Vermont's Rockfall Hazard Rating System: 2015 Update

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ABSTRACT

A scheduled re-evluation of VTrans' Rockfall Hazard Rating System (RHRS) was performed in the summer and fall of 2015. A total of 210 rock slopes ranked as "A" and "B+" during the 2011 study were re-evaluated and visually inspected. One hundred twenty-one "A" ranked rock slopes and ninety-two "B+" ranked rock slopes were identified during the 2015 re-evaluation. As a result of this re-evaluation, two slopes were upgraded to "A" status, four slopes were upgraded to "B+" status, six slopes were downgraded from "A" to "B+" status and one "A" was downgraded to "B-" status. Eight rock slopes were mitigated between 2011 and 2015.

In addition to the rescoring, improvements to the scoring system and data management structure were made and some modifications to the data acquisition process were developed. The effect of remediation options on the rockfall hazard rating (RHR) score for rock slopes that still maintain the rating of "A" after remediation were analyzed.

INTRODUCTION

Between 2005 and 2007, the Vermont Agency of Transportation (VTrans) designed and implemented a Rockfall Hazard Rating System (RHRS) similar to the one outlined in Federal Highway Administration (FHWA) SA-93-085 (Rockfall Hazard Rating System Participant's Manual) and FHWA SA-93-085 (Rockfall Hazard Mitigation Methods Participant Workbook). Vermont's 2007 RHRS consisted of: The identification and ranking of 3,664 rock slopes along Interstate, U.S. and State roadways; Detailed ratings of the highest ranked rock slopes (designated as "A" slopes), and the compilation of thirty-three summary sheets of "A" ranked rock slopes that had Rockfall Hazard Rating Scores (RHR) between 500 and 700. Of the total 3,664 identified slopes, 150 were classified as "A" ranked rock slopes (high hazard), 74 ranked as B+ (significant hazard), 687 ranked as "B" (elevated hazard), 232 as "B-" (moderate hazard) and 2,799 ranked as "C" (low hazard). For discussions regarding geologic conditions in Vermont relative to the RHRS, objectives for conducting these studies, methodologies used in performing the ratings, and findings of the 2007 study, please refer to the following report:

Eliassen, T. D., and Springston, G. E., *Rockfall Hazard Rating of Rock Cuts on U.S. and State Highways in Vermont*, Research Project RSCH010-974, 2007, 31 p.

In 2011, Vermont's RHRS was re-evaluated. This re-evaluation involved the inspection of all "A" ranked rock slopes, visual inspections of all "B+" ranked rock slopes, an evaluation of the ditch effectiveness category, and changes to the database structure.

Based on the recommendations made in the 2007 RHRS and 2011 RHRS reports, a re-evaluation of the RHRS was conducted in 2015. This report details the work performed, methods used and summarizes the findings of the 2015 RHRS re-evaluation. The following modifications from the 2011 RHRS to 2015 RHRS were implemented:

- All "A" ranked rock slopes were re-evaluated and all "B+" ranked rock cuts were visually inspected.
- Slope profiles for slopes that were not measured in the 2011 RHRS were obtained.
- The database used to store the RHRS information was modified and improved.
- The effect of remediation methods performed on rock slopes in relation to the RHR Scoring categories were determined.
- New RHR scores were generated for rock slopes that have been remediated since the 2011 RHRS evaluation and still maintain the ranking of "A".
- Summary sheets for all "A" ranked rock slopes were prepared or updated.
- Remediation options for all "A" ranked rock slopes were reviewed, modified, and updated.
- An error in the database used to calculate RHR scores was identified and corrected. This resulted in the generation of correct RHR scores.

- New photographs of “A” ranked rock slopes and photographs of “B+” ranked rock slopes were obtained.
- The google earth file used to display the location of all rock slopes was updated.

DATABASE STRUCTURE

VTrans utilized Microsoft Access 2003 to store information pertaining to the RHRS. The database underwent some modifications since 2011. These modifications included:

- The addition of a “Year Remediated” text box to the Main Form of the RHRS. This text box will be useful in keeping track of which slopes have been remediated and when they were remediated.
- The addition of a “Project Number” text box to the Main Form of the RHRS. This text box will provide the user(s) quick and easy access to the VTrans project number associated with a rock slope that has been remediated.
- The addition of a “Ramp/Bench?” text box to the Slope Information Form of the RHRS. Ramp/bench features on slopes are important to note. Previously these observations were stored within the “Comments” field of the Main Form.
- The History Form for remediated slopes was reset. The logic behind this decision is that after remediation of a slope, the old history information would become irrelavent as the conditions on the slope after remediation are now different than the conditions that existed before remediation. This resulted in the lowering of RHR scores for slopes that were remediated during the 2015 evaluation and still maintain the ranking of “A”.

An example of the 2015 RHRS database information form is shown below as Figure 1.

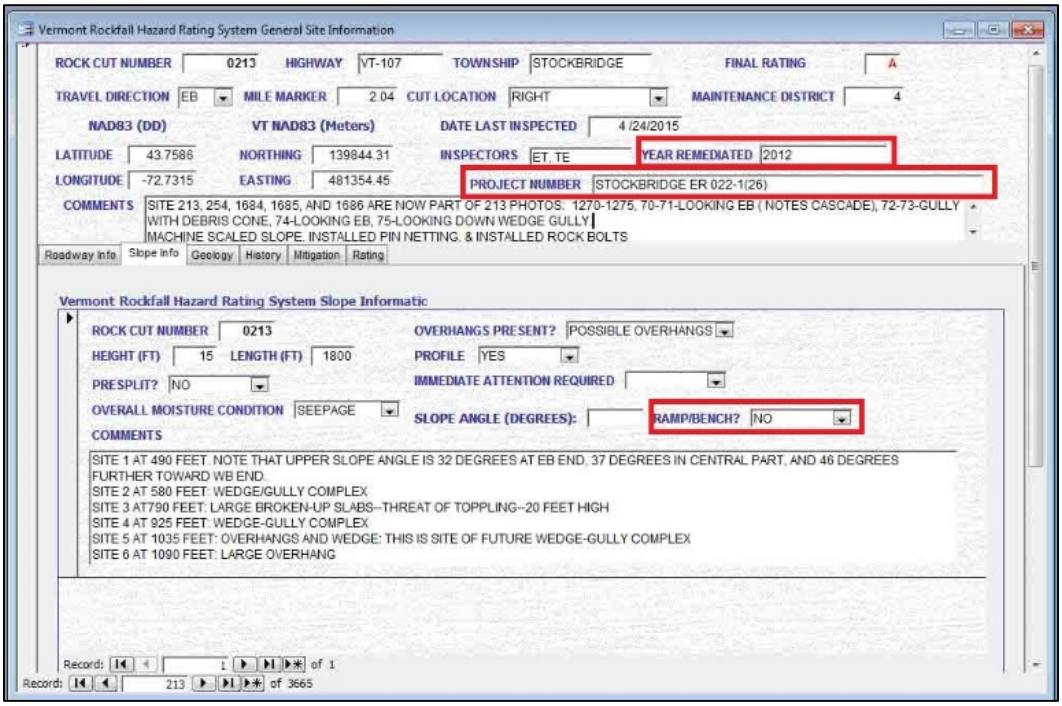


Figure 1: 2015 RHRS Slope Information form for Rock Cut No. 0213. The red boxes denote the newly added Year Remediated, Project Number, and Ramp/Bench text boxes.

RHRS EVALUATION

A total of 210 rock slopes ranked as "A" and "B+" during the 2011 study were visited in the 2015 re-evaluation during the Summer of 2015. All "A" ranked rock slopes were re-evaluated for all of the scoring parameters discussed in the 2007 report as well as modifications noted in the 2011 report. "B+" ranked rock slopes were only visually observed. A determination was made by the VTrans Geologist whether each rock slope retained its former ranking or if, due to changed conditions, re-ranking to a higher or lower ranking was warranted. New photographs of the "A" ranked rock slopes were taken, as well as photographs of the "B+" ranked rock slopes. Also, potential remediation options for each "A" ranked rock slope were noted in the field.

At the end of the 2015 field season, the RHRS consists of 121 "A" ranked rock slopes, 92 "B+" ranked rock slopes, 387 "B" ranked rock slopes, 231 "B-" ranked rock slopes, and 2,798 "C" ranked rock slopes. 3,629 total rock slopes are inventoried within the 2015 RHRS. The database does show 3,665 records though, however this discrepency in number of records is due to the fact that rock slopes that lie close to eachother have been combined.

A complete list of all "A" ranked rock slopes that were evaluated during this study is presented as Appendix A. Of the 210 total rock slopes evaluated, 121 were assigned an "A" ranking and 92 were assigned a "B+" ranking. During the 2015 re-evaluation, 6 rock slopes were upgraded. Out of the slopes upgraded, 2 slopes were upgraded to the ranking of "A" and 4 slopes were

upgraded to the ranking of "B+". 7 slopes were downgraded, of which 6 became "B+" ranked slopes and 1 became a "B-" ranked slope.

Some slopes were evaluated for stability during the 2015 re-evaluation that were not part of the 2011 re-evaluation. One of these slopes was upgraded from a "B" ranking to an "A" ranking due to the natrual deterioration of the slope from 2011. Others were upgraded to "B+". Table 1 shows the details and reasoning for the upgrade and downgrade of the slopes mentioned above.

Table 1: List of rock slopes that were downgraded and upgraded during the 2015 RHRS re-evaluation.

Cut #	TOWN	DISTRICT	2011 RANKING	2015 RANKING	Reason for Upgrade or Downgrade
0003	WOODFORD	1	A	B+	Remediation of slope in 2010.
0019	CASTLETON	3	A	B+	Rockfall event in 2015 resulted in reduced potential for future rock reaching the roadway.
0022	CHESTER	3	A	B+	Remediation of slope in 2010.
0105	MONTPELIER	5	A	B-	Remediation of slope in 2011 by blasting to more stable angle.
0114	WARREN	5	A	B+	Slope was evaluated in 2011 during the summer when vegetation was thick. In 2015, slope was evaluated in fall and vegetation was scarce. This allowed for a more accurate assessment of slope conditions.
0118	WORCESTER	8	A	B+	Remediation of slope in 2011.
0217	WILLISTON	5	B+	A	Deterioration of slope since 2011.
0431	CAVENDISH	2	B	B+	Deterioration of slope since 2011.
1274	BRAINTREE	4	C	B+	Slope became unstable due to over-excavation of toe of slope during ditching.
1860	CORNWALL	5	B	A	Deterioration of slope since 2011.
2018	BERLIN	7	A	B+	Hazardous portion of slope consists of a large block of rock that dips obliquely to the roadway. The surface the block rests on is rough and irregular. After a detailed examination, this block appears to be attached firmly to the slope face.
2287	MONTPELIER	5	B	B+	Deterioration of slope since 2011.
2523	WORCESTER	8	B	B+	Recent rockfalls in 2015 and further deterioration of slope since 2011.

All RHR scores for the "A" ranked rock slopes changed from the 2011 RHRS. The scores changed due to the update of the most recent AADT values, changes in slope conditions that were noted in the 2015 field season, the correction of an error within the RHRS database that led to marginally incorrect RHR scores, new information on rockfall frequency obtained from the Districts, and due to the effects of remediation on RHR scores (discussed later in this report). Figure 2 depicts the distribution of RHR scores for the current (2015) study.

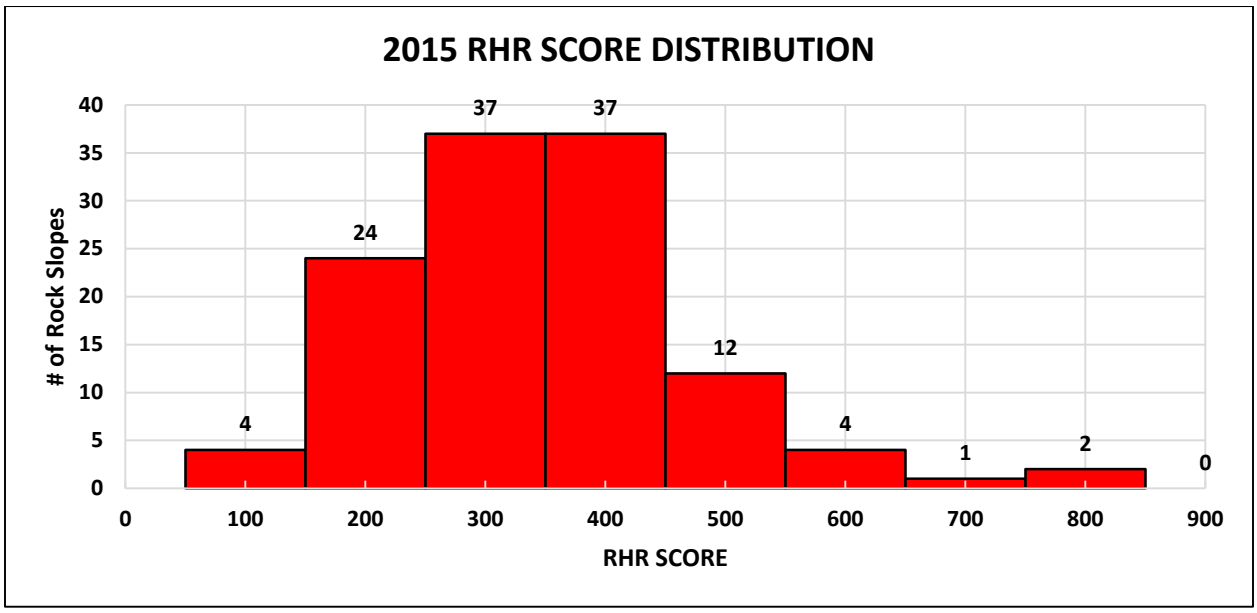


Figure 2: RHR Score Distribution. The number above each column represents the number of rock slopes for each RHR score interval.

Figure 3 shows the combined RHR score distribution for all "A" ranked rock slopes from the 2007 RHRS, 2011 RHRS, and the 2015 RHRS. The total number of "A" ranked rock slopes that have RHR scores between 100 to 400 points and 500 to 600 points decreased from the 2011 RHRS to the 2015 RHRS. The number of "A" ranked rock slopes that have RHR scores between 400 to 500 points increased from the 2011 RHRS to the 2015 RHRS. The number of "A" ranked rock slopes that have RHR scores between 600 to 900 remained the same from the 2011 RHRS to the 2015 RHRS.

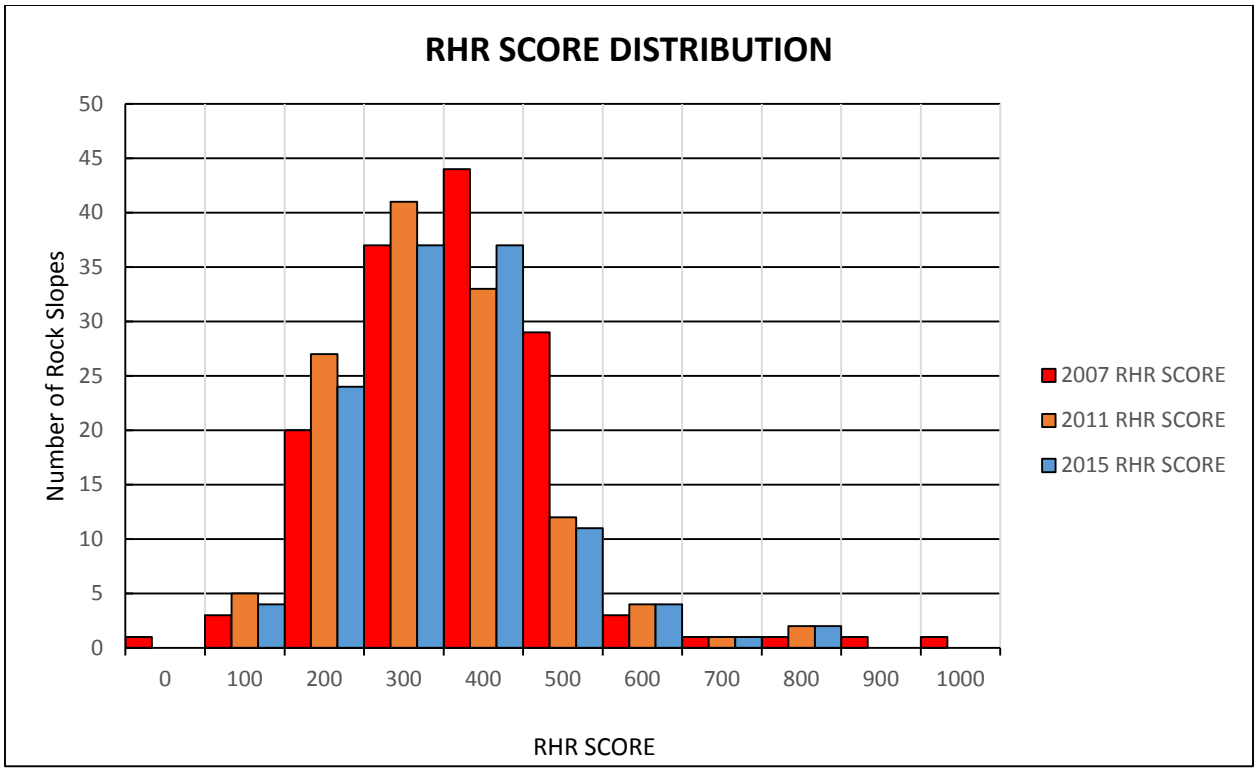


Figure 3: Distribution of RHR scores for "A" ranked rock slopes from the 2007, 2011, and 2015 RHRS.

The RHR scores for each district were plotted in Figure 4 shown below. The degree of hazard expressed numerically (RHR score) can be thought of as relatively low hazard for scores 0 to 300, moderate hazard for scores between 300 and 500 and high hazard for scores above 500. All districts but District 3 have rock slopes that have RHR scores above 500. Districts 4 and 5 have the highest number of rock slopes within them. Districts 7, 8, and 9 have the highest scored rock slopes within them. The Districts were re-organized in 2013. Due to this, rock slopes that exisited in District 6 have now been distributed between District 4, District 5, District 7, and District 8.

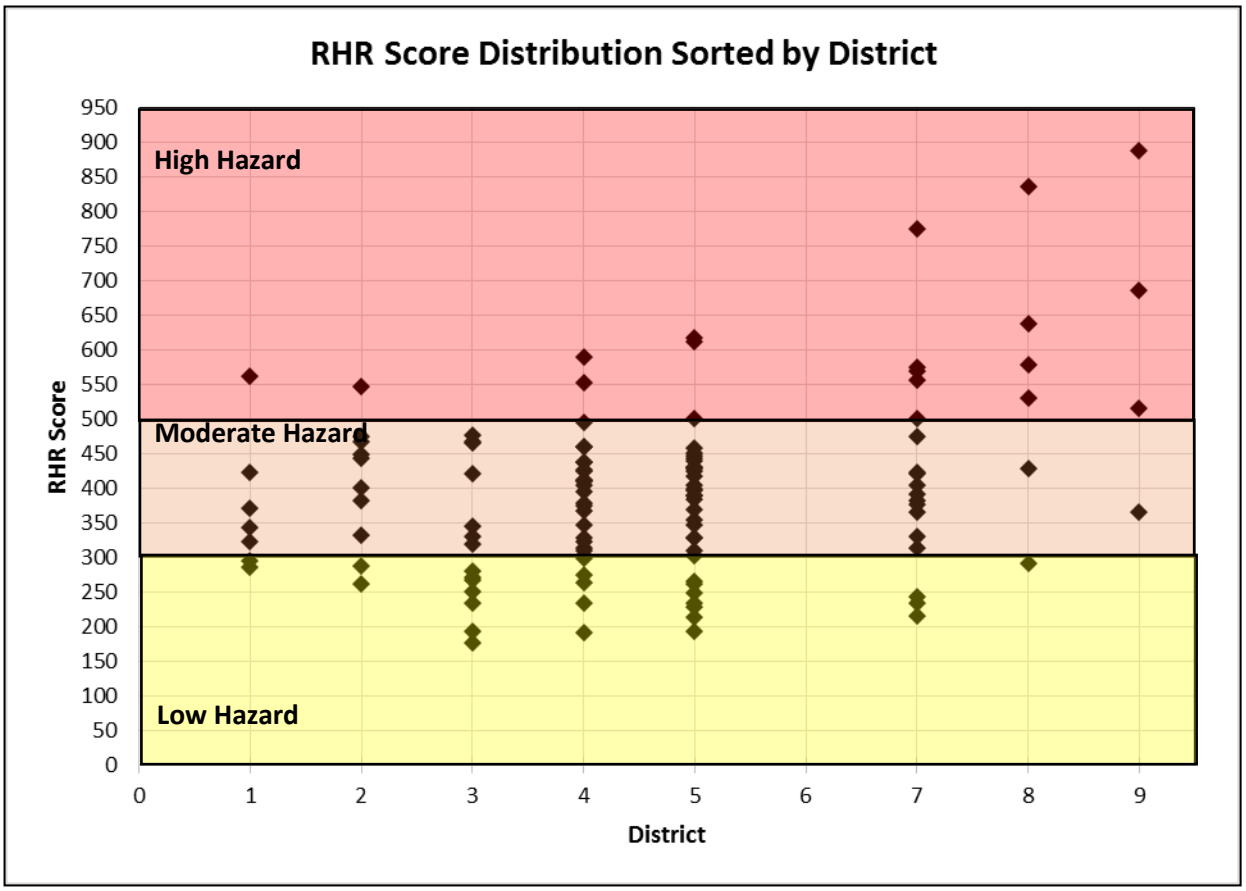


Figure 4: RHR Score Distribution sorted by District.

Included in this report (Appendix B) are summary sheets for 121 "A" ranked rock slopes. The summary sheets include photographs of the rock slope, the rock slope number, location, slope description, remediation options, estimated cost of remedation, and calculated cost/score ratios.

Estimated costs of remediation were calculated for 119 of the "A" ranked rock slopes. Two "A" ranked rock slopes did not have estimated remediation scores calculated because mitigation at these slopes would have been unattainable without drastic, expensive remediation measures.

The estimated remediation costs were sorted by District and graphed (Figure 5). District 9 and 8 have the lowest percentage of rock slopes to be remediated (2%, 3/119 slopes and 3%, 4/119 slopes respectively). District 5 has the highest percentage of rock slopes to be remediated (29%, 35/119 slopes). District 9 has the lowest estimated cost of remediation ($673,000). District 7, has the highest estimated cost of remediation ($6,545,000).

Some rock slopes have more than one remediation option and therefore multiple remediation costs were calculated for the same slope. Generally, the higher remediation costs reflect a potentialy higher degree of hazard reduction for the rock slope. However, due to budgetary constraints and possible Right-of-Way (ROW) issues, these options may not be feasible. The "High End Remediation Cost" depicted below in Figure 5 represents estimated total costs of remediation for the most expensive method of remediation.

