting																												

Note: Assume 6 working days per week and 10 hours shift per working day. This assumption is based on the lane closure hours recommendation as shown on Table 9