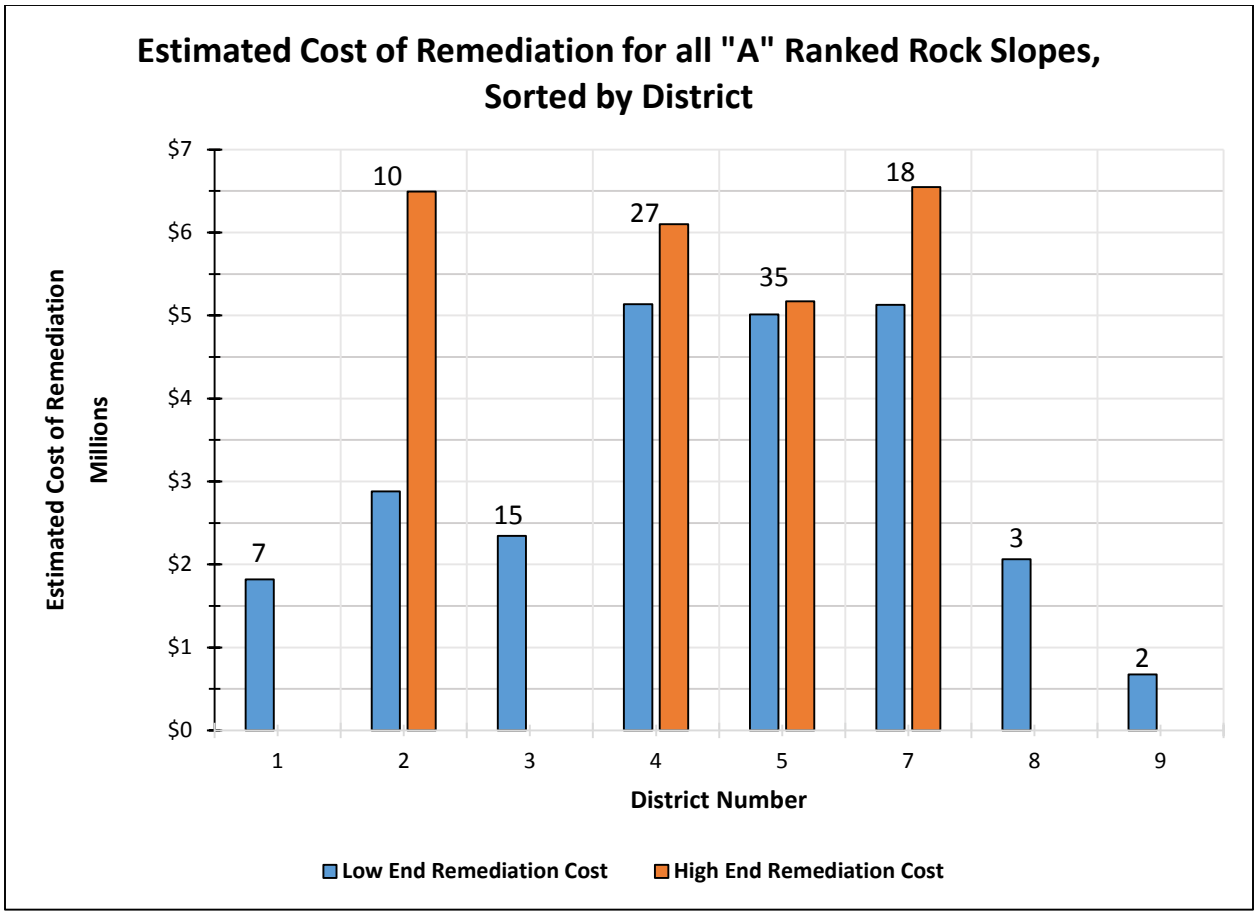


Figure 5: Estimated remediation cost sorted by District. The numbers above the bars represent the number of "A" ranked rock slopes to be remediated in each District.

Total estimated cost of rememdation for all one-hundred and nineteen "A" ranked rock slopes is estimated to be approximately $25 million for the Low End Remediation Cost and approximately $31 million for the High End Remediation Cost.

ROCK SLOPE REMEDIATION & RHR SCORE

Eight rock slopes were remediated between 2011 and 2015. Out of the eight slopes, seven of them retained the ranking of "A". One of the slopes was reduced from an "A" to a "B-". The seven slopes that maintained the "A" ranking after remediation measures were performed had their RHR Scoring categories re-assessed. This assesment included the determination of how each remediation method affects each RHR Scoring category.

RHR Scoring categories include:

- Slope Height
- Paved Width

- Rockfall History
- Accident History
- Overhangs
- Rock Reach Roadway?
- Average Vehicle Risk
- % Decision Sight Distance
- Block Size
- Block Shape
- Geologic Factor
- Ditch Effectiveness (% of Rock Reaching Roadway)
- Moisture Condition

Scores for each of the categories listed above are added together and the resulting value represents the total RHR Score for an "A" ranked rock cut/slope. It is important to note that each rock cut/slope possesses unique geologic conditions. Due to this, certain remediation methods are more appropriate than others. This also means that the same remediation technique(s) applied to different slopes may result in different lowering of their respective RHR Scoring categories.

The following is a list of the most common rock slope remediation techniques currently in use in the industry. A discussion on how each remediation technique affects the appropriate RHR Scoring category is also included.

High Scaling

High scaling utilizing rope access techniques is one of the most common mitigation techniques used for removing loose rocks on slopes that are higher than approximately 30 feet. High scaling typically includes prying loose rock off of slope surfaces utilizing steel scaling bars, air bags, Boulder Blaster® or hydraulic splitters/jacks. High scaling is most effectively performed using rope access techniques whereby scaling crew member's rappel down each section of the slope as they scale. High scaling is not considered a permanent mitigation measure because it is typically effective for a period of two to ten years, depending on site conditions and further degradation of the slope brought on by time and weather.

High scaling can reduce the RHR scores in the categories' Overhangs, Geologic Factor, Block size, and can indirectly change Ditch Effectiveness (if scaling is extensive enough, the slope profile may be altered enough to either improve or worsen ditch effectiveness). Figure 6 shows an example of high scaling being performed.

Figure 6: Example of high scaling being performed on Rock Cut #0013 Townshend.

Machine Scaling

Machine scaling involves the use of heavy equipment to remove loose blocks of rock from slopes that are approximately less than 30 feet in height. Care must be taken when machine scaling, as it can be easy to over excavate a slope and this may result in the development of overhangs and/or global instability. Machine scaling is not considered a permanent mitigation measure due to the same reasons as high scaling not being a permanent mitigation measure.

Machine scaling can reduce the RHR scores for the same categories as high scaling. Figure 7 shows an example of machine scaling being performed.

Figure 7: Example of machine scaling being performed on Rock Cut #0013 Townshend.

Rock Doweling/Bolting

The most common type of rock slope reinforcement applications are rock dowels and rock bolts. Rock dowels are untensioned, usually high strength steel bars installed to increase shear resistance and reinforce a block of rock. Washer plates and nuts can be attached at the slope face end of the bar. Rock dowels are able to increase normal force friction once block movement occurs. Rock bolts are tensioned high strength steel elements where the bar is tensioned in the bond zone (well past the potential plane of failure) and the design load is locked-off by installing a washer and nut.

Rock dowels/bolts can be installed on individual blocks to supply local support or multiple dowels/bolts can be installed in a grid pattern to supply a more global force to a large portion of a slope. Dowels and bolts can be installed using either grout or epoxy, however, VTrans has instituted a moratorium on the use of epoxy for use on critical overhead applications.

Rock doweling/bolting can reduce the RHR scores in the categories' Overhangs and Geologic Factor categories. Rock doweling/bolting helps to reduce the hazard associated with overhangs by locking them into place on the slope. Rock doweling/bolting reduces the geologic factor by increasing the shear resistance along the discontinuities in the rock

mass. Figure 8 shows an example of rock dowels that have been installed into a rock slope.

Figure 8: Example of installed rock dowels at Rock Cut #0013 Townshend.

Blasting/Trim Blasting

One of the most common rock removal methods employed when the goal is to totally eliminate all potential for future rockfall is to flatten the slope to an angle sufficient enough to prevent rocks from sliding/falling. This is usually performed by blasting techniques. Considerations for laying back a slope include the existing slope condition, slope angle, orientation of discontinuites within the rock, availability of right-of way and total volume of rock to be removed.

Laying a slope back to a stable angle utilzing blasting typically eliminates the rock slope from being ranked as an "A". Blasting essentially reduces all scoring categories to zero points.

Trim blasting consists of removing rocks that are too large for conventional scaling operations or removal of individual rock blocks from the slope face utilizing blasting techniques. Trim blasting can be used to remove overhanging faces and protruding knobs and to modify the slope angle to improve rockfall trajectory and slope stability. Trim blasting uses cushion or smooth blasting techniques designed to limit the amount of fly rock produced during the blast and protecting the slope face from over break.

Trim blasting can reduce the RHR scores in the categories' Overhangs and Block Size. Figure 9 and Figure 10 shows an example of a rock slope before blasting and after blasting respectively.

Figure 9: Rock Cut #0105 Montpelier before blasting. This rock cut was ranked as an "A" and had a RHR score of 370.

Figure 10: Rock Cut #0105 Montpelier after blasting. The new rating for this rock cut after blasting is a "B-".

Secured Netting

Secured netting is a method commonly used to secure unstable rocks at the surface of the slope by pinning a wire or cable net to the slope. This helps to tie together the loose masses of rock, creating a cohesive mass that improves the rock face stability.

The system consists of netting material and either steel dowels or cable anchors. The function of the mesh in the secured drapery system is to stabilize the material between the dowels/anchors by limiting rock movement. The netting is flexible yet strong enough to withstand deformation. This method of mitigation is typically used where the number or unstable blocks are too numerous to try to dowel individually or when excavation methods may further destabilize the slope. Secured netting is only appropriate for slope repairs to the top 3 feet (depth) of the slope surface such as the weathered zone near the surface.

Installation of secured netting can reduce the RHR scores in the categories' Geologic Factor and Ditch Effectiveness. This reduction in score is caused by the secured netting forming a more cohesive rock mass and by the netting limiting the amount of rock that can travel to the road way, effectively increasing the ditch effectiveness. Figure 11 shows an example of secured netting installed near the crest of a slope in order to stabalize the unstable soil and rock.

Figure 11: Example of secured netting installed on Rock Cut #0213 Stockbridge. The netting is located within the red rectangle drawn on the photo above.

Wire or Cable Draped Netting

Draped netting systems consist of wire mesh or cable netting that is suspended by anchors and draped over a slope. Drapes are used to contain rockfall by allowing loose rock to fall beneath the netting, thereby controlling the descent of the detached rock in a controlled manor. The bottom of the netting is usually kept some distance above the toe of the slope. This allows rock that may fall beneath the netting to drop harmlessly at the toe of the slope and accumulate in the catchment ditch.

Draped netting systems are designed to mitigate raveling-type rockfalls that involve small-volume slope failures where individual blocks of rock do not exceed approximately 3 feet in diameter. Drapery systems can be either unsecured or secured. Unsecured systems attach the wire mesh only at the top of the slope, allowing rockfall to occur between the mesh and the slope but slowing it as it travels down the slope face. Secured drapery systems incorporate breakaway components, which work to hold the mesh closer to the face but release it when impacted by falling rock.

Draped netting systems help to lower the overall ranking of a rock cut/slope by reducing the probability of rock from reaching the roadway. Draped netting systems also can lower the score generated for Ditch Effectiveness by reducing the amount of rock that reachs the roadway, effectively increasing the ditch effectiveness. Figure 12 shows an example of wire draped netting installed on a rock slope.

Figure 12: Wire draped netting installed at Rock Cut #0041 Fairlee.

Flexible Rockfall Barrier

Flexible Rockfall Barriers are flexible fences constructed of posts, post foundations, fence material, braking elements, and wire cables. These barriers are designed to perform as energy absorbing systems that can withstand the impact of rocks hitting the system while dissipating the rock's energy where the rock can either drop at the base of the fence or pass through in the case of an attenuating drape system (hybrid rockfall fence system). The fencing material can consist of either wire rope panels or steel wire ring nets. Flexible rockfall barrier systems can be classified as light, medium or high capacity and range in designed capacities from 100 kilojules (kJ) to 8,000 kJ.

Flexible rockfall barriers help to lower the overall ranking of a rock cut/slope by reducing the probability of rock from reaching the roadway. Flexible rockfall barriers can also lower the score generated for Ditch Effectiveness by reducing the amount of rock that reaches the roadway, effectively increasing the ditch effectiveness. Figure 13 shows an example of a hybrid flexible rockfall barrier installed on a rock slope.

Figure 13: Example of a hybrid flexible rockfall barrier installed at Rock Cut #0039 Fairlee.

Rigid Rockfall Barrier

Rigid rockfall barriers consist of earthen berms, structural walls, gabion walls and mechanically stabilized earth (MSE) walls. They absorb the kinetic energy of the rocks, block their trajectory, and detain them before they reach the roadway. Ridgid barriers can sustain large kinetic energies and repeated rockfall impacts, however this often

comes at the expense of the integrity of the barrier if high energies are transmitted from the falling rock to the system.

Rigid rockfall barriers help prevent falling rock from reaching the roadway, thus possibly lowering the overall ranking of a rock cut/slope. They can also lower the score generated for Ditch Effectiveness by reducing the amount of rock that reachs the roadway, effectively increasing the ditch effectiveness.

Concrete Barriers (Jersey Barrier)

Concrete barriers help prevent rock from reaching the roadway by blocking their trajectory. Jersey barriers should only be used as a temporary measure to help prevent rock from reaching the roadway. They are often used during emergency rockfall situations where the threat of continued rockfall is possible.

Cable Lashing

Where individual or small groups of unstable blocks of rock or boulders exist on the slope face, cable lashing can be an appropriate mitigation technique. Cable lashing materials consist of wire ropes and anchors. One or more wire ropes are draped around the offending rock block and anchored to sound, stable rock on the slope. The cable is tensioned enough to take out any slack and to apply a measure of positive tension so that the subject block is restrained.

Cable lashing can reduce the RHR score for the Overhangs category.

Shotcrete

Shotcrete is a method where a cementitious mortar with a fine aggregate is sprayed directly onto a slope using compressed air. Often fibers (either fiberglass or stainless steel) are added in order to supply some rigidity to the mix. Shotcrete is applied to rock slopes to protect surfaces from erosion or to provide structural support for otherwise sound rock that is either undermined by erosion or is unstable due to unfavorable orientations or degree of fracturing. To increase tensile strength and structural support, welded wire mesh is often used with shotcrete being applied through and over the mesh. Shotcrete is often used in conjunction with rock doweling/bolting.

Applying shotcrete on a rock cut/slope can potentially lower scores associated with Geologic Factor and Moisture Condition. Figure 14 shows an example of shotcrete being applied to a rock slope.

Figure 14: Shotcrete being applied to Rock Cut #0099 Middlesex.

Buttress

Voids in rock slopes casued by differential weathering, overhangs, or localized degradation can be filled with concrete or shotcrete in order to protect the slope from further degradation or to provide support for the rock mass above the void.

Depending on the purpose of the buttress, scores generated for the Geologic Factor and/or the Overhangs category can be affected.

Drainage

Excessive pore pressure caused by water in the slope acts on the rock mass and lowers the shear strength along open discontinuities. In addition, the build-up of water in a slope can lead to ice jacking during winter as repeated freeze-thaw cycles act to break down the stability of the slope.

Providing drainage is a relatively inexpensive way to prolong the life of a slope. Drainage is usually provided by drilling lateral holes at a slight angle to intersect discontinuity surfaces within the slope. These drain holes can be open or may be cased with a slotted polyvinylchloride (PVC) pipe to maintain the drain opening.

Installing drain holes within a rock cut/slope will lower the score generated from the Moisture Condition category.

Catchment Ditch Improvements

Well designed catchment ditches are probably the most effective form of rockfall control. Not only does the catchment area provide a collection area for fallen rock, but it also provides recovery zones for errant vehicles, facilitates the drainage of water and allows for snow storage in winter months. Improvements to catchment ditches include widening the ditch, increasing the depth of the ditch, and modifying the angle of the foreslope of the ditch towards the rock cut/slope.

Improving the catchment ditches width, depth, and modifying the foreslope angle will increase the ditch effectiveness. By increasing ditch effectiveness, scores generated for the Ditch Effectiveness category will be lowered.

Vegetation Removal

Vegetative growth on rock slopes is considered detrimental to the stability of the slope. Tree roots can wedge themselves deep within discontinuity openings and actually open these features further. Trees can also act as pry-bars during high wind and snow/ice events. As the trees sway, the roots place lateral pressures on the openings in the rock allowing water to penetrate which increases exposure of the discontinuities to weather induced deterioration.

Vegetation removal is a temporary remediation method that is always used in tandem with other remediation methods. Vermont's RHRS does not account for the effect of vegetation on the RHR Score.

Table 2 is an example of the changes in RHR Scores generated for Rock Cut Number #0013 Townshend after remediation was performed in the summer and fall of 2015. The RHR Score analysis for all seven slopes that were remediated between 2011 through 2015 is attached to this report as Appendix C.

Table 2: Example of how RHR Scores for Rock cut #0013 Townshend changed after remediation. This rock cut was remediated in 2015 by machine scaling, high scaling, installing drains within the slope, and by installing rock dowels.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	100	100	N/A
Paved Width Score	3	3	N/A
Rockfall History	9	0	Rockfall history is reset after remediation of slope
Accident History	9	0	Rockfall history tab is reset after remediation of slope.
Overhangs	27	27	Although doweling and scaling were performed, the slope still contains overhangs.
Rock Reach Roadway?	81	0	Rockfall history tab is reset after remediation of slope.
Average Vehicle Risk	3	4	Increased AADT from 2011 increased vehicle risk.
% Decision Sight Distance	100	100	N/A
Block Size	81	81	Large blocks still remain on upper portions of slope. Those that are deemed unstable were bolted.
Block Shape	14	14	N/A
Geologic Factor	81	27	Doweling and scaling has reduced geologic score.
Ditch Effectiveness	100*	85	*Ditch effectiveness in 2011 was estimated to be zero, due to extremely small ditch width and depth. The ditch was modified in 2015 during remediation and new ditch measurements were obtained and ditch effectiveness was calculated.
Moisture Condition	9	3	Drains were installed to address moisture conditions.
TOTAL RHR SCORE	**617**	**444**	
Change in RHR Score	**173**		
% Change in RHR Score	**28%**		

Rock Slope Management Plan

To meet current VTrans Rock Slope Management Plan goals, it is expected that the total RHR score for all "A" ranked rock slopes be reduced by 1% per year. The total RHR score for the 2011 RHRS was 49,232 points. The current total RHR score for the 2015 RHRS is equal to

47,766 points. This implies that over four years the total RHR score has been reduced by 1,466 points (3% total in four years). It is expected that in order to meet the goal for total RHR score for 2016, the total RHR score for 2015 (47,766 points) will need to be reduced by 478 points.

RHRS EVALUATION CONCLUSIONS

A total of 210 rock slopes ranked as "A" and "B+" during the 2011 study were visited in the 2015 re-evaluation during the Summer of 2015. At the end of the 2015 field season, the RHRS consists of 121 "A" ranked rock slopes, 92 "B+" ranked rock slopes, 387 "B" ranked rock slopes, 231 "B-" ranked rock slopes, and 2,798 "C" ranked rock slopes. Eight rock slopes were remediated between 2011 and 2015. Seven of the eight slopes that were remediated were downgraded. Six slopes were upgraded.

New RHR scores for all "A" ranked rock slopes were generated and compaired to the 2007 RHRS and 2011 RHRS. Updated summary sheets for all "A" ranked rock slopes were created and modified, as well as new cost/score ratios.

The effect of remediation options on the RHR score for rock slopes that still maintain the ranking of "A" after remediation, was analyzed. As such, it was decided, that after remediation of a slope that still maintains the ranking of "A", that the whole slope will be re-evaluated for all RHR scoring categories and any changes in RHR score will be updated within the Access Database.

The VTrans Rock Slope Management Plan sets a goal of reducing the total RHR score for all "A" ranked rock slopes by 1% per year. At the time of the 2011 RHRS re-evaluation, the total RHR score was 49,232 points. The current total RHR score for the 2015 RHRS is equal to 47,766 points. 1,466 points have been subtracted from the 2011 RHRS to the 2015 RHRS. It is expected that in order to meet the goal for total RHR score reduction for 2016, the total RHR score for 2015 (47,766 points) will need to be reduced by 478 points.

The VTrans RHRS will continue to undergo edits as rock cuts are mitigated, conditions deteriorate or other parameters change over time. It is proposed that the re-evaluation of all "A" ranked rock slopes and visual inspection of all "B+" ranked rock slopes be performed every five years. Lower ranked rock cuts will not be re-evaluated unless asked to by the districts and/or if rockfall events necessitate inspection.

REFERENCES

Eliassen, T. D., and Springston, G. E., *Rockfall Hazard Rating of Rock Cuts on U.S. and State Highways in Vermont*, Research Project RSCH010-974, 2007, 31 p.

Eliassen, T.D., and Thomas, E. J., *Vermont's Rockfall Hazard Rating System 2011 Update, 2011, 12 p.*

APPENDIX A

SUMMARY LIST OF ALL “A” RANKED ROCK SLOPES

ROCK CUT NUMBER	DISTRICT	TOWN	HIGHWAY	TOWN MILE MARKER	TRAVEL DIRECTION	CUT LOCATION	FINAL RANKING	RHR
0150	9	WESTMORE	VT-5A	1.84	NB	RIGHT	A+	**888**
0176	8	CAMBRIDGE	VT-108	1.08	N/A	RIGHT/LEFT	A+	**836**
0129	7	FAIRLEE	US-5	6.15	SB	RIGHT	A	**774**
0156	9	WESTMORE	VT-5A	3.33	NB	RIGHT	A	**685**
0178	8	CAMBRIDGE	VT-108	1.75	NB	RIGHT	A+	**638**
0082	5	BUELS GORE	VT-17	2.31	EB	RIGHT	A	**617**
0099	5	MIDDLESEX	I-89	55.11	NB	RIGHT	A	**611**
0039	4	FAIRLEE	I-91	89.52	SB	RIGHT	A	**589**
0142	8	GEORGIA	I-89	107.74	NB	RIGHT	A+	**578**
0119	7	BARNET	US-5	4.21	SB	RIGHT	A	**575**
0120	7	RYEGATE	I-91	117.00	SB	OUTSIDE	A	**569**
0002	1	WOODFORD	VT-9	2.93	WB	RIGHT	A	**562**
0136	7	ST. JOHNSBURY	I-91	N/A	NB	INT. 19 RAMP C RIGHT	A	**557**
0046	4	GRANVILLE	VT-100	5.89	SB	RIGHT	A	**553**
0009	2	ROCKINGHAM	I-91	34.94	NB	RIGHT	A	**546**
0240	8	CAMBRIDGE	VT-108	1.29	NB	RIGHT	A	**531**
0147	9	COVENTRY	US-5	3.35	SB	RIGHT	A	**516**
0112	8	STOWE	VT-100	2.84	NB	RIGHT	A	**501**
0127	7	BARNET	I-91		SB	INT. 18 RAMP A RIGHT	A	**500**
0049	4	GRANVILLE	VT-100	6.35	SB	RIGHT	A	**495**
0024	3	HUBBARDTON	VT-30	3.08	SB	RIGHT	A	**477**
0011	2	ROCKINGHAM	I-91	36.25	SB	RIGHT	A	**475**
0135	7	ST. JOHNSBURY	I-91	129.30	SB	OUTSIDE	A	**475**
0008	2	DUMMERSTON	VT-30	0.21	EB	RIGHT	A	**468**
0029	3	PLYMOUTH	VT-100A	0.11	NB	RIGHT	A	**468**
0036	3	WELLS	VT-30	4.94	NB	RIGHT	A	**465**
0075	4	BERLIN	VT-12	2.86	SB	RIGHT	A	**459**
0159	4	WINDSOR	I-91	56.06	SB	RIGHT	A-	**459**
0070	5	BRISTOL	VT-17	2.09	WB	RIGHT	A	**458**
0108	4	NORTHFIELD	VT-12A	1.88	SB	RIGHT	A	**450**
0010	2	ROCKINGHAM	I-91	34.96	SB	RIGHT	A	**448**

ROCK CUT NUMBER	DISTRICT	TOWN	HIGHWAY	TOWN MILE MARKER	TRAVEL DIRECTION	CUT LOCATION	FINAL RANKING	RHR
0079	5	BERLIN	I-89	51.98	NB	RIGHT	A	**446**
0013	2	TOWNSHEND	VT-30	4.15	WB	RIGHT	A	**444**
0078	4	BERLIN	I-89	46.72	NB	RIGHT	A	**444**
0073	5	CORNWALL	VT-125	2.21	WB	RIGHT	A	**439**
0050	4	GRANVILLE	VT-100	6.47	SB	RIGHT	A	**438**
0107	5	MORETOWN	VT-100B	0.44	SB	RIGHT	A	**437**
0090	5	DUXBURY	VT-100	1.78	NB	RIGHT	A	**431**
0217	5	WILLISTON	I-89	80.10	SB	RIGHT	A	**431**
0144	8	MILTON	I-89	102.42	NB	RIGHT	A	**429**
0115	5	WATERBURY	US-2	0.67	WB	RIGHT	A	**428**
0074	5	WILLISTON	I-89	80.07	NB	RIGHT	A	**426**
0064	4	SHARON	I-89	12.94	NB	RIGHT	A	**425**
0086	5	BUELS GORE	VT-17	2.48	EB	RIGHT	A	**424**
0006	1	BRATTLEBORO	VT-9	1.39	WB	RIGHT	A	**422**
0123	7	BARNET	I-91	122.15	NB	MEDIAN	A	**422**
0234	7	LYNDON	I-91	142.55	NB	RIGHT	A	**421**
0033	3	WALLINGFORD	VT-140	2.45	EB	RIGHT	A	**420**
0087	5	BUELS GORE	VT-17	2.55	WB	RIGHT	A	**418**
0060	4	NORWICH	I-91	77.29	SB	RIGHT	A	**412**
0067	4	THETFORD	US-5	6.59	SB	RIGHT	A	**411**
0062	4	ROYALTON	I-89	21.77	SB	RIGHT	A	**410**
1931	5	RIPTON	VT-125	0.19	EB	RIGHT	A	**405**
0117	4	WILLIAMSTOWN	I-89	41.18	NB	RIGHT	A	**404**
0124	7	BARNET	I-91	122.24	SB	OUTSIDE	A	**404**
0252	2	TOWNSHEND	VT-30	5.17	WB	RIGHT	A	**401**
0092	5	FAYSTON	VT-17	1.19	EB	RIGHT	A	**398**
0102	5	MIDDLESEX	I-89	55.42	NB	RIGHT	A	**397**
0055	4	HARTFORD	I-91	71.61	NB	RIGHT	A	**395**
0125	7	BARNET	I-91	122.82	SB	OUTSIDE	A	**392**
0160	5	MIDDLESEX	I-89	54.61	NB	RIGHT	A-	**390**
1933	5	RIPTON	VT-125	0.32	EB	RIGHT	A	**389**
0100	5	MIDDLESEX	I-89	55.17	NB	RIGHT	A	**383**
0140	7	WATERFORD	I-93	6.09	NB	OUTSIDE	A	**382**
0187	2	DUMMERSTON	VT-30	4.28	EB	RIGHT	A	**382**
0037	3	WEST RUTLAND	US-4	13.51	EB	RIGHT	A	**379**
0139	7	WATERFORD	I-93	3.11	NB	OUTSIDE	A	**377**
0059	4	NORWICH	US-5	3.51	SB	RIGHT	A	**375**

ROCK CUT NUMBER	DISTRICT	TOWN	HIGHWAY	TOWN MILE MARKER	TRAVEL DIRECTION	CUT LOCATION	FINAL RANKING	RHR
0004	1	BRATTLEBORO	VT-9	0.07	WB	RIGHT	A	**370**
0071	5	COLCHESTER	I-89	96.67	SB	RIGHT	A	**369**
0047	4	GRANVILLE	VT-100	5.97	SB	RIGHT	A	**368**
0137	7	ST. JOHNSBURY	I-91	N/A	SB	INT. 19 RAMP D LEFT	A	**366**
0149	9	JAY	VT-105	3.66	WB	RIGHT	A	**366**
0116	5	WATERBURY	VT-100	0.55	SB	RIGHT	A	**355**
0032	3	WALLINGFORD	US-7	3.11	SB	RIGHT	A	**353**
0052	4	HARTFORD	I-89	5.53	SB	RIGHT	A	**347**
0104	5	MONTPELIER	I-89	54.08	NB	RIGHT	A	**346**
0182	1	POWNAL	VT-346	2.27	WB	RIGHT	A	**343**
0193	2	TOWNSHEND	VT-30	5.00	WB	RIGHT	A	**332**
0021	3	CAVENDISH	VT-103	0.82	NB	RIGHT	A	**330**
0133	7	RYEGATE	I-91	114.62	NB	OUTSIDE	A	**330**
0072	5	CORNWALL	VT-74	0.13	WB	RIGHT	A	**329**
1860	5	CORNWALL	VT-74	0.12	EB	RIGHT	A	**329**
0058	4	NORWICH	US-5	2.60	SB	RIGHT	A	**328**
0005	1	BRATTLEBORO	VT-9	0.35	WB	RIGHT	A	**323**
0044	4	GRANVILLE	VT-100	4.46	SB	RIGHT	A	**323**
0017	3	BRIDGEWATER	VT-100A	0.23	SB	RIGHT	A	**319**
0061	4	READING	VT-106	7.04	NB	RIGHT	A	**314**
0233	7	LYNDON	I-91	141.70	NB	RIGHT	A	**313**
0110	5	RICHMOND	I-89	73.67	SB	MEDIAN	A	**310**
0040	4	FAIRLEE	I-91	89.78	SB	RIGHT	A	**309**
0076	4	BERLIN	VT-12	3.00	SB	RIGHT	A	**303**
1937	5	RIPTON	VT-125	1.00	EB	RIGHT	A	**302**
0063	4	SHARON	I-89	12.62	NB	RIGHT	A	**298**
0260	1	ARLINGTON	VT-313	5.45	WB	RIGHT	A	**295**
0111	5	RICHMOND	I-89	73.76	NB	MEDIAN	A	**292**
0012	2	ROCKINGHAM	I-91	37.61	SB	RIGHT	A	**287**
0180	1	DORSET	US-7	4.59	NB	RIGHT	A	**286**
0888	3	CAVENDISH	VT-103	1.15	NB	RIGHT	A	**280**
0213	4	STOCKBRIDGE	VT-107	2.04	EB	RIGHT	A	**274**
0025	3	HUBBARDTON	VT-30	3.79	NB	RIGHT	A	**270**
0202	3	SHREWSBURY	VT-103	3.49	NB	RIGHT	A	**268**
0080	5	BOLTON	US-2	5.66	WB	RIGHT	A	**265**

ROCK CUT NUMBER	DISTRICT	TOWN	HIGHWAY	TOWN MILE MARKER	TRAVEL DIRECTION	CUT LOCATION	FINAL RANKING	RHR
0045	4	GRANVILLE	VT-100	5.45	SB	RIGHT	A	**264**
0015	2	WEATHERSFIELD	I-91	47.58	SB	RIGHT	A	**261**
0069	4	WINDSOR	VT-44	3.14	WB	RIGHT	A	**261**
0028	3	PLYMOUTH	VT-100	7.63	NB	RIGHT	A	**251**
0094	5	MIDDLESEX	US-2	3.53	WB	RIGHT	A	**249**
0132	7	LYNDON	I-91	137.52	SB	OUTSIDE	A	**244**
3665	5	RIPTON	VT-125	0.25	EB	RIGHT	A	**243**
0038	4	BRIDGEWATER	US-4	2.57	EB	RIGHT	A	**234**
0161	5	WATERBURY	I-89	64.90	NB	RIGHT	A-	**234**
0162	7	RYEGATE	I-91	116.93	NB	OUTSIDE	A-	**234**
0027	3	MENDON	US-4	2.30	EB	RIGHT	A	**233**
0109	5	RICHMOND	I-89	73.67	SB	RIGHT	A	**229**
0131	7	LYNDON	I-91	136.68	NB	OUTSIDE	A	**215**
0222	5	MIDDLESEX	US-2	4.58	WB	RIGHT	A	**213**
0113	5	WAITSFIELD	VT-100	3.60	SB	RIGHT	A	**194**
0026	3	HUBBARDTON	VT-30	3.94	NB	RIGHT	A	**193**
0077	4	BERLIN	VT-12	3.40	SB	RIGHT	A	**192**
0020	3	CAVENDISH	VT-103	0.74	SB	RIGHT	A	**176**

APPENDIX B

SUMMARY SHEETS OF ALL “A” RANKED ROCK SLOPES

Rock Cut Number	**0002**
Maintenance District	1
Highway	VT-9
Mile	2.93
Town	WOODFORD
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	670
AADT (2012)	3,500
Posted Speed Limit	50
Date Last Inspected	06/10/2015
Inspectors	ET, RM
Total RHR Score	**562**

SLOPE DESCRIPTION:
This rock cut is 83 ft tall and 670 ft long. It lies on a sharp curve in the roadway. This cut has had problems in the past requiring rock slope investigations. The District had wanted in the past to cut the slope back (not necessarily on a shallower angle) to provide a larger ditch area to accommodate snow storage during winter plowing. There are large loose blocks on this slope especially near the top. The rock cut was constructed with a prominent bench approximately half-way up the slope. This bench could be used as a ramping feature, launching rock onto the highway, if rockfalls occurred at the top of the slope.

REMEDIATION OPTION:
This slope is currently under design as Project Woodford NH010-1(51). Remediation of the slope will consist of cutting the slope back to 4V:1H and improving ditch catchment. The estimated cost reflects current design estimates.

CONDITIONS:
Roadway is two lane (one each way) with limited shoulder area. VT-9 is a major route and prolonged lane closures would not be possible as there are no other detour routes that could be used

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
Cut slope back 20-feet on a 4:1 slope	**19,000 cy**	**$1,100,000**	**1,957**

***Quantities and Estimated Cost come from current preliminary project plans and may not represent final quantities and cost.

Rock Cut Number	**0004**
Maintenance District	1
Highway	VT-9
Mile	0.07
Town	BRATTLEBORO
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	765
AADT (2012)	7,300
Posted Speed Limit	50
Date Last Inspected	6/19/2015
Inspectors	ET, MB
Total RHR Score	**370**

SLOPE DESCRIPTION:
This rock cut is 22 feet tall and 765 feet long. The slope consists of phyllitic schist that lies extremely close to the roadway in some areas. The primary failure type is toppling. The slope is moderately vegetated and wet. This slope has produced occasional rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by machine scaling the slope face and by modifying the current ditch to improve ditch effectiveness.

CONDITIONS:
Remediation will require the closure of one lane of traffic and traffic control. This cut is on a long, broad curve in the roadway.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **Ditch Excavation**	**4 Days** **250 cy**	**$21,600**	**58**

Rock Cut Number	**0005**
Maintenance District	1
Highway	VT-9
Mile	0.39
Town	BRATTLEBORO
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	373
AADT (2012)	7,300
Posted Speed Limit	50
Date Last Inspected	6/19/2015
Inspectors	ET, MB
Total RHR Score	**323**

SLOPE DESCRIPTION:
This rock cut is 23 feet tall and 373 feet long. The slope consists of phyllitic schist that, in some areas, lies extremely close to the road way. The primary failure type is toppling failure. The slope is dry and is moderately vegetated.

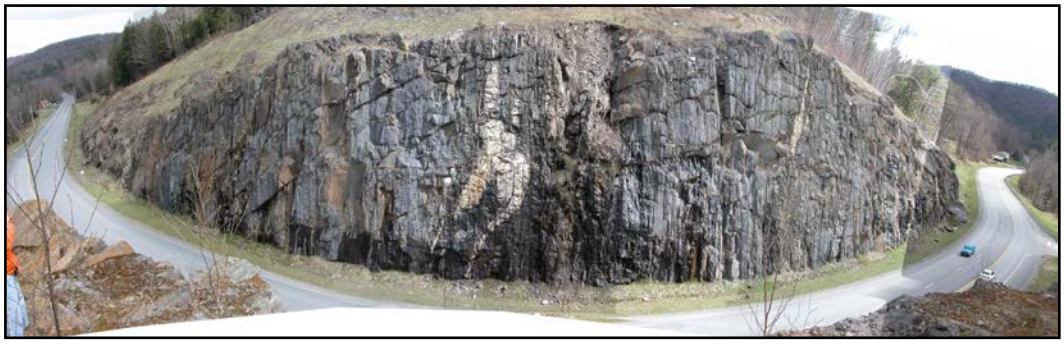
REMEDIATION OPTION:
Remediation of the slope consists of the removal of loose and unstable rock by machine scaling the slope face and by improving the ditch effectiveness by modifying the current ditch.

CONDITIONS:
Remediation will require the closure of one lane of traffic and traffic control. This cut is on a long, broad curve in the roadway.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Ditch Excavation **Machine Scaling**	**100 cy** **2 Days**	**$17,500**	**54**

Rock Cut Number	**0006**
Maintenance District	1
Highway	VT-9
Mile	1.39
Town	BRATTLEBORO
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	1,195
AADT (2012)	7,300
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, MB
Total RHR Score	**422**



SLOPE DESCRIPTION:
This cut is relatively new (constructed in the late 80's). As seen in the right (east) portion of the photo (bottom photo), a very large block had slid out and landed in the ditch. This block has subsequently been removed. During construction of this cut instability issues were encountered. Note the area at the top of the cut in the center of the photo (panorama). This is an overburden failure that continues to erode. The top photo shows a close up of a large overhang near the top of the slope.

REMEDIATION OPTIONS:
High scaling of loose blocks, installation of rock dowels, machine scaling of slope, and installation of Tecco Mesh in the area of the failing overburden.

CONDITIONS:
This cut is on a broad curve. There are wide shoulders and ditch area that will allow ample room for the contractor.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization, and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels** **Tecco Mesh** **Machine Scaling**	**20 Days** **1,400 Lin. ft** **5,000 ft^2** **2 Days**	**$404,000**	**957**

Rock Cut Number	**0008**
Maintenance District	2
Highway	VT-30
Mile	0.21
Town	DUMMERSTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	1,355
AADT (2012)	5,500
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, TE
Total RHR Score	**468**

SLOPE DESCRIPTION:
This slope consists of a rock cut in the northern portion of its extent and soil covered slopes with erosional features in the central and southern parts of the slope. This summary sheet details only remediation options for the rock cut.

This slope is heavily vegetated, which makes it difficult to ascertain exactly how hazardous this slope really is. However, at the northern part of this slope there are very large rectangular blocks of rock high on the slope that are resting on jointing that dip toward the roadway. These blocks could overwhelm the ditch if they fail.

REMEDIATION OPTIONS:
Remove loose rock from the slope utilizing high scaling, machine scaling supplemented with possible rock doweling.

CONDITIONS:
Roadway is two lane (one each way) with wide shoulder areas. Although there should be plenty of room to limit traffic to one lane through here, Upper Dummerston Road parallels VT-30 and could be used as a possible detour (3.5 miles).

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Machine Scaling Rock Doweling	**10 Days 40 Hours 200 Lin. ft**	**$173,000**	**370**

Rock Cut Number	**0009**
Maintenance District	2
Highway	I-91
Mile	34.94
Town	ROCKINGHAM
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,900
AADT (2012)	12,400
Posted Speed Limit	65
Date Last Inspected	07/15/2015
Inspectors	ET, RM
Total RHR Score	**546**

SLOPE DESCRIPTION:
This is a long, high cut that has had a long history of rockfalls. Rockfalls here tend to involve large rectangular blocks and although there is a wide catchment ditch, rock does reach the roadway. Its sister cut (on the southbound barrel) had failed in 1968 covering the interstate. The southbound cut was partially remediated by cutting the slope back to the responsible fault surface. It appears that selective scaling of loose blocks was conducted in the early 1990s. There are a number of joint sets in this slope that result in many possible failure geometries.

Remediation activities were performed in 2010. Remediation included high scaling of the slope, machine scaling, installation of rock dowels, and re-ditching. Although the risk for rockfall at this slope was reduced as the result of mitigation, this cut remains an "A" because continued weathering of the slope face will continue to produce rockfalls.

REMEDIATION OPTIONS:
Option1: Remove loose and unstable rock utilizing high scaling techniques and spot rock dowel installation.
Option2: Cut the slope back to 1.5V:1H.

CONDITIONS:
This is an interstate highway. The northbound barrel and southbound barrel will need to be closed if remediation Option 2 is chosen. If Option 1 is chosen, a temporary rockfall fence can be used to prevent rock from getting into the roadway during scaling. One lane of traffic will need to be closed during scaling. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.
Option 1:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Rock Dowel Installation	**20 Days 600 Lin. ft**	**$313,000**	**573**

Option 2:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut Slope Back to 1.5V:1H	**160,000 cy**	**$1,700,000**	**3,113**

Rock Cut Number	**0010**
Maintenance District	2
Highway	I-91
Mile	34.96
Town	ROCKINGHAM
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	2,000
AADT (2012)	12,400
Posted Speed Limit	65
Date Last Inspected	8/5/2015
Inspectors	ET, RM
Total RHR Score	**448**

SLOPE DESCRIPTION:
This slope is 81 feet tall and 2,000 feet long. The slope consists of quartzose phyllite and meta-limestone. Though the slope has a good ditch (27 feet wide and 1 foot deep), the sheer volume of potentially unstable rock can overwhelm the ditch and easily spill into the roadway. The slope exhibits three types of rock failure, (plane failure, wedge failure, and toppling). The slope has overhangs, is heavily vegetated at the crest, and is dry. This site produces occasional rockfalls.

REMEDIATION OPTION:
Option 1: Remediation of this slope requires trim blasting, the installation of rock dowels, high scaling, and machine scaling.
Option 2: Cut the slope back to 1.5V:1H.

CONDITIONS:
This is Interstate highway with ample shoulder area. Detour possibilities might include the use of crossovers. The slope is quite long.

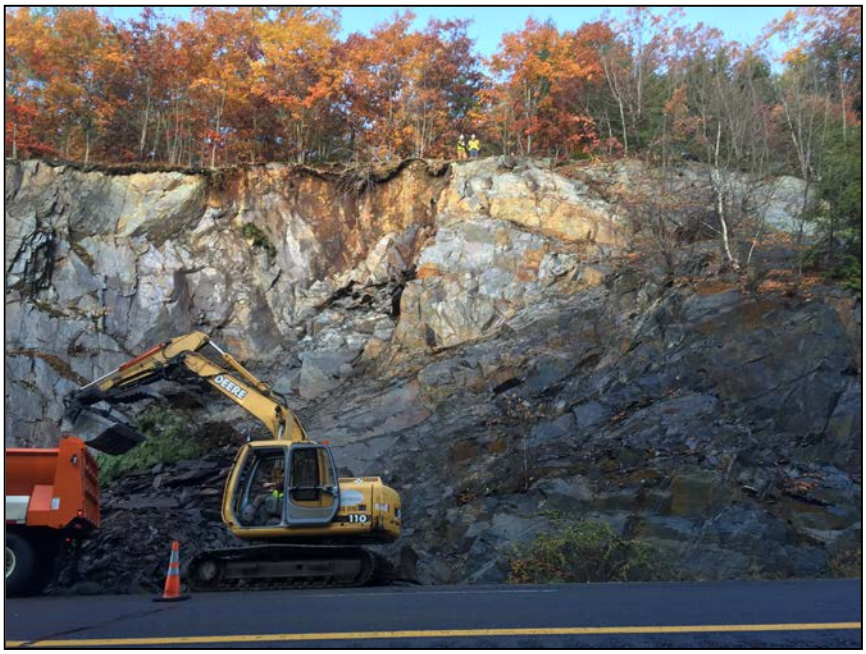
GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control and Mobilization.
Option 1:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Rock Dowel Installation** **Machine scaling** **High Scaling**	**200 cy** **750 Lin. ft** **4 Weeks** **8 Weeks**	**$571,000**	**1,275**

Option 2:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut slope back to 1.5V:1H.	**214,300 cy**	**$2,300,000**	**5,134**

Rock Cut Number	**0011**
Maintenance District	2
Highway	I-91
Mile	36.25
Town	ROCKINGHAM
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,225
AADT (2012)	10,900
Posted Speed Limit	65
Date Last Inspected	10/29/2015
Inspectors	ET, TE
Total RHR Score	**475**



SLOPE DESCRIPTION:
This rock cut is 56 feet tall and 1,225 feet long. The slope consists of slate and the primary failure types are plane failure and toppling. This slope has moderate vegetation on the summit and is dry. There were major rockfall events in 2005 and 2015 that spread rock debris across the roadway. The 2015 rockfall caused five traffic accidents and motorists suffered minor injuries. A portion of the slope immediately adjacent to that which failed was scaled and trim blasting was performed to remove the immediate hazard.

REMEDIATION OPTIONS:
Option 1: Remediation of the slope will require machine scaling, high scaling, and the installation of rock dowels.
Option 2: Cut the slope back on 1V:1H.

CONDITIONS:
This is Interstate highway. Detour possibilities might include the use of crossovers. At least one lane of traffic will have to be closed during remediation. The southbound barrel of the Interstate would need to be closed if blasting is performed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control and Mobilization and Clearing and Grubbing.

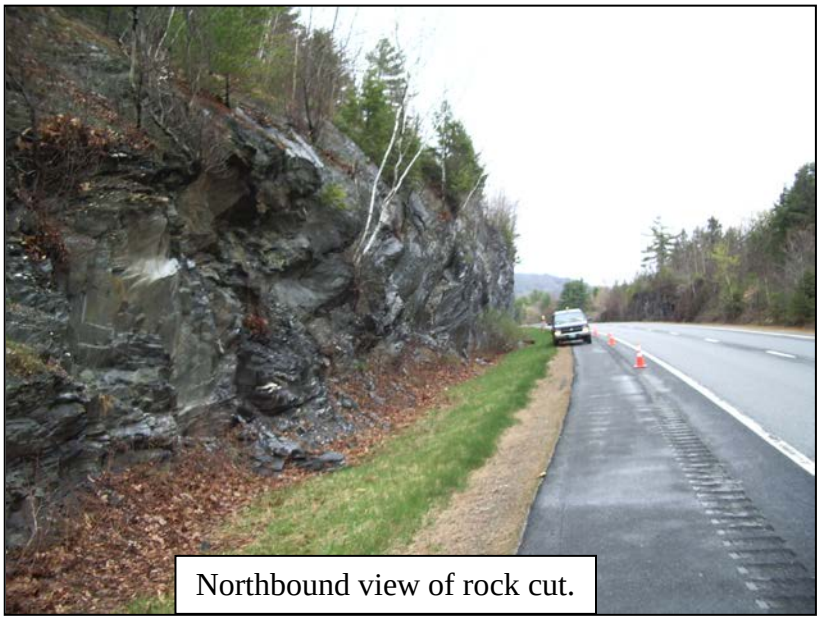
Option 1:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine scaling **High Scaling** **Rock Dowels**	**5 Days** **3 Weeks** **1,000 Lin. ft**	**$280,000**	**589**

Option 2:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut slope back to 1V:1H	**108,000 cy**	**$776,000**	**1,634**

Rock Cut Number	**0012**
Maintenance District	2
Highway	I-91
Mile	37.61
Town	ROCKINGHAM
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	798
AADT (2012)	10,900
Posted Speed Limit	65
Date Last Inspected	07/15/2015
Inspectors	ET, RM
Total RHR Score	**287**



Northbound view of rock cut.

SLOPE DESCRIPTION:
This rock cut is 26 feet tall and 798 feet long. The slope consists of phyllite and the primary failure type is toppling. The stereonet plot does show the potential for plane failure along jointing. This slope has overhangs, is wet, and is moderately vegetated.

REMEDIATION OPTIONS:
This rock cut is currently a project in the design phase (Rockingham IM 091-1(71)). Planned remediation consists of cutting the slope back to a stable angle by using controlled blasting techniques.

CONDITIONS:
This is Interstate highway. The southbound barrel will need to be closed during blasting. The northbound barrel will likely also need to be closed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control and Mobilization and Clearing and Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
Cut slope back to 1V:1H	**20,000 cy**	**$839,000**	**2923**

***Quantities and Estimated cost come from preliminary estimates from current project plans and may not represent final quantities and cost.

Rock Cut Number	**0013**
Maintenance District	2
Highway	VT-30
Mile	4.15
Town	TOWNSHEND
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	614
AADT (2012)	3,000
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, MB
Total RHR Score	**444**

SLOPE DESCRIPTION:
This 114 feet tall, 614 feet long rock slope was remediated in 2015. The slope was machine scaled, high scaled, and approximately 980 linear feet of rock dowels were installed. Three hundred linear feet of drains were also installed. The slope consists of interbedded garnet schist and amphibolite. The roadway here lies extremely close to the rock slope. The remediation measures conducted in 2015 significantly reduced the chances of future rockfall however continued weathering of the slope face in the future could lead to an increase of rockfall events and as such, this slope remains ranked as an "A".

REMEDIATION OPTIONS:
Future remediation at this site might consist of periodic (10 year?) machine scaling and high scaling to remove loose rock from the slope that deteriorates over time.

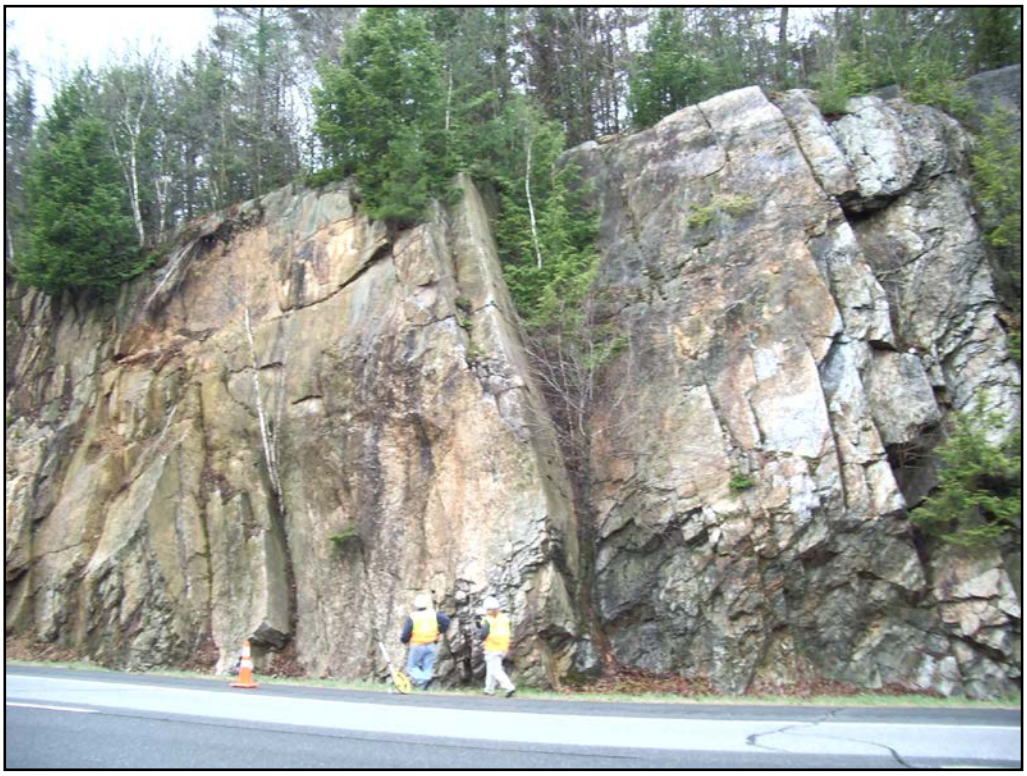
More permanent remediation may be obtained by re-locating the roadway away from the rock slope and creating a rock catchment ditch adjacent to the slope.

CONDITIONS:
This cut is on a curve that limits sight distance and there is poor ditch catchment.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **High Scaling**	**100 Hours (2 Weeks)** **15 Days (3 Weeks)**	**$206,000**	**464**

Rock Cut Number	**0015**
Maintenance District	2
Highway	I-91
Mile	47.58
Town	WEATHERSFIELD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	700
AADT (2012)	10,200
Posted Speed Limit	65
Date Last Inspected	07/15/2015
Inspectors	ET, RM
Total RHR Score	**261**



SLOPE DESCRIPTION:
This rock cut is 52 feet tall and 700 feet long. The slope consists of a quartzite conglomerate. The primary failure types are planar failure along foliation and wedge failure along the intersection of the joint surfaces and foliation. The slope has overhangs, is damp and is moderately vegetated.

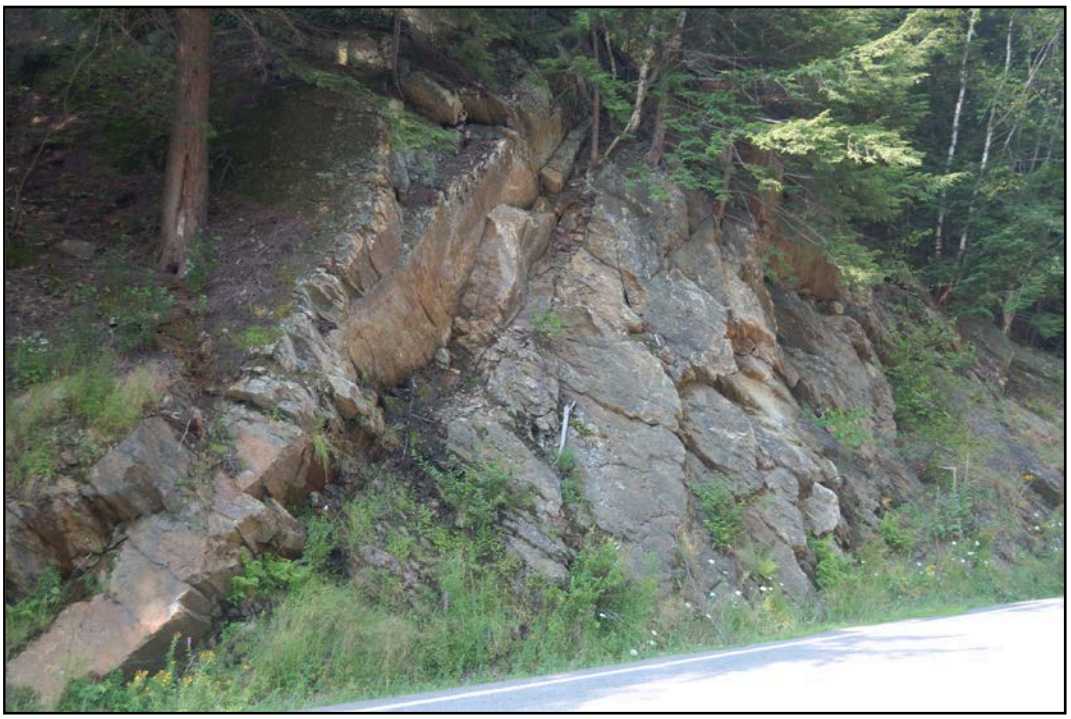
REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock utilizing high scaling techniques, machine scaling of the slope, and the installation of rock dowels.

CONDITIONS:
This is an interstate highway. Detour possibilities might include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Rock Dowels**	**5 Days** **2 Days** **400 Lin. ft**	**$113,000**	**433**

Rock Cut Number	**0017**
Maintenance District	**3**
Highway	VT-100A
Mile	0.23
Town	BRIDGEWATER
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	150
AADT (2012)	680
Posted Speed Limit	50
Date Last Inspected	06/12/2015
Inspectors	ET, MB
Total RHR Score	**319**



SLOPE DESCRIPTION:
This rock cut is 32 feet high and 150 feet long. The slope consists of garnet schist. The primary failure types are toppling and plane failure. The center of the cut is severely weathered along the intersection of two joints. The slope is heavily vegetated making it difficult to judge the extent of deterioration of the slope from the roadway. The most recent rockfall from this cut occurred in 2005 and rock did reach the roadway.

REMEDIATION OPTIONS:
Remediation of this slope requires the removal of loose and unstable rock by machine scaling the slope.

CONDITIONS:
This rock cut is located on VT-100A and will require one lane closure for mitigation purposes.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**5 Days**	**$19,000**	**60**

Rock Cut Number	**0020**
Maintenance District	3
Highway	VT-103
Mile	0.74
Town	CAVENDISH
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	217
AADT (2012)	5,200
Posted Speed Limit	50
Date Last Inspected	06/18/2015
Inspectors	TE, ET
Total RHR Score	**176**

SLOPE DESCRIPTION:
This rock cut is 42 feet high and 217 feet long. A major rockfall occurred at this site in 2004. The failure occurred near the top of the slope to the left of the orange traffic cone in the picture above. The slope consists of schist with adverse jointing. The primary failure type is toppling. The slope has overhangs and is moderately vegetated.

REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock utilizing high scaling techniques, machine scaling the slope, and the installation of Tecco Mesh across the slope face.

CONDITIONS:
This rock cut exists on VT-103 and will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Tecco Mesh**	**5 Days** **10 Days** **8,000 ft^2**	**$204,000**	**1159**

Rock Cut Number	**0021**
Maintenance District	3
Highway	VT-103
Mile	0.82
Town	CAVENDISH
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	290
AADT (2012)	5,200
Posted Speed Limit	50
Date Last Inspected	06/18/2015
Inspectors	TE, ET
Total RHR Score	**330**

SLOPE DESCRIPTION:
This rock cut is 46 feet tall and 290 feet long. The slope consists of rusty weathering, graphitic schist. The primary failure type is wedge failure along the intersection of the foliation and a joint set. The slope is wet and is highly vegetated during the spring and summer months.

REMEDIATION OPTIONS:
Remediation of this slope requires the removal of loose and unstable rock utilizing high scaling techniques, machine scaling the slope, installation of rock dowels, and the installation of a rockfall catchment fence.

CONDITIONS:
This is rock cut is located on VT-103 and remediation will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Rock Dowels** **Rockfall Catchment Fence Med. Capacity**	**5 Days** **2.5 Days** **400 Lin. Ft** **100 Lin. Ft**	**$164,000**	**497**

Rock Cut Number	**0024**
Maintenance District	3
Highway	VT-30
Mile	3.08
Town	HUBBARDTON
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	550
AADT (2012)	1,500
Posted Speed Limit	50
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**477**

SLOPE DESCRIPTION:
This rock cut is 39 feet tall and 550 feet long. This slope is known to continuously shed rock into the roadway. The primary failure type is planar failure along foliation. The slope consists of slate that is dipping towards the roadway. The district has conducted partial remediation of the slope in the past (machine scaling) and has installed Jersey Barrier at the base of the cut. This cut is currently programmed for mitigation as Hubbardton STP 0161(32).

REMEDIATION OPTION:
Planned remediation for this slope consists of the removal of loose and unstable rock utilizing high scaling techniques and machine scaling of the slope face.

CONDITIONS:
This rock cut exists on VT-30 and will require one lane of closure for remediation to take place. A power pole exists adjacent to the slope face. This will need to be temporarily removed during scaling activities. Care must be taken by the contractor performing the machine scaling, as it will be quite easy to over-excavate the slope and cause further destabilization of the slope.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
High Scaling **Machine Scaling**	**4 Days** **20 Days**	**$214,000**	**449**

***Quantities and Estimated Cost come from current preliminary plans and may not represent final quantities and cost.

Rock Cut Number	**0025**
Maintenance District	3
Highway	VT-30
Mile	3.79
Town	HUBBARDTON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	925
AADT (2012)	1,500
Posted Speed Limit	50
Date Last Inspected	6/11/2015
Inspectors	TE, ET
Total RHR Score	**270**

SLOPE DESCRIPTION:
This rock cut is 40 feet tall and 925 feet long. The slope consists of phyllite and the primary failure type is toppling. Fallen rock debris was located over the embankment signifying a past rockfall event. The slope is moderately vegetated and is dry.

REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock by machine scaling the slope and high scaling of the slope.

CONDITIONS:
This rock cut exists on VT-30. One lane of traffic will need to be closed for remediation purposes.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **High Scaling**	**5 Days** **5 Days**	**$74,000**	**275**

Rock Cut Number	**0026**
Maintenance District	3
Highway	VT-30
Mile	3.94
Town	HUBBARDTON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	640
AADT (2012)	1,500
Posted Speed Limit	50
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**193**

SLOPE DESCRIPTION:
This rock cut is approximately 16 feet tall and is 640 feet long. The slope consists of phyllite that is being undermined by the erosion of less competent layers, which in turn, is causing toppling failure. This slope was machine scaled in 2003 after a rockfall event had shed rock into the roadway. The slope has excessive vegetation on the summit.

REMEDIATION OPTIONS:
Remediation of this rock cut will require the removal of loose and unstable rock by machine scaling the slope face.

CONDITIONS:
This rock cut exists on VT-30 and will require the closure of one lane of traffic for remediation purposes.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**2 Days**	**$8,000**	**41**

Rock Cut Number	**0027**
Maintenance District	3
Highway	US-4
Mile	2.30
Town	MENDON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	835
AADT (2012)	9,300
Posted Speed Limit	50
Date Last Inspected	6/11/2015
Inspectors	ET, MB
Total RHR Score	**233**

SLOPE DESCRIPTION:
This slope is 21 feet high, 835 feet long, and consists of a combination of quartzite, schist, and gneiss. The primary failure type is plane failure along foliation. The stereonet shows that toppling failure along a joint set can also occur. The slope is moderately vegetated and is also quite wet.

REMEDIATION OPTIONS:
Remove loose rock utilizing machine scaling. This slope is scheduled to be machine scaled in 2016 as part of Rutland-Killington NH 020-2(36).

CONDITIONS:
Remediation will require the closure of the east bound lane for the duration of machine scaling.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**10 Days**	**$34,000**	**146**

Rock Cut Number	**0028**
Maintenance District	3
Highway	VT-100
Mile	7.63
Town	PLYMOUTH
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	307
AADT (2012)	1,200
Posted Speed Limit	50
Date Last Inspected	06/12/2015
Inspectors	ET, MB

Total RHR Score **251**

SLOPE DESCRIPTION:
This 70 feet tall, 307 feet long rock cut consists of meta-dolomite. The picture above shows potential overhanging blocks that could easily reach the roadway if/when they fall. The two primary failure types for this cut are wedge failure and plane failure along foliation and the intersection of joint sets. Roadside vegetation at this site severely limits sight distance.

REMEDIATION OPTIONS:
Remediation consists of trim blasting potential overhangs, installing rock dowels, machine scaling the slope, and removing loose and unstable rock by high scaling the slope.

CONDITIONS:
This rock cut is on VT-100 and requires the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Rock Dowels** **High Scaling** **Machine Scaling**	**50 cy** **1,500 Lin. ft** **10 Days** **5 Days**	**$322,000**	**1283**

Rock Cut Number	**0029**
Maintenance District	3
Highway	VT-100A
Mile	0.11
Town	PLYMOUTH
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	291
AADT (2012)	930
Posted Speed Limit	50
Date Last Inspected	06/12/2015
Inspectors	ET, MB
Total RHR Score	**468**

SLOPE DESCRIPTION:
This slope is a high cut/natural exposure that sheds large slabs of rock along planes that dip at high angles toward the roadway. The natural portion of this cut is heavily vegetated and the slope is very wet. The toe of the rock slope is within 4-feet of the pavement.

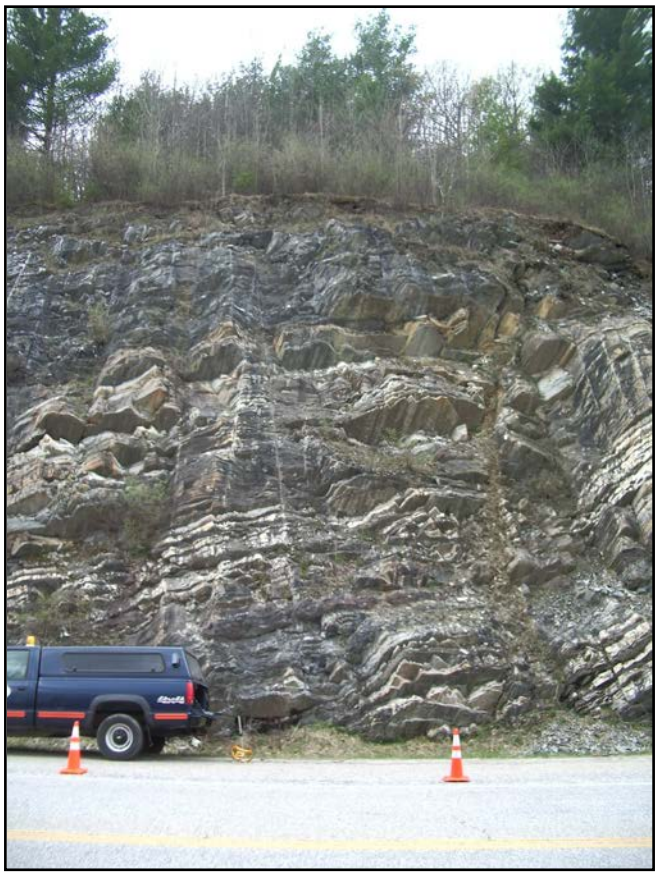
REMEDIATION OPTIONS:
Remove loose rock from the slope utilizing high scaling techniques and using pattern rock doweling.

CONDITIONS:
Roadway is narrow here and the slope is heavily vegetated. There is limited ditch area and rock slabs that fall could easily topple out onto the roadway. Mitigation operations should require only closing one lane and flagging one way traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Pattern Rock Dowling	**30 Days 1,800 Lin. ft**	**$478,000**	**1,021**

Rock Cut Number	**0032**
Maintenance District	3
Highway	US-7
Mile	3.11
Town	WALLINGFORD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	773
AADT (2012)	4,200
Posted Speed Limit	50
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**353**



SLOPE DESCRIPTION:
This rock cut is 45 feet tall and 773 feet long. The slope consists of interbedded marble, phyllite, and quartzite with large overhangs. The primary failure type is toppling, with the less resistant phyllites and marbles eroding away faster than the more resistant quartzite. Many rockfall events have occurred at this site in the past.

REMEDIATION OPTIONS:
Remediation of this rock slope will consist of trim blasting overhangs, removing loose and unstable rock by utilizing high scaling techniques, machine scaling the slope face, and installing a concrete buttress to provide support for overhangs and to fill voids.

CONDITIONS:
This rock slope exists on US-7 and will require closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **High Scaling** **Machine Scaling** **Buttress**	**100 cy** **10 Days** **10 Days** **500 ft^2**	**$181,000**	**513**

Rock Cut Number	**0033**
Maintenance District	3
Highway	VT-140
Mile	2.45
Town	WALLINGFORD
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	325
AADT (2012)	780
Posted Speed Limit	40
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**420**

SLOPE DESCRIPTION:
This rock cut is 37 feet tall and 325 feet long. The slope consists of quartzite and gneiss. The primary failure types are wedge failure, plane failure, and toppling. The slope is moderately vegetated, is wet, and has overhangs. There was a major rockfall at this site in 2005.

REMEDIATION OPTIONS:
Remediation of this slope requires installation of rock dowels and removing loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
This rock cut is located on VT-140 and will require closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**5 Days** **600 Lin. ft**	**$124,000**	**295**

Rock Cut Number	**0036**
Maintenance District	3
Highway	VT-30
Mile	4.94
Town	WELLS
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,450
AADT (2012)	1,900
Posted Speed Limit	40
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**465**

SLOPE DESCRIPTION:
This slate rock cut is 66 feet tall and 1,450 feet long. The primary failure type is toppling failure. The slope was high scaled and machine scaled in 2002. The District has reported that this site has been a source of constant rockfalls in the past. Approximately 0.5 inch tension cracks were observed forming behind small overhangs on the rock slope during the 2015 evaluation. The width of the ditch varies throughout the cut. Ditch width ranges from 5 feet at the northern end of the slope to 18 feet at the southern end of the slope. It is possible for the present overhangs to overwhelm the ditch and spill into the roadway. This slope will continue to be monitored. It is expected that further deterioration of the slope will occur over time.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
This rock slope lies on VT Route 30 next to Lake Saint Catherine. High scaling will force stop and go traffic. One lane of closure will be needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**3 Weeks**	**$201,000**	**432**

Rock Cut Number	**0037**
Maintenance District	3
Highway	US-4
Mile	13.51
Town	WEST RUTLAND
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	5,000
AADT (2012)	13,100
Posted Speed Limit	65
Date Last Inspected	6/12/2015
Inspectors	ET, MB
Total RHR Score	**379**

SLOPE DESCRIPTION:
This rock cut is 35 feet tall and approximately 5,000 feet long. The slope is quite wet and consists of phyllite dipping towards the roadway. The primary failure type is plane failure occurring along foliation. There was a major rockfall here in 2004.

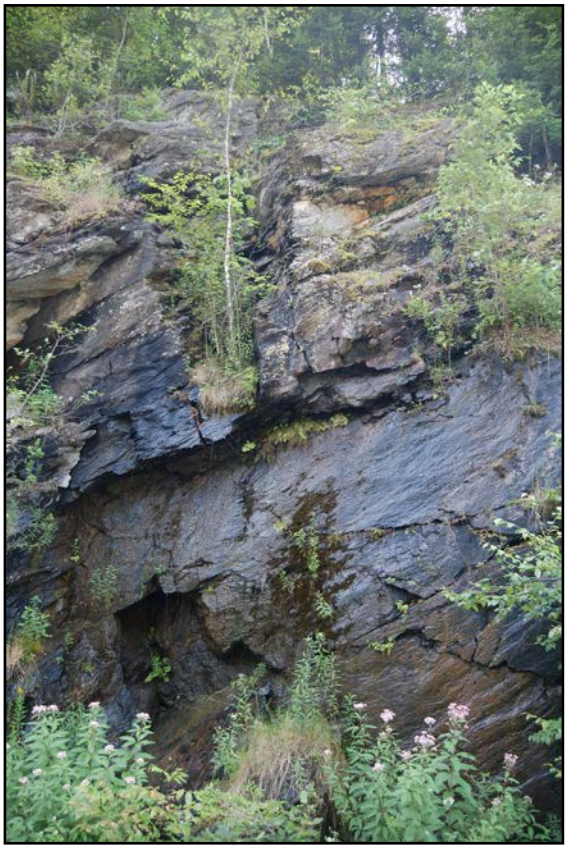
REMEDIATION OPTIONS:
Remediation of this slope will require trim blasting and removing loose and unstable rock by machine scaling the slope.

CONDITIONS:
This rock cut exists on US-4 and will require one traffic lane to be closed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Machine Scaling**	**500 cy** **20 Days**	**$116,000**	**306**

Rock Cut Number	**0038**
Maintenance District	4
Highway	US-4
Mile	2.57
Town	BRIDGEWATER
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	485
AADT (2012)	3,700
Posted Speed Limit	50
Date Last Inspected	06/12/2015
Inspectors	ET, MB
Total RHR Score	**234**



SLOPE DESCRIPTION:
This rock cut is 41 feet tall and 485 feet long. The slope is composed of phyllitic schist. The primary failure type is toppling failure. The stereonet also shows the potential for plane failure. The slope is quite wet and is moderately vegetated. This rock cut has produced few rockfalls in the past.

REMEDIATION OPTION:
Remediation consists of the removal of loose and unstable rock utilizing high scaling techniques and machine scaling of the slope. Also drain holes should be drilled into rock for water drainage.

CONDITIONS:
This rock cut lies on US-4 and will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Drain Holes in Rock**	**10 Days** **10 Days (100 Hours)** **150 Lin. ft**	**$147,000**	**628**

Rock Cut Number	**0039**
Maintenance District	4
Highway	I-91
Mile	89.52
Town	FAIRLEE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	864
AADT (2012)	10,300
Posted Speed Limit	65
Date Last Inspected	08/1/2015
Inspectors	TE, ET
Total RHR Score	**589**

SLOPE DESCRIPTION:
This slope is very active, as it has been producing rockfalls for many years. The rock type here is phyllite that has been folded multiple times. Due to the folding, various plane and toppling failure orientations are present. The slope was partially mitigated as part of the Hartford-Newbury Project in 2009. Remediation included high scaling, machine scaling and installation of a hybrid rockfall fence. The most recent rockfall occurred on Dec. 5th, 2011. The rockfall originated in the area adjacent to the end of the netting. Nearly all debris was contained within the ditch. Overhangs were noted in 2015 that are forming at the top of a folded section of the slope adjacent to the fence.

REMEDIATION OPTION:
Remove loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
High scaling should be performed on the section of the slope adjacent to the netting. If scaling is performed in the section that contains the netting, then care must be taken not to damage or overwhelm the netting. The netting will have to be cleaned out as well. This is an interstate highway with some shoulder room. One lane of traffic will need to be closed during remediation. A temporary rockfall fence can be used during high scaling operations.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**21 Days**	**$243,000**	**413**

Cut Number	**0040**
Maintenance District	4
Highway	I-91
Mile	89.78
Town	FAIRLEE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,540
AADT (2012)	10,300
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**309**

SLOPE DESCRIPTION:
This rock cut is 81 feet tall and 1,540 feet long. The slope consists of slate and phyllite. The primary failure type is toppling, which occurs along foliation. The slope is moderately vegetated. The rock cut was remediated in 2009 as part of the Hartford-Newbury Project. Remediation consisted of high scaling, machine scaling, and the installation of rock dowels.

It was noticed during the 2015 evaluation that 3 bolts have failed and the rock mass being supported has moved. It appears the cause of failure was induced by a lack of grout between the bolt and rock mass. The bolts above and around the failed bolts appear in good condition. The slope will continued to be monitored and it is expected that further machine scaling, high scaling, and possibly more rock dowels will be needed in the future.

REMEDIATION OPTIONS:
Further remediation of this slope will consists of the removal of loose and unstable rock utilizing high scaling techniques, machine scaling the slope face, and possibly installing rock dowels.

CONDITIONS:
This is Interstate highway with ample shoulder room. One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Rock Dowel Installation**	**2 Weeks** **2 Weeks** **300 Lin. Ft**	**$200,000**	**647**

Rock Cut Number	**0044**
Maintenance District	4
Highway	VT-100
Mile	4.46
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	96
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	ET, TE
Total RHR Score	**323**

SLOPE DESCRIPTION:
This rock cut is 30 feet tall and 96 feet long. The slope here is heavily vegetated and consists of schist. The primary failure types are planar failure along foliation and raveling. There is little to no ditch at this site and the cut is located on a curve in the road, making it more hazardous. The District has reported that this slope has produced some minor rockfalls in the past that have gotten into the roadway.

REMEDIATION OPTION:
Remediation consists of removing loose and unstable rocks by machine scaling the slope.

CONDITIONS:
This rock cut lies on VT-100. There is little shoulder room here and mitigation will require closure of one lane of traffic and stop and go traffic. This cut is also located on National Forest land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**5 Days (50 Hours)**	**$17,000**	**53**

Rock Cut Number	**0045**
Maintenance District	4
Highway	VT-100
Mile	5.45
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	386
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	ET, TE
Total RHR Score	**264**

SLOPE DESCRIPTION:
This rock cut is 60 feet tall and 386 feet long. The slope consists of schist and the primary failure type is plane failure along foliation. The slope is heavily vegetated and because of this much of the rock slope is hidden to the driver. Some seeps of water were noted on the slope.

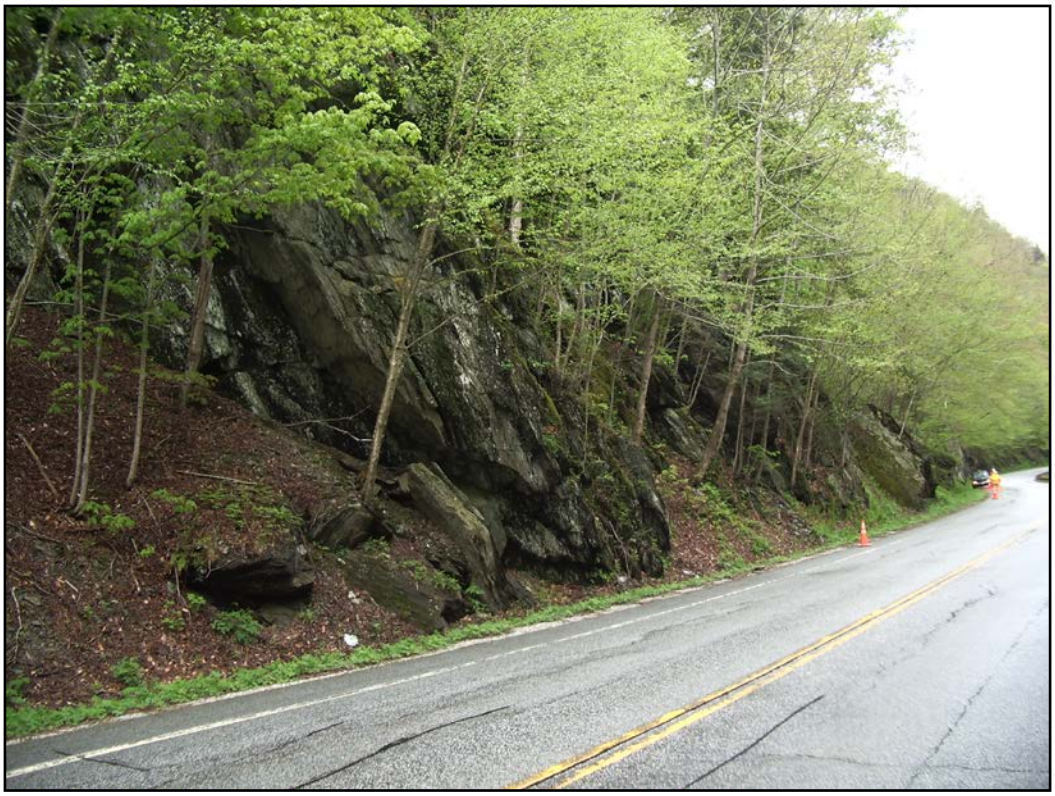
REMEDIATION OPTION:
Remediation of this slope consists of the removal of loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
This rock slope lies on VT-100 and has little shoulder room. Remediation will require the closure of one lane of traffic and possibly stop and go traffic. This slope lies on National Forest land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**3 Days (30 Hours)**	**$31,000**	**117**

Rock Cut Number	**0046**
Maintenance District	4
Highway	VT-100
Mile	5.89
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	330
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	ET, TE
Total RHR Score	**553**



SLOPE DESCRIPTION:
This rock cut is approximately 70 feet tall and 330 feet long. The slope is heavily vegetated and consists of schist. The primary failure type is plane failure and toppling. The rock cut has very large overhangs further up the slope, which are hidden by the excessive vegetation.

REMEDIATION OPTION:
Remediation consists of the removal of loose and unstable rock by utilizing high scaling techniques, trim blasting potential overhangs, and the installation of rock dowels.

CONDITIONS:
This rock slope lies on VT-100 and has little shoulder room. Mitigation will require the closure of both lanes. This rock slope lies on National Forest Land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **High Scaling** **Rock Dowels**	**1,000 cy** **20 Days** **1,000 Lin. ft**	**$520,000**	**940**

Rock Cut Number	**0047**
Maintenance District	4
Highway	VT-100
Mile	5.97
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	200
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	ET, TE
Total RHR Score	**368**

Southbound view

Northbound view

SLOPE DESCRIPTION:
This rock cut is 52 feet tall and 200 feet long. The slope is heavily vegetated, has large overhangs, and sits close to the roadway. The slope consists of schist and the primary failure type is plane failure. The District has reported that this site has produced some minor rockfalls in the past.

REMEDIATION OPTION:
Remediation will consist of trim blasting potential overhangs and removing loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
This rock slope lies on VT-100 and has little shoulder room. Mitigation will require closure of both lanes of traffic. This cut lies on National Forest land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting High Scaling	**500 cy 3 Days**	**$88,000**	**239**

Rock Cut Number	**0049**
Maintenance District	4
Highway	VT-100
Mile	6.35
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	625
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	ET, TE
Total RHR Score	**495**

SLOPE DESCRIPTION:
This rock slope is 52 feet tall and 625 feet long. The rock consists of schist and greenstone. The primary failure types are plane failure and raveling. This slope has large overhangs, is heavily vegetated and is wet. The District has reported that this slope has produced some minor rockfalls that have gotten into the roadway in the past.

REMEDIATION OPTIONS:
Remove loose rock from the slope utilizing high scaling and machine scaling techniques. Some trim blasting to remove overhangs may be required.

CONDITIONS:
Traffic control may be an issue here because of the limited space conditions. One lane of traffic must be closed during remediation. This slope lies on National Forest land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Rock Doweling** **High Scaling** **Machine Scaling**	**50 cy** **100 Lin. ft** **10 Days** **60 Hours**	**$152,000**	**307**

Rock Cut Number	**0050**
Maintenance District	4
Highway	VT-100
Mile	6.47
Town	GRANVILLE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	180
AADT (2012)	950
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	TE, ET
Total RHR Score	**438**

SLOPE DESCRIPTION:
This slope is 38 feet tall and 180 feet long. The rock is made up of schist and greenstone. The primary failure types are plane failure and raveling. The slope has overhangs, is heavily vegetated at the crest, and is wet.

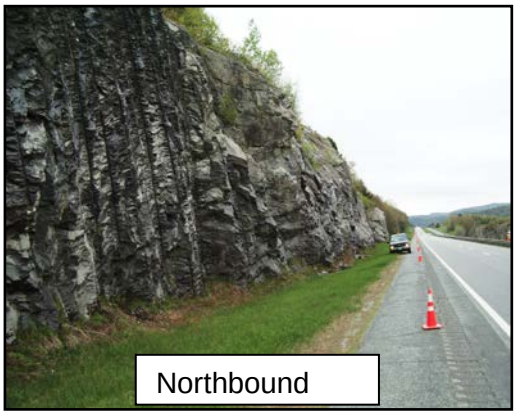
REMEDIATION OPTIONS:
Remove loose rock from the slope utilizing high scaling and machine scaling techniques. Some trim blasting and rock dowels may be required.

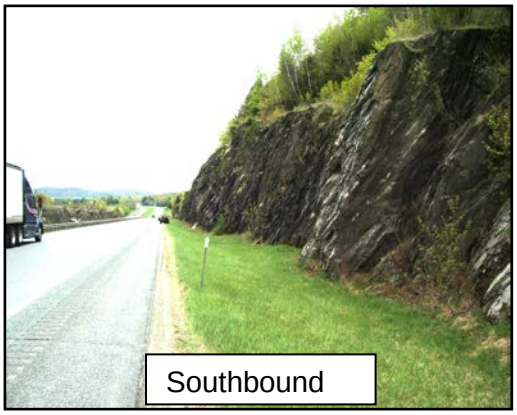
CONDITIONS:
Traffic control may be an issue here because of the limited space conditions. Stop and go traffic will need to be used. This slope lies on National Forest land.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Trim Blasting** **Rock Dowels**	**10 Days** **60 Hours** **50 cy** **100 Lin. ft**	**$134,000**	**306**

Rock Cut Number	**0052**
Maintenance District	4
Highway	I-89
Mile	5.53
Town	HARTFORD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,005
AADT (2012)	16,500
Posted Speed Limit	65
Date Last Inspected	07/17/2015
Inspectors	ET, MB
Total RHR Score	**347**





SLOPE DESCRIPTION:
This rock cut is 46 feet tall and 1,005 feet long. The primary rock type is schist and gneiss. The primary failure types are wedge failure and plane failure. The summit of the slope is moderately vegetated. There is a large overhang in the center of the cut that is dipping towards the roadway. It is likely that this block will overwhelm the ditch when it fails.

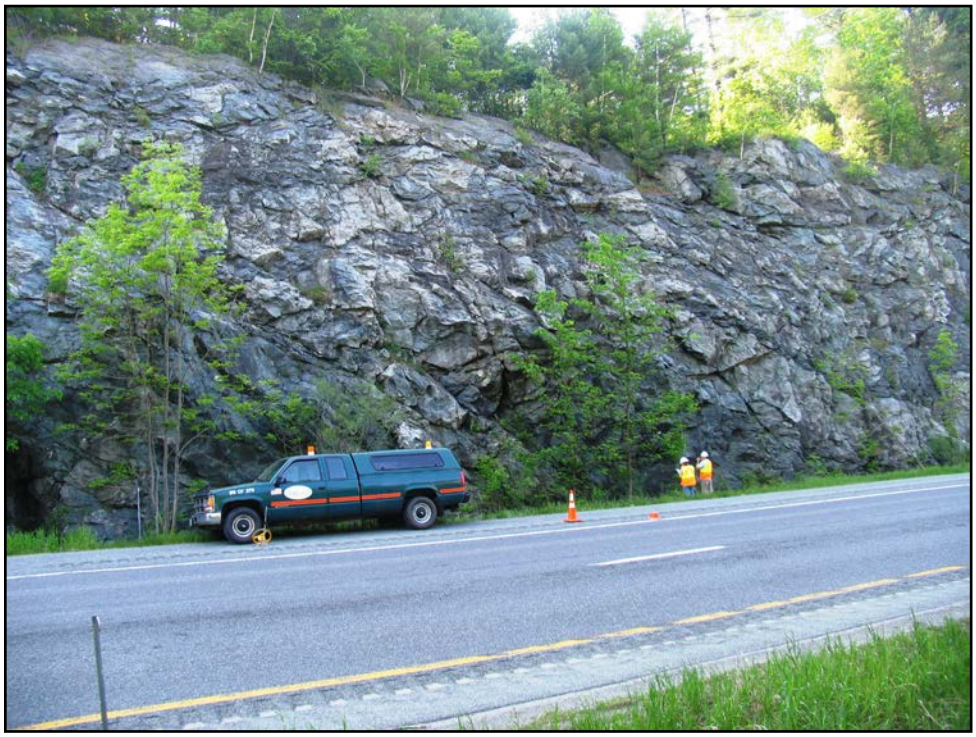
REMEDIATION OPTIONS:
Remediation consists of removing loose and unstable rock by utilizing high scaling techniques, machine scaling the slope, trim blasting overhangs, and the installation of rock dowels.

CONDITIONS:
This is Interstate highway with decent shoulder area. Detour possibilities might include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Trim Blasting** **Rock Dowel**	**5 Days** **2 Days** **1,000 cy** **150 Lin. ft**	**$201,000**	**579**

Rock Cut Number	**0055**
Maintenance District	4
Highway	I-91
Mile	71.61
Town	HARTFORD
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,414
AADT (2012)	19,800
Posted Speed Limit	55
Date Last Inspected	8/28/2015
Inspectors	ET, MG
Total RHR Score	**395**



SLOPE DESCRIPTION:
This rock cut is 69 feet tall and 1,414 feet long. The slope consists of meta-volcanic rock that is broken up by faulting and jointing. The primary failure type is raveling. The stereonet plot shows the potential for plane failure along the fault surface as well. This site has produced rockfall events in the past that have reached the roadway.

The slope was remediated in 2009 as part of the Hartford-Newbury IM 091-2(72) Project. Remediation consisted of high scaling, machine scaling, and the installation of rock dowels. The sections that were scaled are expected to deteriorate overtime. No recent rockfall was observed in the ditch during the 2015 survey. This slope will continue to be monitored.

REMEDIATION OPTIONS:
Further remediation of this slope will consist of the removal of loose and unstable rock utilizing high scaling techniques and the installation of rock dowels as needed.

CONDITIONS:
This is Interstate highway with decent shoulder area. Detour possibilities might include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel Installation**	**10 Days** **200 Lin. ft**	**$157,000**	**397**

Rock Cut Number	**0058**
Maintenance District	4
Highway	US-5
Mile	2.60
Town	NORWICH
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	626
AADT (2012)	1,600
Posted Speed Limit	40
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**328**

SLOPE DESCRIPTION:
This rock cut is 40 feet tall and 626 feet long. The slope consists of quartzite that is broken up by jointing and faulting. The primary failure type is plane failure, however, there is a potential for toppling failure. The slope is heavily vegetated and is dry. On March 29, 2007, there was a rockfall that landed in the roadway and caused approximately $3,000 worth of damage to a Thetford Police cruiser. The previous interview with the District indicated that there were few rockfalls at this site and no history of accidents.

REMEDIATION OPTIONS:
Option 1: Remediation of the slope will require the removal of loose and unstable rock utilizing high scaling techniques, machine scaling of the slope, installation of rock dowels, and application of shotcrete.
Option2: Cut the slope back to 1H:1V.

CONDITIONS:
Mitigation for either option will require closure of both lanes of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

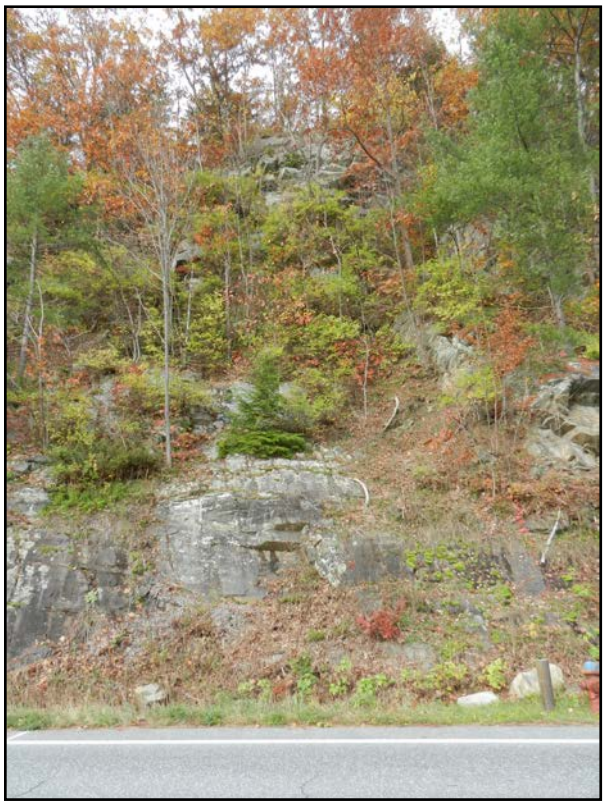
OPTION 1:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **High Scaling** **Rock Dowels** **Shotcrete**	**3 Days** **10 Days** **150 Lin. ft** **50 cy**	**$243,000**	**741**

OPTION2:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blasting Slope to 1H:1V	**25,538 cy**	**$483,000**	**1473**

Rock Cut Number	**0059**
Maintenance District	4
Highway	US-5
Mile	3.51
Town	NORWICH
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	840
AADT (2012)	1,600
Posted Speed Limit	50
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**375**



SLOPE DESCRIPTION:
This rock cut is 99 feet tall and 840 feet long. The slope consists of amphibolite and quartzite. The primary failure types are toppling and plane failure. The slope is heavily vegetated and is damp. The upper part of the slope sits further back from the roadway and has large overhangs.

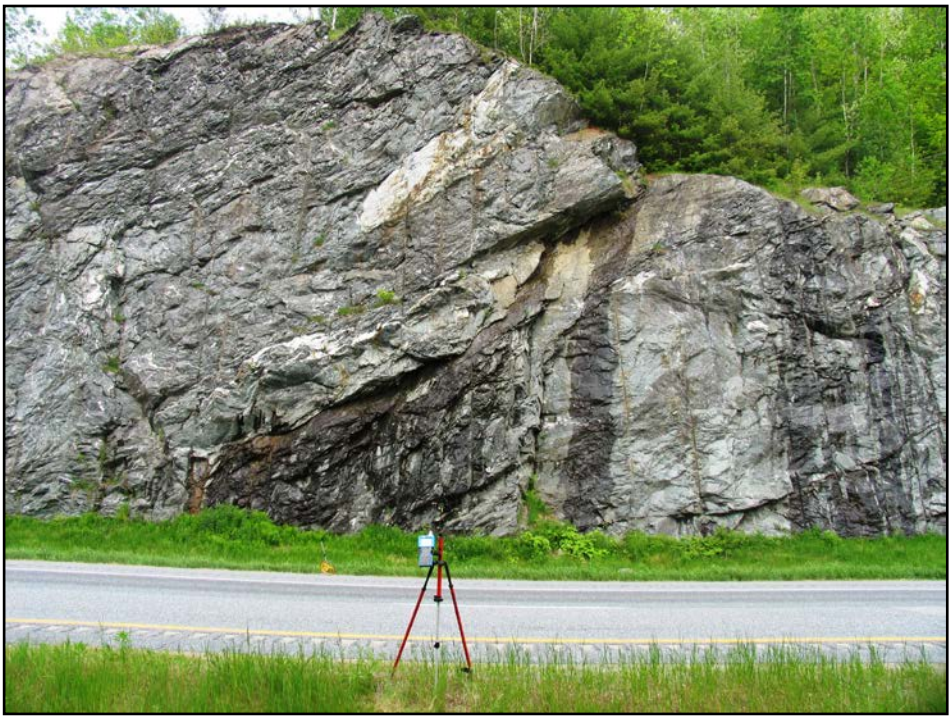
REMEDIATION OPTION:
Remediation of this slope will require the removal of loose rock by machine scaling the slope, removal of loose rock by high scaling, and drilling drain holes into rock.

CONDITIONS:
This slope lies on US-5 and will require closure of both lanes of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Drain Holes**	**20 Days** **5 Days** **200 Lin. ft**	**$238,000**	**635**

Rock Cut Number	**0060**
Maintenance District	4
Highway	I-91
Mile	77.29
Town	NORWICH
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,345
AADT (2012)	11,700
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**412**



SLOPE DESCRIPTION:
This rock cut is 71 feet high and 1,345 ft long. The slope consists of meta-volcanic-greenstone rock. This slope has a fault within it that acts as a major sliding surface. The primary failure type at this slope is raveling. Large overhangs are present on the slope.

This area was remediated in 2008 as part of the Hartford – Newbury IM091-2(72) Project. 13 rock dowels were installed and 4 drain holes were installed. No recent rockfall was observed during the 2015 evaluation. It is expected that further deterioration of the slope will lead to the creation of more unstable overhangs, which could overwhelm the ditch if they fail. The slope will continue to be monitored.

REMEDIATION OPTIONS:
Further remediation of this slope will consist of high scaling of the slope to remove loose and unstable rock and the installation of rock dowels as needed.

CONDITIONS:
This is Interstate highway with decent shoulder width. One lane of traffic will need to be closed during remediation. Stop and Go traffic can be used as needed. The use of crossovers may also be considered.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel Installation**	**7 Days** **300 Lin. ft**	**$138,000**	**335**

Rock Cut Number	**0061**
Maintenance District	4
Highway	VT-106
Mile	7.04
Town	READING
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	150
AADT (2012)	1,000
Posted Speed Limit	50
Date Last Inspected	06/18/2015
Inspectors	TE, ET
Total RHR Score	**314**

SLOPE DESCRIPTION:
This rock cut is 23 feet high and 150 feet long. The slope consists of moderately dipping schist and quartzite. The primary failure type includes toppling and raveling. The slope is moderately vegetated. During the 2011 field season, evidence of rock reaching the road was observed. There is still a high potential for loose blocks to ravel down the slope.

REMEDIATION OPTION:
Remediation of this slope will consist of removing loose rock from the slope by utilizing machine scaling.

CONDITIONS:
This section of VT-106 requires the closure of one lane to perform machine scaling.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**2 Days**	**$8,000**	**25**

Rock Cut Number	**0062**
Maintenance District	4
Highway	I-89
Mile	21.77
Town	ROYALTON
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	700
AADT (2012)	15,100
Posted Speed Limit	65
Date Last Inspected	04/22/2015
Inspectors	TE, ET
Total RHR Score	**410**

Rockfall at MM 21.8 on 04/22/2015

SLOPE DESCRIPTION:
This is a very wet slope with some dramatic folding of the rock fabric. Because of the folded nature of the rock, numerous unfavorable orientations of discontinuities will make cutting the slope difficult while maintaining a stable slope. The District conducted some machine scaling in the early 2000's here after rock let loose from the fold axis and spilled out onto the highway. The ground surface continues to rise steeply above the top of the cut. A rockfall also occurred on April 22, 2015. The rockfall filled the ditch and spilled into the shoulder. Emergency scaling of the area was performed to remove the remaining overhanging blocks. Further scaling of the slope is recommended.

REMEDIATION OPTIONS:
Option 1: Cut the slope back on a lower angle. For conceptual design estimating, assume cutting the slope back on a 1.5V:1H slope. This might necessitate right of way issues.
Option 2: Remove loose rock from the slope utilizing high scaling, machine scaling and trim blasting techniques. Some pattern doweling may be necessary here possibly with some kind of retaining mesh.

CONDITIONS:
This is Interstate highway with ample shoulder area. Detour possibilities might include the use of crossovers. The slope rises steeply, however there is an old logging road that may give access to machinery.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

OPTION1:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut Slope back to 1:5V: 1H	**44,136 cy**	**$698,000**	**1702**

OPTION2:

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Trim Blasting** **Rock Doweling** **Machine Scaling**	**10 Days** **200 cy** **500 Lin. ft** **200 Hours**	**$312,000**	**761**

Rock Cut Number	**0063**
Maintenance District	4
Highway	I-89
Mile	12.62
Town	SHARON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	800
AADT (2012)	16,500
Posted Speed Limit	65
Date Last Inspected	07/17/2015
Inspectors	TE, ET
Total RHR Score	**298**

SLOPE DESCRIPTION:
This rock cut is 48 feet tall and 800 feet long. The slope consists of schist and quartzite that is broken up by at least two joint sets. The intersection of the joint sets causes wedge failure. There is also a strong potential for plane failure. The slope has overhangs, is moderately vegetated at the crest, and is wet. Standing water was observed at the top of the cut.

REMEDIATION OPTION:
Remediation of this slope will require the installation of rock dowels, high scaling, machine scaling, Tecco Mesh, and drilling drain holes into the rock.

CONDITIONS:
This rock cut lies on the interstate and mitigation will require the closure of one traffic lane.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **High Scaling** **Machine Scaling** **Tecco Mesh** **Drain Holes**	**400 Lin. ft** **5 Days** **2 Days** **1,000 ft^2** **200 Lin. ft**	**$144,000**	**483**

Rock Cut Number	**0064**
Maintenance District	4
Highway	I-89
Mile	12.94
Town	SHARON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,100
AADT (2012)	16,500
Posted Speed Limit	65
Date Last Inspected	07/17/2015
Inspectors	ET, MB
Total RHR Score	**425**

SLOPE DESCRIPTION:
This rock cut is 56 feet tall and 1,100 feet long. The slope consists of schist and quartzite that have been broken up by jointing and shearing. There are many loose rocks near the top of the slope. The primary failure types are wedge failure and plane failure. The stereonet plot shows that there is also the potential for toppling failure. Standing water has been observed at the top of the cut, as well as surface cracks likely caused by previous blasting of the cut. This rock cut has produced occasional rockfalls in the past. The summit of the slope is moderately to heavily vegetated.

REMEDIATION OPTIONS:
Remediation of the slope will consist of a combination of rock dowel installation, trim blasting, high scaling, machine scaling, and ditching to reduce the amount of water at the summit of the slope.

CONDITIONS:
This is Interstate highway and one lane of traffic will have to be closed. If detours are needed, crossovers may be used.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **Trim Blasting** **High Scaling** **Machine Scaling** **Ditching**	**1,000 Lin. ft** **600 cy** **5 Days** **2 Days** **2,200 yd**	**$324,000**	**762**

Rock Cut Number	**0067**
Maintenance District	4
Highway	US-5
Mile	6.59
Town	THETFORD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	178
AADT (2012)	1,700
Posted Speed Limit	50
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**411**

Detached block of rock on slope. 01/20/2015

Detached block of rock on slope. 09/2/2015

SLOPE DESCRIPTION:
This rock cut is 36 feet tall and 178 feet long. The slope consists of phyllite that is broken up by adverse jointing. The primary failure type is toppling failure; however, the stereonet shows strong potential for wedge failure and plane failure as well. The slope is moderately to heavily vegetated in some areas. There was a major rockfall here in 2006. The debris from the event easily overwhelmed the ditch and spilled out onto the roadway. Detached rock was noticed resting on the upper slope surface during the 2015 evaluation.

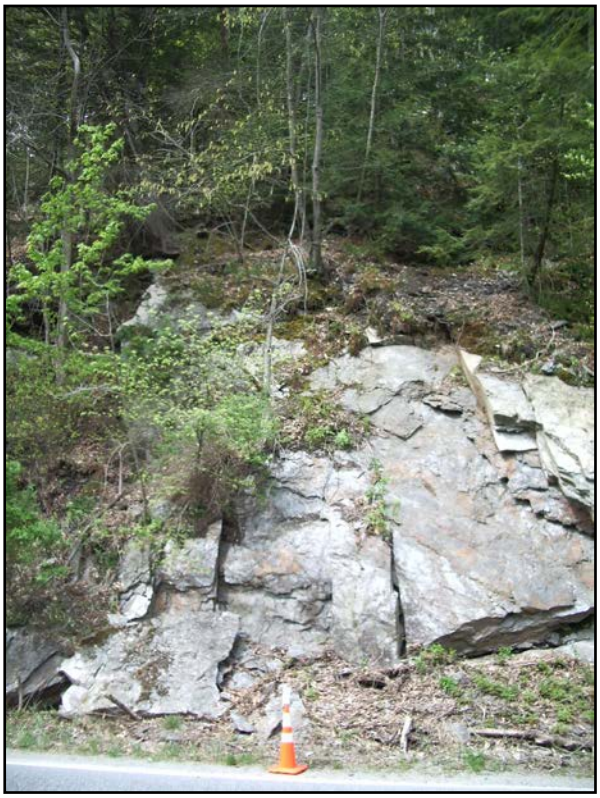
REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock by utilizing high scaling techniques and machine scaling the slope on a re-occurring basis.

CONDITIONS:
This rock slope exists on US-5 and will require closure of both lanes of traffic. Care must be taken when scaling the slope. It will be easy to over-scale the slope leading to further instability.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**2 Days** **3 Days (30 Hours)**	**$28,000**	**68**

Rock Cut Number	**0069**
Maintenance District	4
Highway	VT-44
Mile	3.14
Town	WINDSOR
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	200
AADT (2012)	1,400
Posted Speed Limit	50
Date Last Inspected	07/17/2015
Inspectors	ET, MB
Total RHR Score	**261**



SLOPE DESCRIPTION:
This rock cut is 40 feet tall and 200 feet long. The slope consists of phyllite that is dipping towards the roadway. The primary failure type is plane failure along foliation. Thick vegetation across the slope hides most of the rock slope.

REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock by utilizing high scaling and machine scaling techniques.

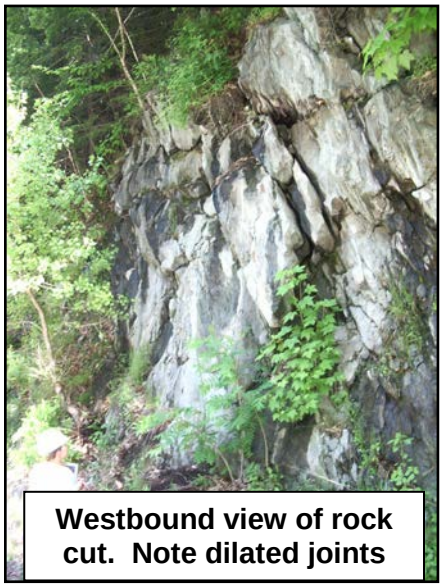
CONDITIONS:
This rock slope exists on VT-44 and remediation will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

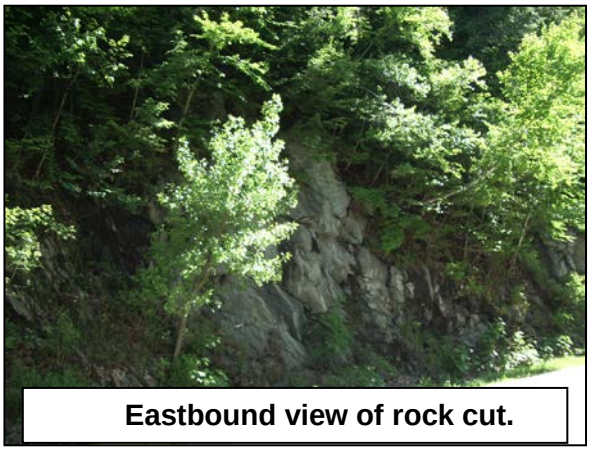
Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**2 Days** **3 Days (30 Hours)**	**$33,000**	**126**

Rock Cut Number	**0070**
Maintenance District	5
Highway	VT-17
Mile	2.09
Town	BRISTOL
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	573
AADT (2012)	1,500
Posted Speed Limit	50
Date Last Inspected	05/21/2015
Inspectors	TE, ET

Gully forming in slope. Debris can easily spill into roadway.



Westbound view of rock cut. Note dilated joints



Eastbound view of rock cut.

Total RHR Score **458**

SLOPE DESCRIPTION:
This rock cut is 47 feet tall and 573 feet long. The slope consists of schist and quartzite. The slope is a combination of soil, boulders, and rock. The slope is heavily vegetated and this masks the massive boulders that sit higher up on the slope.
The primary failure type here is toppling failure. Large volumes of rock and soil (>10 yards) have been shed off this slope in the past.

REMEDIATION OPTIONS:
Remediation consists of removing loose rock utilizing high scaling and machine scaling techniques. Installation of Tecco Mesh or pinned mesh will help to control soil erosion.

CONDITIONS:
This rock slope lies on VT-17 and remediation will require closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **High Scaling** **Tecco Mesh**	**5 Days (50 Hours)** **5 Days (50 Hours)** **1,000 ft^2**	**$90,000**	**197**

Rock Cut Number	**0071**
Maintenance District	5
Highway	I-89
Mile	96.67
Town	COLCHESTER
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	280
AADT (2012)	30,100
Posted Speed Limit	65
Date Last Inspected	08/7/2015
Inspectors	ET, MG
Total RHR Score	**369**

SLOPE DESCRIPTION:
This rock cut is 30 feet tall and 280 feet long. The slope consists of dolomite and the primary type of failure is plane failure. There are large overhangs which could overwhelm the ditch. The slope is moderately vegetated.

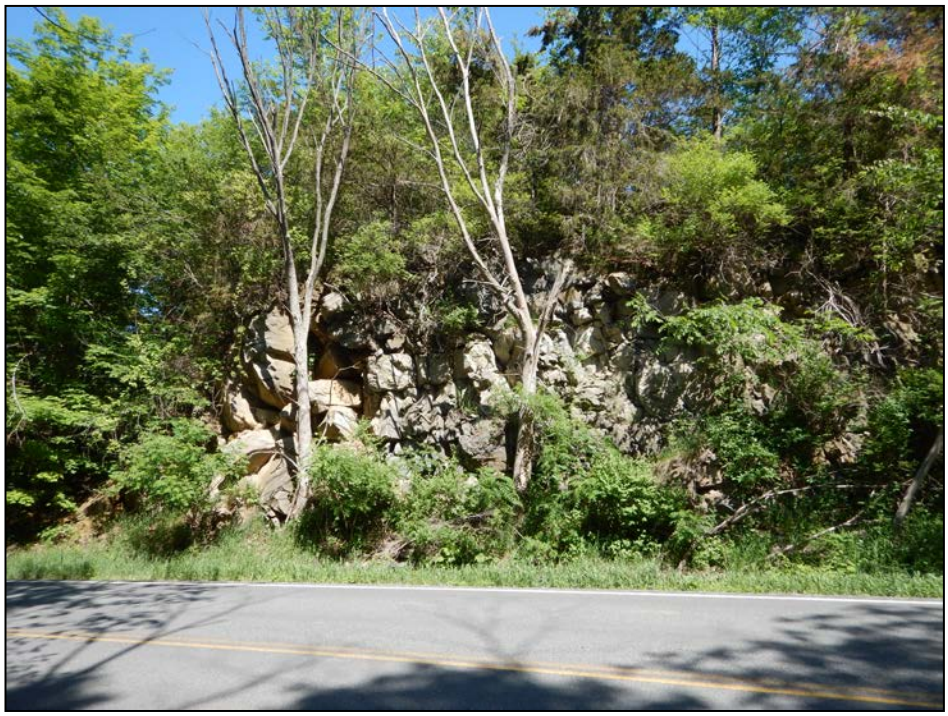
REMEDIATION OPTIONS:
Remediation consists of trim blasting and removing loose rock by machine scaling of the slope.

CONDITIONS:
This is Interstate highway and remediation will require closure of both lanes of traffic. Detour possibilities might include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting Machine Scaling	**500 cy 2 Days (20 Hours)**	**$86,000**	**233**

Rock Cut Number	**0072**
Maintenance District	5
Highway	VT-74
Mile	0.13
Town	CORNWALL
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	110
AADT (2012)	1,900
Posted Speed Limit	50
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**329**



SLOPE DESCRIPTION:
This rock cut is 30 feet tall and 110 feet long. The slope consists of meta-limestone. The primary failure is raveling. The slope has overhangs, is dry and is heavily vegetated. The heavy vegetation makes it difficult for drivers to see the rock cut. This slope has produced occasional rockfalls in the past.

REMEDIATION OPTIONS:
Heavy machine scaling is all that is required to remediate this slope.

CONDITIONS:
This rock slope lies on VT-74 and has little shoulder room. One lane of traffic will need to be closed for remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**3 Days (30 Hours)**	**$17,000**	**52**

Rock Cut Number	**0073**
Maintenance District	5
Highway	VT-125
Mile	2.21
Town	CORNWALL
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	484
AADT (2012)	1,900
Posted Speed Limit	50
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**439**

SLOPE DESCRIPTION:
This rock cut is 22 feet tall and 484 feet long. The slope consists of limestone. The primary failure types are toppling and raveling. The slope is heavily vegetated. This slope has produced rockfalls in the past that have shed >10 yards of rock onto the roadway.

REMEDIATION OPTIONS:
Remediation will be obtained by removing loose and unstable rock by machine scaling the slope.

CONDITIONS:
This rock slope lies on VT-125 and remediation will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**3 Days (30 Hours)**	**$25,000**	**57**

Rock Cut Number	**0074**
Maintenance District	5
Highway	I-89
Mile	80.07
Town	WILLISTON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	585
AADT (2012)	29,300
Posted Speed Limit	65
Date Last Inspected	08/7/2015
Inspectors	TE, ET
Total RHR Score	**426**

SLOPE DESCRIPTION:
This rock cut is 57 feet tall and 585 feet long. The slope consists of phyllite and quartzite. The primary failure types for this site are wedge failure, raveling, and toppling failure. The slope is heavily vegetated and has large overhangs.

Rockfall occurred in the spring of 2015. Wedge failure occurred at the southbound end of the slope and rock spilled into the roadway. The rock was removed, the slope in the area of the rockfall was machine scaled and Jersey Barriers were installed at the base of the slope.

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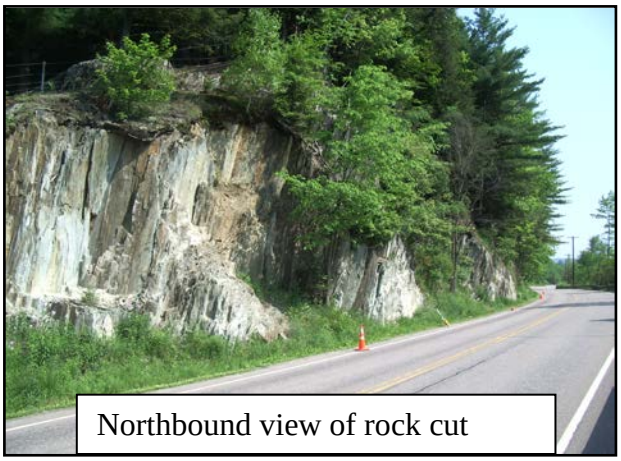
REMEDIATION OPTIONS:
Remediation will consist of the installation of rock dowels and the removal of loose and unstable rock by high scaling and machine scaling the slope.

CONDITIONS:
This is Interstate highway. One lane of traffic will need to be closed during remediation. Detour possibilities might include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **Machine Scaling** **High Scaling**	**400 Lin. ft** **4 Days (40 Hours)** **10 Days**	**$171,000**	**401**

Rock Cut Number	**0075**
Maintenance District	4
Highway	VT-12
Mile	2.86
Town	BERLIN
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	410
AADT (2012)	4,100
Posted Speed Limit	50
Date Last Inspected	05/14/2015
Inspectors	ET
Total RHR Score	**459**



Northbound view of rock cut

Recent rockfall observed 05/14/2015

SLOPE DESCRIPTION:
This 58 feet high, 410 feet long rock cut is composed of schist and greenstone. Toppling failure is the primary mode of rockfall. Failure occurs along steeply dipping foliation planes. There is little to no ditch here so anything that falls would land in the roadway. Recent rockfall was observed in the 2015 evaluation.

REMEDIATION OPTIONS:
Remediation of the slope consists of the installation of rock dowels and the removal of loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
Work can be completed with only closing one lane.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Rock Dowels	**3 Days 300 Lin. ft**	**$80,000**	**174**

Rock Cut Number	**0076**
Maintenance District	4
Highway	VT-12
Mile	3
Town	BERLIN
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	277
AADT (2012)	4,100
Posted Speed Limit	50
Date Last Inspected	05/14/2015
Inspectors	ET

Total RHR Score **303**

SLOPE DESCRIPTION:
This rock cut is 44 feet tall and 277 feet long. The slope consists of phyllite and the primary failure types are toppling and raveling. The slope is heavily vegetated and the slope extends further into the wooded area. The ditch in the central section of the photo has been filled with talus. If the talus was removed the ditch effectiveness would be improved.

REMEDIATION OPTIONS:
Remediation of the rock cut will consist of high scaling of loose blocks and installation of rock dowels.

CONDITIONS:
This rock slope lies on VT-12 and remediation can be completed with only closing one lane.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**2 Days** **150 Lin. ft**	**$48,000**	**158**

Rock Cut Number	**0077**
Maintenance District	4
Highway	VT-12
Mile	3.40
Town	BERLIN
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	245
AADT (2012)	4,100
Posted Speed Limit	50
Date Last Inspected	05/14/2015
Inspectors	ET
Total RHR Score	**192**

SLOPE DESCRIPTION:
This rock cut is 30 feet tall and 245 feet long. The slope consists of greenstone and schist. The primary failure type is toppling. This slope is heavily vegetated and is dry. This rock cut was machine scaled in 2013. It is expected that this slope will need further machine scaling as the slope ages. The slope will continue to be monitored.

REMEDIATION OPTIONS:
Remediation of the slope will consist of the removal of loose and unstable rock by machine scaling.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Stop and go traffic will be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**3 Days (30 Hours)**	**$19,000**	**99**

Rock Cut Number	**0078**
Maintenance District	4
Highway	I-89
Mile	46.72
Town	BERLIN
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,700
AADT (2012)	18,600
Posted Speed Limit	65
Date Last Inspected	07/19/2011
Inspectors	TE, ET
Total RHR Score	**444**

SLOPE DESCRIPTION:
This rock cut is 69 ft tall and 2,000 ft long. The slope consists of slate and meta-limestone. The primary failure type is plane failure. This cut has a predominant joint set that dips toward the roadway at about 50 degrees. The slope is moderately to heavily vegetated at the top and is dry. There have been many rockfalls in this area in the past. The slope was partially remediated in 2012 by scaling, installation of rock dowels and drilling drain holes.

The slope is currently a programmed project (Berlin IM 089-1(62)) and remediation will be facilitated by blasting the slope back to a more stable angle. As this slope is currently a project, the slope was not visited during the 2015 evaluation.

REMEDIATION OPTION:
Planned remediation for this rock cut will consist of cutting the slope back to 1V:1H using controlled blasting techniques.

CONDITIONS:
This is Interstate highway with ample shoulder area. However, a portion of the cut exists on the exit ramp for Exit 6 to Barre. Traffic will need to be stopped during remediation. Likely traffic will need to be detoured to Exit 7.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
Cut Slope back to 1V:1H	**61,000 cy**	**$756,000**	**1,702**

*Quantities and Estimated cost come from current preliminary plans and may not represent final quantities and cost.

Rock Cut Number	**0079**
Maintenance District	5
Highway	I-89
Mile	51.98
Town	BERLIN
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,500
AADT (2012)	21,200
Posted Speed Limit	65
Date Last Inspected	07/17/2015
Inspectors	ET, MB
Total RHR Score	**446**

Southbound view of Rock Cut 0079. Note the rockfall catchment fence installed at base of slope.

SLOPE DESCRIPTION:
This rock slope is 1,500 feet long and 123 feet tall. The rock type is phyllite and meta-limestone. Cleavage within the phyllite dips at high angles oblique to the cut face. Large slabs have been breaking away from the slope (especially near the top of the cut) and in some instances have ramped out onto the Interstate.

This rock cut was remediated in 2012. Remediation included high scaling of the slope and the installation of a light duty rockfall fence along the base of the cut. Recent rockfall was observed contained behind the fence during the 2015 evaluation. The fence appears to have suffered no damage from rockfall since installation in 2012. It is expected that the rock cut will still deteriorate over time. The slope will continue to be monitored.

REMEDIATION OPTIONS:
Further remediation options for this slope include possible spot rock doweling of overhangs and the removal of loose and unstable rock utilizing high scaling techniques.

CONDITIONS:
This slope lies on I-89 north bound barrel. At least one lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed. If high scaling is performed, the guardrail and light duty rockfall catchment fence will need to be removed or protected in some manner and then after remediation it should be re-installed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Rock Dowels	**10 Days 400 Lin. ft**	**$229,000**	**513**

Rock Cut Number	**0080**
Maintenance District	5
Highway	US-2
Mile	5.66
Town	BOLTON
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	500
AADT (2012)	2,700
Posted Speed Limit	50
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**265**

SLOPE DESCRIPTION:
This rock cut is 97 feet tall and is 500 feet long. This slope consists of schist that is broken up by numerous joints. The primary failure type is raveling; however, the stereonet also shows the potential for plane failure and wedge failure. The slope is heavily vegetated at the base and summit and flowing water was present through the face of the cut.

REMEDIATION OPTIONS:
Remediation will consist of trim blasting, high scaling, the installation of rock dowels, and drilling drain holes within the rock to address water issues.

CONDITIONS:
Both traffic lanes will need to be closed during remediation. Traffic can be detoured onto the adjacent interstate.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **High Scaling** **Rock Dowels** **Drains in Rock**	**500 cy** **10 Days** **400 Lin. ft** **200 Lin. ft**	**$229,000**	**864**

Rock Cut Number	**0082**
Maintenance District	5
Highway	VT-17
Mile	2.31
Town	BUEL'S GORE
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	890
AADT (2012)	930
Posted Speed Limit	50
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**617**

SLOPE DESCRIPTION:
This site is a combination of rock cut and natural exposure and is approximately 167 ft tall and 890 ft long. It is heavily vegetated and this hides how dangerous this slope really is. The slope consists of schist. There are numerous large overhangs and the primary failure type is raveling. This site has a history of producing many large rockfall events. Due to the massive nature of this rock exposure, complete mitigation of this area may not be possible.

REMEDIATION OPTIONS:
Partial remediation would consist of installation of rock dowels and high scaling.

CONDITIONS:
Remediation would require closure of both lanes of traffic and possible stop and go traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **High Scaling**	**3,000 Lin. ft** **25 Days**	**$814,000**	**1320**

Rock Cut Number	**0086**
Maintenance District	5
Highway	VT-17
Mile	2.48
Town	BUEL'S GORE
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	430
AADT (2012)	930
Posted Speed Limit	40
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**424**

SLOPE DESCRIPTION:
This rock cut is 60 feet tall and 430 feet long. The slope consists of schist with numerous dilated joints. Water seeping out of some joints was noticed. The primary failure type is toppling. Some parts of the slope are heavily vegetated.

REMEDIATION OPTIONS:
Remediation will consist of high scaling and installing medium duty rock netting across the face of the rock slope.

CONDITIONS:
Both lanes of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Wire Rock Netting**	**10 Days** **16,500 ft^2**	**$183,000**	**432**

Rock Cut Number	**0087**
Maintenance District	5
Highway	VT-17
Mile	2.55
Town	BUEL'S GORE
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	200
AADT (2012)	930
Posted Speed Limit	40
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**418**

SLOPE DESCRIPTION:
This rock cut is 53 feet tall and 200 feet long. The slope consists of tightly folded schist. The primary failure type is raveling. Many of the blocks appear to be loose and some form large overhangs. A large portion of this slope is adjacent to a parking area. Some parts of the slope are heavily vegetated.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
This rock slope lies adjacent to a parking area. Only one lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**3 Days** **600 Lin. ft**	**$103,000**	**246**

Rock Cut Number	**0090**
Maintenance District	5
Highway	VT-100
Mile	1.78
Town	DUXBURY
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	335
AADT (2012)	4,000
Posted Speed Limit	50
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**431**

SLOPE DESCRIPTION:
This rock cut is 35 feet tall and 335 feet long. The slope consists of fine-grained schist and the primary failure type is toppling. This is a damp slope that is moderately vegetated and has large overhangs. The most potentially dangerous overhang is shown in the photo above. Further dilation along this overhang was noted in 2015 and District personnel were informed.

REMEDIATION OPTIONS:
Remediation will consist of the installation of rock dowels, removal of loose rock utilizing high scaling and machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed, during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **High Scaling** **Machine Scaling**	**150 Lin. ft** **2 Days** **3 Days (30 Hours)**	**$49,000**	**114**

Rock Cut Number	**0092**
Maintenance District	5
Highway	VT-17
Mile	1.19
Town	FAYSTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	95
AADT (2012)	930
Posted Speed Limit	40
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**398**

SLOPE DESCRIPTION:
This rock cut is 31 feet tall and 95 feet long. The slope consists of schist. The primary failure types are plane failure and toppling. This slope has small overhangs and is heavily vegetated. There are large boulders perched on the top of the rock cut that are difficult to see through the vegetation.

REMEDIATION OPTIONS:
Utilize machine scaling techniques to remove loose rock from the rock cut.

CONDITIONS:
One traffic lane will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**2 Days (20 Hours)**	**$10,000**	**25**

Rock Cut Number	**0094**
Maintenance District	5
Highway	US-2
Mile	3.53
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	600
AADT (2012)	2,300
Posted Speed Limit	50
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**249**

SLOPE DESCRIPTION:
This rock cut is 40 feet tall and 600 feet long. The slope consists of greenstone and phyllitic quartzite. The slope is broken up by jointing, some of which are continuous throughout the cut. These joint surfaces are potential failure surfaces for plane failure. Toppling can also occur here. The slope is damp and moderately vegetated.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling and machine scaling techniques.

CONDITIONS:
This rock slope lies on US-2 and will require one lane of traffic to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**5 Days** **3 Days (30 Hours)**	**$80,000**	**321**

Rock Cut Number	**0099**
Maintenance District	5
Highway	I-89
Mile	55.11
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	335
AADT (2012)	25,500
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**611**

SLOPE DESCRIPTION:
This slope is 71 feet high and 335 feet long. There is very little ditch here and the distance from the cut face to U.S.-2 is narrow. Shotcrete and doweling were performed on the upper portion of the cut in October 2006. Recent rockfall was noticed during the 2015 evaluation. The rockfall was contained within the ditch. This slope will continue to be monitored and it is recommended that this slope undergo periodic (10 year?) high scaling to remove loose and unstable rock as it develops.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock from the slope face by utilizing high scaling techniques.

CONDITIONS:
This is Interstate highway with limited shoulder room. Stop and go traffic will need to be used during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**10 Days**	**$199,000**	**326**

Rock Cut Number	**0100**
Maintenance District	5
Highway	I-89
Mile	55.17
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	450
AADT (2012)	25,500
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**383**

SLOPE DESCRIPTION:
This rock cut is 62 feet tall and 450 feet long. The slope consists of phyllitic quartzite. The primary failure type is toppling. Cracks associated with over-blasting of the slope are located near the crest. The slope is moderately vegetated and is dry.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques, installation of rock dowels, and the application of shotcrete.

CONDITIONS:
This is an interstate highway and one lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel Installation** **Shotcrete Application**	**8 Days** **600 Lin. ft** **25 cy**	**$224,000**	**585**

Rock Cut Number	**0102**
Maintenance District	5
Highway	I-89
Mile	55.42
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	950
AADT (2012)	25,500
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**397**

SLOPE DESCRIPTION:
This rock cut is 34 feet and 950 long. This slope consists of phyllitic quartzite. The primary failure type is toppling failure. This site has large overhangs and is moderately vegetated.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by machine scaling the slope, applying shotcrete to the slope, and installing rock dowels.

CONDITIONS:
This is an interstate highway and remediation will require closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **Shotcrete** **Rock Dowel**	**10 Days (100 Hours)** **20 cy** **300 Lin. ft**	**$139,000**	**350**

Rock Cut Number	**0104**
Maintenance District	5
Highway	I-89
Mile	54.08
Town	MONTPELIER
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	250
AADT (2012)	25,500
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**346**

SLOPE DESCRIPTION:
This rock cut is 35 feet tall and 250 feet long. The slope consists of phyllitic greenschist and quartzite. The primary failure types are toppling and plane failure. This is a wet slope with large overhangs. The large blocks of rock in the photo above rest on a wet joint that dips towards the roadway. Plane failure is possible along this surface and rock could fall into the roadway

REMEDIATION OPTIONS:
Remediation will be achieved by cutting the slope back to 50 degrees. The current slope angle for the rock cut is 78°.

CONDITIONS:
This is Interstate highway and remediation will require the closure of two lanes of traffic. It will require barrel closure and crossover detours.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut slope back to 50°	**10,000 cy**	**$337,000**	**974**

Rock Cut Number	**0107**
Maintenance District	5
Highway	VT-100A
Mile	0.44
Town	MORETOWN
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	175
AADT (2012)	3,400
Posted Speed Limit	30
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**437**

SLOPE DESCRIPTION:
This slope is a composite of ledge and overlying soil with angular boulders. Erosion is taking place which is creating debris cones that reach the roadway. Jersey barrier has been installed at the base of the slope to help contain debris, however if the rock in the slope fails, it will easily reach the roadway.

REMEDIATION OPTIONS:
Remediation of the slope will consist of machine scaling and scraping the soil off the slope to the top of bedrock.

CONDITIONS:
The roadway here is narrow. Traffic control may consist of blocking off the roadway and intermittingly letting traffic pass or using VT-100 as a possible detour.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling Soil Excavation	**5 Days (50 Hours) 200 cy**	**$19,000**	**43**

Rock Cut Number	**0108**
Maintenance District	4
Highway	VT-12A
Mile	1.88
Town	NORTHFIELD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	119
AADT (2012)	2,300
Posted Speed Limit	50
Date Last Inspected	05/14/2015
Inspectors	ET
Total RHR Score	**450**

SLOPE DESCRIPTION:
This rock cut is 40 feet high and 119 feet long. Foliation of the rock at this location dips steeply into the cut. Toppling failure is the predominant mode of failure and since there is little to no ditch here any rockfalls would land in the roadway. The rock cut lies on a curve in the roadway, making sight distance limited. The crest of the slope is heavily vegetated, overhangs are present on the slope, and the slope is dry.

REMEDIATION OPTIONS:
Remediation of the slope will consist of removing loose and unstable rock by utilizing high scaling and machine scaling techniques.

CONDITIONS:
One lane closure with stop and go traffic is recommended here.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**5 Days** **16 Hours**	**$53,000**	**118**

Rock Cut Number	**0109**
Maintenance District	5
Highway	I-89
Mile	73.67
Town	RICHMOND
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	355
AADT (2012)	25,700
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**229**

SLOPE DESCRIPTION:
This rock cut is 91 feet high and 355 feet long. The slope consists of muscovite schist. The primary failure type is raveling; however, the stereonet plot shows the potential for plane failure and wedge failure. The slope is moderately vegetated and has some overhangs. There is a bench nearly halfway up the cut. This bench can serve as a ramp to launch falling rock into the roadway.

This slope was remediated in 2013. Remediation consisted of the removal of loose rock utilizing high scaling techniques, the installation of rock dowels, the application of shotcrete, and the installation of drains within rock. It is expected that over time further deterioration of the slope due to weathering will create loose, unstable rock on the slope. The slope will continue to be monitored. Future remediation may include selective high scaling of unstable rock.

REMEDIATION OPTIONS:
Remediation will consist of selective high scaling of loose and unstable rock as it develops overtime.

CONDITIONS:
This is Interstate highway with narrow shoulder width. One lane of traffic will need to be closed during remediation. A temporary rockfall catchment fence will need to be set up during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**5 Days**	**$81,000**	**354**

Rock Cut Number	**0110**
Maintenance District	5
Highway	I-89
Mile	73.67
Town	RICHMOND
Cut Location	MEDIAN
Travel Direction	SB
Length (ft)	450
AADT (2012)	25,700
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**310**

SLOPE DESCRIPTION:
This rock cut is 102 feet high and 450 feet long. The slope consists of quartz-rich muscovite schist. The primary failure types are raveling and plane failure. This slope has a bench nearly halfway up the slope. This bench can act as a ramp to launch rock into the roadway.

This rock cut was remediated in 2013. Remediation consisted of the removal of loose rock by utilizing high scaling techniques, the installation of rock dowels, the application of shotcrete, and the installation of drains within rock. It is expected that over time further deterioration of the slope due to weathering will create loose, unstable rock on the slope. The slope will continue to be monitored.

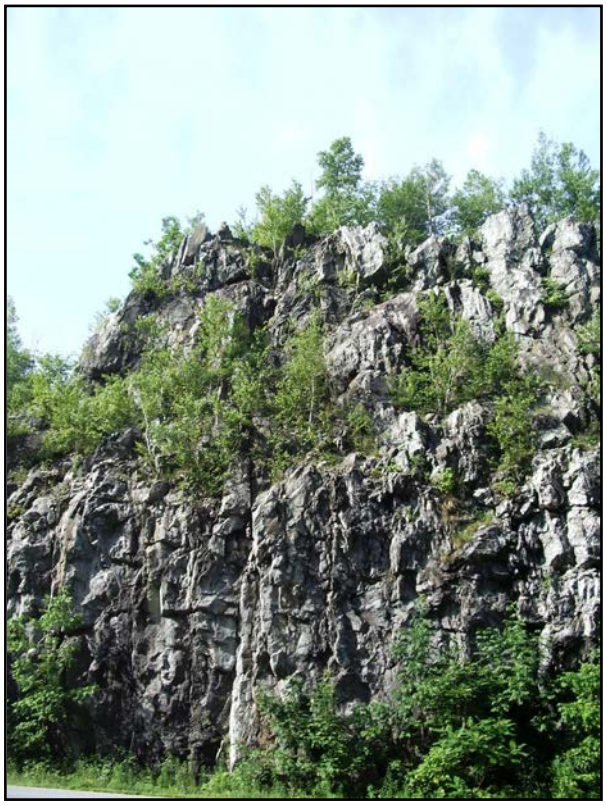
REMEDIATION OPTIONS:
Further remediation of this rock slope will consist of the removal of loose and unstable rock by utilizing high scaling techniques.

CONDITIONS:
This is Interstate highway with narrow shoulder room. One lane of traffic will need to be closed during remediation. A temporary rockfall fence should be emplaced during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**5 Days**	**$89,000**	**287**

Rock Cut Number	**0111**
Maintenance District	5
Highway	I-89
Mile	73.76
Town	RICHMOND
Cut Location	MEDIAN
Travel Direction	NB
Length (ft)	160
AADT (2012)	25,700
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**292**



SLOPE DESCRIPTION:
This rock cut is 71 feet tall and 160 feet long. The slope consists of muscovite schist. There is a bench nearly halfway up the slope that can act as a ramp to launch rock into the roadway. The primary failure types are wedge failure and raveling. The slope is moderately vegetated and has a history of producing rockfalls. There are fractured, loose rocks at the top of the slope.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock by utilizing high scaling techniques and rock dowel installation.

CONDITIONS:
This is an interstate highway. One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel**	**7 Days** **300 Lin. ft**	**$116,000**	**397**

Rock Cut Number	**0112**
Maintenance District	8
Highway	VT-100
Mile	2.84
Town	STOWE
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	334
AADT (2012)	10,400
Posted Speed Limit	30
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**501**

SLOPE DESCRIPTION:
The slope here is 47 feet high and 334 feet long. This is a very steep (almost vertical) cut/slope that is heavily vegetated. The thick vegetation makes it difficult to ascertain the true hazardous nature of this slope. There is little to no ditch here and there is very poor sight distance. Residential structures are present on top of slope.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
Traffic control will be challenging here as there is not much room. The use of hanging drape nets and temporary rock fencing may allow the closure of only one lane. If necessary, it may be possible to detour on Thomas Lane/Depot Street North.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Doweling**	**14 Days** **300 Lin. ft**	**$166,000**	**331**

Cut Number	**0113**
Maintenance District	5
Highway	VT-100
Mile	3.60
Town	WAITSFIELD
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	140
AADT (2012)	7,000
Posted Speed Limit	30
Date Last Inspected	05/21/2015
Inspectors	TE, ET
Total RHR Score	**194**

SLOPE DESCRIPTION:
This rock cut is 22 feet high and 140 feet long. The slope consists of schist and the primary failure type is plane failure. However, the stereonet plot for this rock cut does show the potential for toppling failure along jointing. Heavy vegetation masks much of this rock cut.

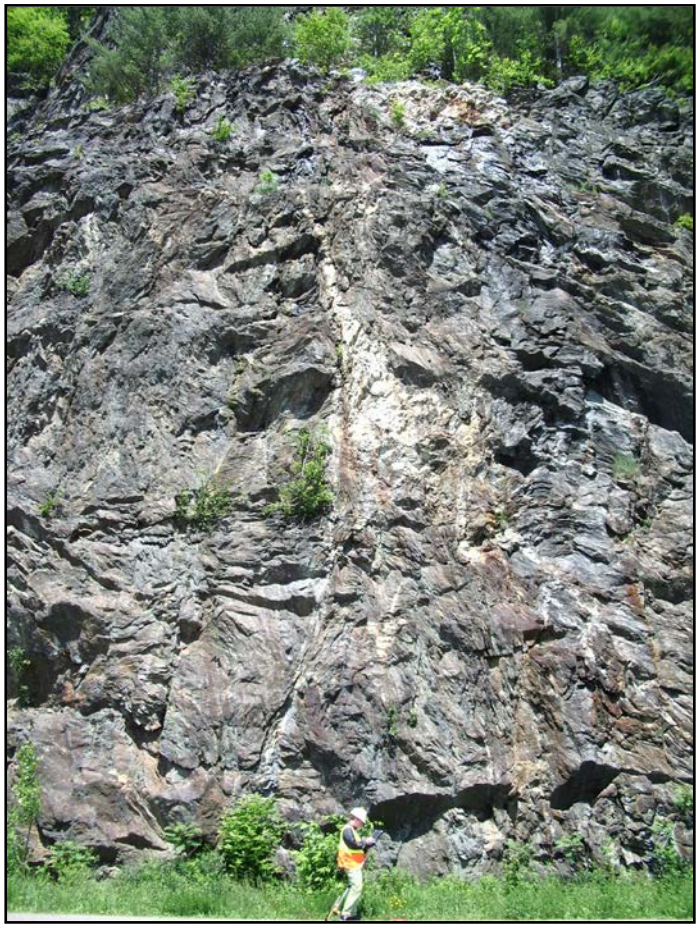
REMEDIATION OPTIONS:
Remediation of this slope requires machine scaling of loose blocks from the slope.

CONDITIONS:
This rock slope lies on VT-100 in the town of Waitsfield. One lane of traffic will need to be closed during remediation and stop and go traffic will be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**2 Days (20 Hours)**	**$12,000**	**62**

Cut Number	**0115**
Maintenance District	5
Highway	US-2
Mile	0.67
Town	WATERBURY
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	395
AADT (2012)	2,600
Posted Speed Limit	50
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**428**



SLOPE DESCRIPTION:
This rock cut is 174 feet high and 395 feet long. The slope consists of schist and the primary failure type is ravelling. The rock cut is wet and is moderately vegetated at the summit. This rock cut has experienced many rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of trim blasting of overhangs, the removal of loose rock utilizing high scaling techniques, and the installation of rock dowels.

CONDITIONS:
This rock cut lies on US-2 and one lane of traffic will need to be closed for remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **High Scaling** **Rock Dowel**	**200 cy** **15 Days** **400 Lin. ft**	**$235,000**	**549**

Cut Number	**0116**
Maintenance District	5
Highway	VT-100
Mile	0.55
Town	WATERBURY
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	728
AADT (2012)	14,400
Posted Speed Limit	50
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**355**

SLOPE DESCRIPTION:
This rock cut is 34 feet high and 728 feet long. The slope consists of schist that is failing along highly weathered foliation planes. The primary failure type is plane failure. The stereonet plot does show the potential for toppling failure along one joint set. The rock cut is moderately vegetated and has produced few rockfalls in the past.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock by utilizing machine scaling techniques.

CONDITIONS:
Remediation of this slope will require closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**5 Days (50 Hours)**	**$25,000**	**70**

Cut Number	**0117**
Maintenance District	4
Highway	I-89
Mile	41.18
Town	WILLIAMSTOWN
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,500
AADT (2012)	13,700
Posted Speed Limit	65
Date Last Inspected	7/17/2015
Inspectors	ET, MB
Total RHR Score	**404**

SLOPE DESCRIPTION:
This rock cut is 35 feet high and 1,500 feet long. The slope consists of slate and meta-limestone. The primary failure type is plane failure along foliation. The stereonet plot also shows the potential for toppling failure along a joint set. The rock cut is moderately vegetated at the top, has large overhangs, and has produced many rockfalls in the past. Rockfall was observed contained within the ditch during the 2015 evaluation.

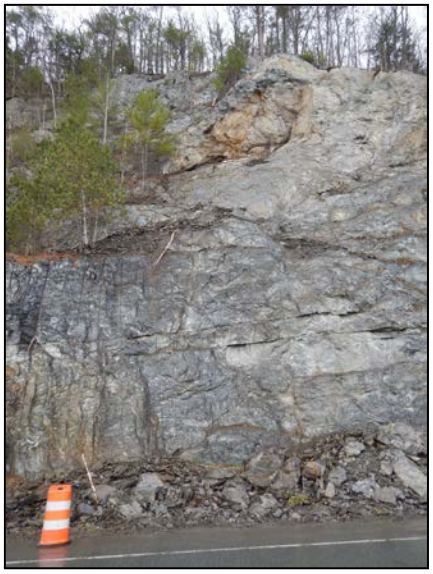
REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock by utilizing machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**10 Days (100 Hours)**	**$49,000**	**121**

Rock Cut Number	**0119**
Maintenance District	7
Highway	US-5
Mile	4.21
Town	BARNET
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	2,112
AADT (2012)	870
Posted Speed Limit	50
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**575**



SLOPE DESCRIPTION:
This slope is a very long (over 2000 feet) very high (120 feet) rock exposure. The northern portion of this rock exposure experienced a major Rockfall in 2002 that covered US-5. The cause of the Rockfall was a large column of rock that had toppled away from the slope. High scalers conducting the mitigation in 2002 traversed the length of the rock exposure near the top and reported numerous potentially unstable rock masses.

A rockfall occurred on April 27, 2015. The rockfall completely filled the ditch and some pieces spilled into the roadway.

REMEDIATION OPTIONS:
Remove loose rock from the slope utilizing high scaling techniques and install rock dowels on selected rock masses. Trim blasting could also be used here to remove dangerous overhanging or dilated blocks of rock. For estimation purposes assume 2 months of scaling and the installation of 100 twenty-five foot rock dowels.

CONDITIONS:
The roadway here consists of two lanes (one each direction) with enough room to maintain one way traffic. Traffic could be stopped at risky areas of the slope. A temporary rock fence should be set up between US-5 and the Interstate. Cliffs in this area reportedly contain nesting peregrine falcons. This may effect the time of year work could be performed on this slope.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Doweling** **Trim Blasting** **Machine Scaling**	**60 Days** **2,500 Lin. ft.** **500 cy** **3 Days (30 Hours)**	**$1,000,000**	**1739**

Rock Cut Number	**0120**
Maintenance District	7
Highway	I-91
Mile	117.00
Town	RYEGATE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,320
AADT (2012)	5,100
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**569**

SLOPE DESCRIPTION:
This slope is 117 feet tall and 1,320 feet long. The slope consists of phyllitic quartzite and greenstone. The primary failure type is raveling. The slope is heavily vegetated at the summit and is dry. This site has been a source of constant rockfalls.

REMEDIATION OPTIONS:
This slope is currently programmed (Ryegate IM 091-21(80)). Plans for remediation include removal of loose and unstable rock by utilizing high scaling techniques, trim blasting of select overhangs, the installation of a wire mesh drape across the face of the slope, and excavation of a rockfall catchment ditch.

CONDITIONS:
This rock slope lies on Interstate highway and begins at the end of a curve in the roadway. One lane of traffic will need to be closed during remediation. A temporary rockfall catchment fence may be used during scaling operations.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
High Scaling **Wire Mesh Netting** **Trim Blasting** **Ditch Excavation**	**32 Days (320 Hours)** **33,000 ft^2** **400 cy** **280 cy**	**$1,000,000**	**1757**

***Quantities and Estimated Cost come from current preliminary plans and may not reflect final quantities and cost.

Cut Number	**0123**
Maintenance District	7
Highway	I-91
Mile	122.15
Town	BARNET
Cut Location	MEDIAN
Travel Direction	NB
Length (ft)	1,270
AADT (2012)	5,700
Posted Speed Limit	65
Date Last Inspected	8/28/2015
Inspectors	ET, MG
Total RHR Score	**422**

SLOPE DESCRIPTION:
This rock cut is 110 feet high and 1,270 feet long. The slope consists of phyllitic quartzite and phyllite. The primary failure type is toppling along foliation. The rock cut is heavily vegetated at the top, has overhangs, and has produced occasional rockfalls in the past. There is a large open fracture behind the face of foliation.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel Installation**	**15 Days** **400 Lin. ft**	**$212,000**	**502**

Cut Number	**0124**
Maintenance District	7
Highway	I-91
Mile	122.24
Town	BARNET
Cut Location	OUTSIDE
Travel Direction	SB
Length	1,690
AADT (2012)	5,700
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**404**

SLOPE DESCRIPTION:
This rock cut is 64 feet high and 1,690 feet long. The slope consists of phyllitic quartzite and phyllite. Basalt dikes cut across the slope and along shear zones. The primary failure types are wedge failure, toppling, and raveling. The rock cut is heavily vegetated at the top, is wet, has overhangs, and has produced many rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing machine scaling techniques, laying a portion of the slope to 45 degrees and the installation of rock dowels.

CONDITIONS:
This is Interstate highway. One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed. Total closure will be necessary during blasting activities.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **Lay slope back to 45º** **Rock Dowels**	**2 Weeks (100 Hours)** **8,400 cy** **400 Lin. ft**	**$487,000**	**1205**

Rock Cut Number	**0125**
Maintenance District	7
Highway	I-91
Mile	122.82
Town	BARNET
Cut Location	OUTSIDE
Travel Direction	SB
Length (ft)	1,426
AADT (2012)	5,700
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**392**

SLOPE DESCRIPTION:
This rock cut is 67 feet tall and 1,426 feet long. The slope consists of phyllitic quartzite and phyllite that is cross-cut by basalt dikes. This rock cut is heavily vegetated at the top, is dry, and has large overhangs. The District has reported that this site has produced rockfalls, which have caused two traffic accidents in the past.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock by utilizing high scaling techniques, machine scaling the slope face, trim blasting select overhangs, and the installation of rock dowels.

CONDITIONS:
This is an interstate highway and one lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Trim Blasting** **Rock Dowels**	**8 Days (80 Hours)** **8 Days (80 Hours)** **500 cy** **700 Lin. ft**	**$254,000**	**648**

Rock Cut Number	**0127**
Maintenance District	7
Highway	I-91
Mile	INT. 18 Ramp A Right
Town	BARNET
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	1,050
AADT (2012)	2,700
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**500**

SLOPE DESCRIPTION:
This slope is 116 feet tall and 1,050 feet long. The slope consists of phyllitic quartzite and phyllite. The primary failure type is plane failure. This slope has produced occasional rockfalls, has overhangs, is heavily vegetated at the top, and is dry.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock utilizing high scaling techniques and trim blasting of select overhangs.

CONDITIONS:
This rock cut lies on Interstate – 91, Exit 18 Ramp A, on the outside. Remediation will require closure of the ramp.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Trim Blasting**	**15 Days (150 Hours)** **200 cy**	**$237,000**	**474**

Rock Cut Number	**0129**
Maintenance District	7
Highway	US-5
Mile	6.15
Town	FAIRLEE
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	2,100
AADT (2012)	2,500
Posted Speed Limit	50
Date Last Inspected	08/28/2015
Inspectors	TE, ET
Total RHR Score	**774**

SLOPE DESCRIPTION:
This natural exposure is 300 feet tall and 2,100 feet long. The slope consists of quartz monzonite. The primary failure type is toppling failure. The rock slope is heavily vegetated, is dry, has large overhangs, and has produced constant rockfalls in the past. A rockfall catchment fence has been installed at the base of the slope in 1996. 2015 inspection of the fence shows that it has suffered some impacts from rock, however, the fence maintains its integrity. Inspections of the catchment fence will continue as well as needed scaling of the slope and installation of rock dowels.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
If the catchment fence is left installed at the base of the slope, care must be taken that no rocks break through it and enter the roadway. The fence will have to be repaired if it suffers any damage during remediation. If the fence is taken down during remediation, both lanes of traffic will need to be closed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**15 Days** **2,000 Lin. ft**	**$385,000**	**497**

Rock Cut Number	**0131**
Maintenance District	7
Highway	I-91
Mile	136.68
Town	LYNDON
Cut Location	OUTSIDE
Travel Direction	NB
Length (ft)	370
AADT (2012)	10,900
Posted Speed Limit	65
Date Last Inspected	07/28/2015
Inspectors	ET, MG

Total RHR Score **215**

SLOPE DESCRIPTION:
This rock cut is 45 feet high and 370 feet long. The slope consists of meta-limestone and phyllite. The primary failure type is plane failure. The stereonet plot shows the potential for toppling failure along foliation and the potential for wedge failure along jointing. The rock cut has overhangs and is moderately vegetated at the top. This rock cut has produced occasional rockfalls in the past. In response to a rockfall that occurred in 2003, the slope was high scaled and 5 rock bolts were installed. Rockfall was observed contained within the ditch during the 2015 evaluation.

REMEDIATION OPTIONS:
Option 1: Blast the slope back to 35°.
Option 2: Install a cable drape mesh over the rockface.
Option 3: Install a rock catchment fence at the base of the slope.

CONDITIONS:
This is an interstate highway and at least one lane of traffic will need to be closed during remediation. The rock slope lies just before the exit ramp to Lyndon, it is likely the ramp will need to be closed during remediation as well. Two lanes and the exit ramp will need to be closed if blasting is chosen as the remediation method.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Option 1

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blast slope to 35°	**19,854 cy**	**$613,000**	**2,851**

Option 2

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cable Drape Mesh	**15,750 ft^2**	**$197,000**	**916**

Option 3

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Low Capacity Rock Fence	**360 Lin. ft**	**$114,000**	**530**

Rock Cut Number	**0132**
Maintenance District	7
Highway	I-91
Mile	137.52
Town	LYNDON
Cut Location	OUTSIDE
Travel Direction	SB
Length (ft)	1,003
AADT (2012)	5,200
Posted Speed Limit	65
Date Last Inspected	07/29/2015
Inspectors	ET, RM
Total RHR Score	**244**

SLOPE DESCRIPTION:
This rock cut is 50 feet high and 1,003 feet long. The slope consists of meta-limestone and phyllite. The primary failure type is plane failure. The sterenet plot shows the potential for toppling failure as well. The rock cut has possible overhangs and is moderately vegetated at the top. This rock cut has produced occasional rockfalls in the past.

REMEDIATION OPTIONS:
Remediation consists of the removal of loose and unstable rock by utilizing high scaling techniques and machine scaling the slope.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Stop and go traffic as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**5 Days (50 Hours)** **2 Weeks (100 Hours)**	**$122,000**	**500**

Rock Cut Number	**0133**
Maintenance District	7
Highway	I-91
Mile	114.62
Town	RYEGATE
Cut Location	OUTSIDE
Travel Direction	NB
Length (ft)	900
AADT (2012)	5,100
Posted Speed Limit	65
Date Last Inspected	8/28/2015
Inspectors	ET, MG
Total RHR Score	**330**

SLOPE DESCRIPTION:
This rock cut is 46 feet high and 900 feet long. The slope consists of quartzite. The primary failure types are plane failure and wedge failure. The rock cut has overhangs and is moderately vegetated at the crest. This rock cut has produced many rockfalls in the past that have reached the roadway.

REMEDIATION OPTIONS:
Option 1: Lay slope back to 1V:1H by blasting.
Option 2: Remove loose and unstable rocks by utilizing high scaling techniques.

CONDITIONS:
This is an interstate highway. Remediation will require closure of one lane of traffic for high scaling and closure of two lanes of traffic during blasting.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

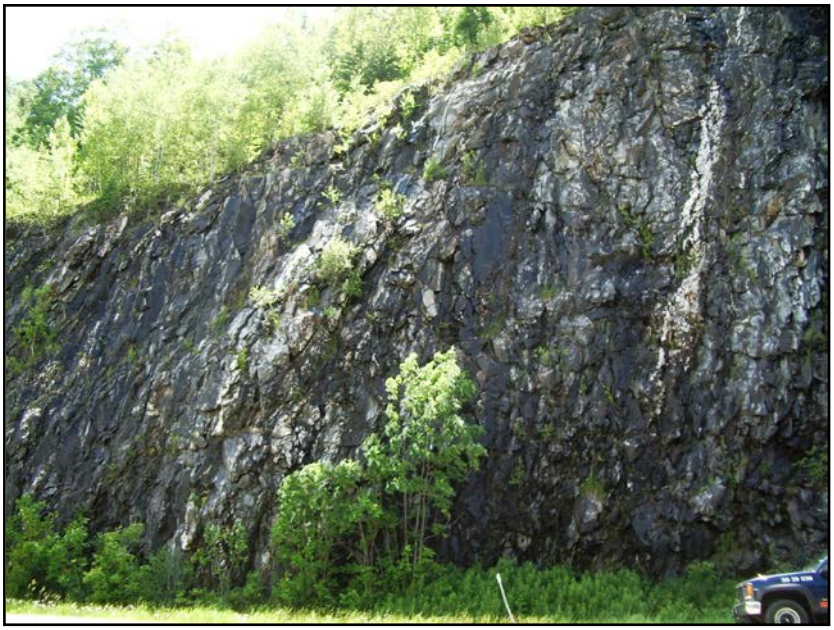
OPTION 1

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Cut Slope to 1V:1H	**10,200 cy**	**$385,000**	**1,167**

OPTION 2

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling	**5 Days**	**$77,000**	**233**

Rock Cut Number	**0135**
Maintenance District	7
Highway	I-91
Mile	129.30
Town	ST. JOHNSBURY
Cut Location	OUTSIDE
Travel Direction	SB
Length (ft)	1056
AADT (2012)	7,800
Posted Speed Limit	65
Date Last Inspected	09/2/2015
Inspectors	TE, ET
Total RHR Score	**475**



SLOPE DESCRIPTION:
This rock cut is 79 feet high and 1,056 feet long. The slope consists of meta-limestone and phyllite. The primary failure types are plane failure, wedge failure, and raveling. The rock cut has overhangs and is moderately vegetated at the top. This rock cut has produced constant rockfalls in the past. Rockfalls are observed most frequently in the winter months.

REMEDIATION OPTIONS:
Option 1: Intensive high scaling.
Option 2: High scaling and rock dowel installation.
Option 3: Cable mesh installation across rock face.
Option 4: Install rockfall catchment fence.
Option 5: Lay slope back to a shallower angle.

CONDITIONS:
This is an interstate highway and at least one lane of traffic will need to be closed during remediation for options 1 through 4. Total closure of the southbound barrel would be necessary for option 5.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Option 1

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Intensive High Scaling	10 Days	$113,000	238

Option 2

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Installation of Rock Dowels`	10 Days 750 Lin. ft	$210,000	442

Option 3

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Installing Cable Mesh across rock face	45,000 ft^2	$563,000	1185

Option 4

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Installation of Rock Catchment Fence	900 Lin. ft	$276,000	581

Option 5

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blast Slope to Shallower Angle	24,185 cy	$722,000	1,520

Rock Cut Number	**0136**
Maintenance District	7
Highway	I-91
Mile	INT. 19 RAMP C RIGHT
Town	ST. JOHNSBURY
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,300
AADT (2012)	2,500
Posted Speed Limit	65
Date Last Inspected	08/28/2015
Inspectors	ET, MG
Total RHR Score	**557**

SLOPE DESCRIPTION:
This 82 feet tall, 1,300 feet long rock cut is on the ramp from I-93 to I-91 north at Interchange 19. The rock type here consists of meta-limestone, phyllite and quartzite. Potential wedge, toppling and raveling failures here have resulted in frequent rockfalls that if large enough in volume, may overwhelm the capacity of the ditch.

REMEDIATION OPTIONS:
Remediation of the slope requires the removal of loose and unstable rock by utilizing high scaling techniques and trim blasting of select overhangs. The installation of rock dowels may also be needed.

CONDITIONS:
The ramp would have to be closed and I-93 northbound traffic re-routed onto I-93 Exit 1 to US-2 and through St. Johnsbury.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Trim Blasting** **Rock Dowel Installation**	**10 Days** **200 cy** **200 Lin. ft**	**$201,000**	**361**

Rock Cut Number	**0137**
Maintenance District	7
Highway	I-91
Town	ST. JOHNSBURY
Cut Location	INT. 19 RAMP D LEFT
Travel Direction	SB
Length (ft)	725
AADT (2012)	2,500
Posted Speed Limit	65
Date Last Inspected	08/28/2015
Inspectors	ET, MG
Total RHR Score	**366**

SLOPE DESCRIPTION:
This rock cut is 75 feet high and 725 feet long. The slope consists of meta-limestone and phyllite. The primary failure types are wedge failure and toppling. The rock cut has large overhangs and is heavily vegetated at the top. This rock cut has produced occasional rockfalls in the past.

REMEDIATION OPTIONS:
Remediation options include the removal of loose and unstable rock by utilizing high scaling and machine scaling techniques.

CONDITIONS:
This rock cut lies on the Exit 19 off ramp. Remediation will require closure of the traffic lane and stop and go traffic will be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**2 Weeks (200 Hours)** **10 Days (100 Hours)**	**$152,000**	**415**

Rock Cut Number	**0139**
Maintenance District	7
Highway	I-93
Mile	3.11
Town	WATERFORD
Cut Location	OUTSIDE
Travel Direction	NB
Length (ft)	1,162
AADT (2012)	6,200
Posted Speed Limit	65
Date Last Inspected	08/28/2015
Inspectors	ET, MG
Total RHR Score	**377**

SLOPE DESCRIPTION:
This rock cut is 54 feet high and 1,162 feet long. The slope consists of phyllite and quartzite. The primary failure types are wedge failure and raveling. Wedge failure seems to be concentrated in the middle of the rock cut. The rock cut has large overhangs and is heavily vegetated at the top. This rock cut has produced many rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of overhangs by trim blasting, machine scaling the face of the slope, and the installation of rock dowels.

CONDITIONS:
This is Interstate highway with ample shoulder area. One lane of traffic will need to be closed during remediation. The slope rises too steeply to allow equipment access to the top of the cut.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Machine Scaling** **Rock Dowels**	**50 cy** **2 Days (20 Hours)** **90 Lin. ft**	**$40,000**	**106**

Rock Cut Number	**0140**
Maintenance District	7
Highway	I-93
Mile	6.09
Town	WATERFORD
Cut Location	OUTSIDE
Travel Direction	NB
Length (ft)	1,056
AADT (2012)	6,200
Posted Speed Limit	65
Date Last Inspected	08/28/2015
Inspectors	ET, MG
Total RHR Score	**382**

SLOPE DESCRIPTION:
This rock cut is 61 feet high and 1,056 feet long. The slope consists of phyllite, granite, and quartzite. The primary failure types are toppling, wedge failure, and plane failure. The rock cut has large overhangs and is heavily vegetated at the top. The District has reported that this rock cut has produced many rockfalls in the past.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock by utilizing high scaling techniques and machine scaling of the slope.

CONDITIONS:
This is an interstate highway and one lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**5 Days (50 Hours)** **5 Days (50 Hours)**	**$88,000**	**230**

Rock Cut Number	**0142**
Maintenance District	8
Highway	I-89
Mile	107.74
Town	GEORGIA
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	2,376
AADT (2012)	16,600
Posted Speed Limit	65
Date Last Inspected	04/14/2015
Inspectors	TE, ET
Total RHR Score	**578**

SLOPE DESCRIPTION:
This rock cut consists of dolomite with major planar jointing dipping obliquely toward the roadway at about 45 to 50 degrees. Water is frequently seen here weeping out of discontinuities on the cut surface. This cut experienced a major rockfall in 1974 that covered the northbound lanes.

REMEDIATION OPTIONS:
This rock cut is currently a programmed project (Georgia IM 089-3(72)). Remediation will consist of the removal of loose and unstable rock utilizing high scaling techniques, light machine scaling of the slope, trim blasting of overhangs, the installation of rock dowels, the application of shotcrete, and installation of rock drains.

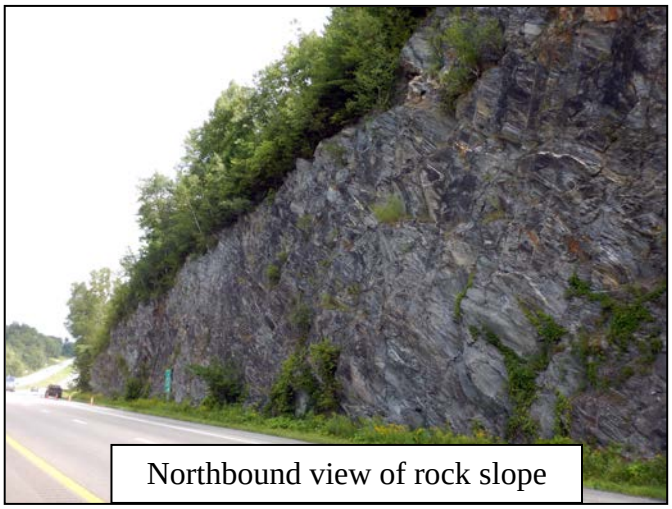
CONDITIONS:
This is Interstate highway with ample shoulder room. One lane of traffic will need to be closed during remediation efforts. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

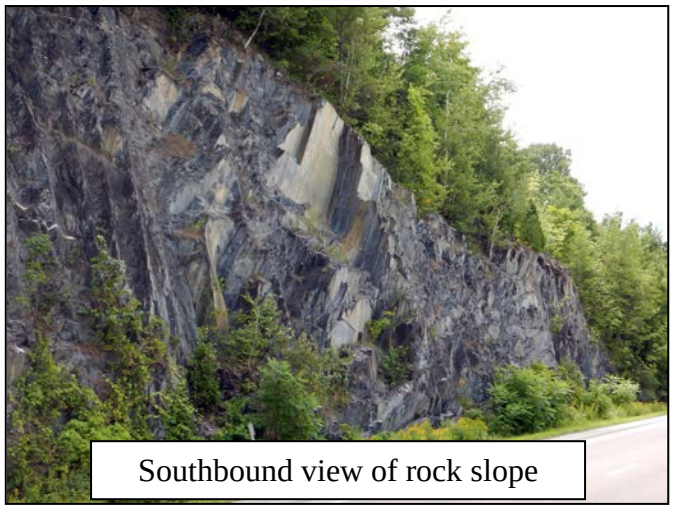
Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
High Scaling	**11 Days (110 Hours)**	**$1,300,000**	**2250**
Machine Scaling	**5 Days (50 Hours)**		
Trim Blasting	**5,000 cy**		
Rock Dowels	**700 Lin. ft**		
Shotcrete	**20 cy**		
Drains in rock	**40 Lin. ft**		

*Quantities and estimated cost come from preliminary estimates from current project plans.

Rock Cut Number	**0144**
Maintenance District	8
Highway	I-89
Mile	102.42
Town	MILTON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	750
AADT (2012)	20,800
Posted Speed Limit	65
Date Last Inspected	08/7/2015
Inspectors	ET, MG
Total RHR Score	**429**



Northbound view of rock slope



Southbound view of rock slope

SLOPE DESCRIPTION:
This rock cut is 69 feet high and 750 feet long. The slope consists of phyllite. The primary failure type is toppling. The rock cut has large overhangs and is heavily vegetated at the top. Rockfall occurred on10/5/2011 and this led to high scaling of the slope as part of the Milton IM-089-3(66) Slide Project. Toppling failure occurred along foliation and all debris was contained within the ditch. Less than 1 ft wide pieces of rock were observed on the edge of the shoulder during the 2015 evaluation.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
This is an interstate highway. Both lanes of traffic will need to be closed down in order to remediate the slope. Detour possibilities include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel**	**15 Days** **1,000 Lin. ft**	**$286,000**	**667**

Rock Cut Number	**0147**
Maintenance District	9
Highway	US-5
Mile	3.35
Town	COVENTRY
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	320
AADT (2012)	2,600
Posted Speed Limit	50
Date Last Inspected	07/11/2011
Inspectors	TE, ET
Total RHR Score	**516**

SLOPE DESCRIPTION:
This rock cut is 41 feet tall and 320 feet long. The soil and vegetation covered upper slope lays at a 45-degree angle and continues at this angle for quite some distance up the slope. There is no ditch here and there are large overhangs high up on the slope. Joint sets dipping directly toward the roadway at approximately 45-degrees provide release surfaces for potential plane and wedge failures. In addition, cleavage dips into the slope at high angles and can provide release surfaces that lead to toppling failures.

This slope is currently under design as project Coventry Ledge STP 0113(66) and as such, it was not evaluated during the 2015 evaluation.

REMEDIATION OPTIONS:
Planned remediation for this slope consists of the removal of loose and unstable rock utilizing high scaling techniques, light machine scaling of the slope, installation of rock dowels, installation of rock drains, and the application of shotcrete.

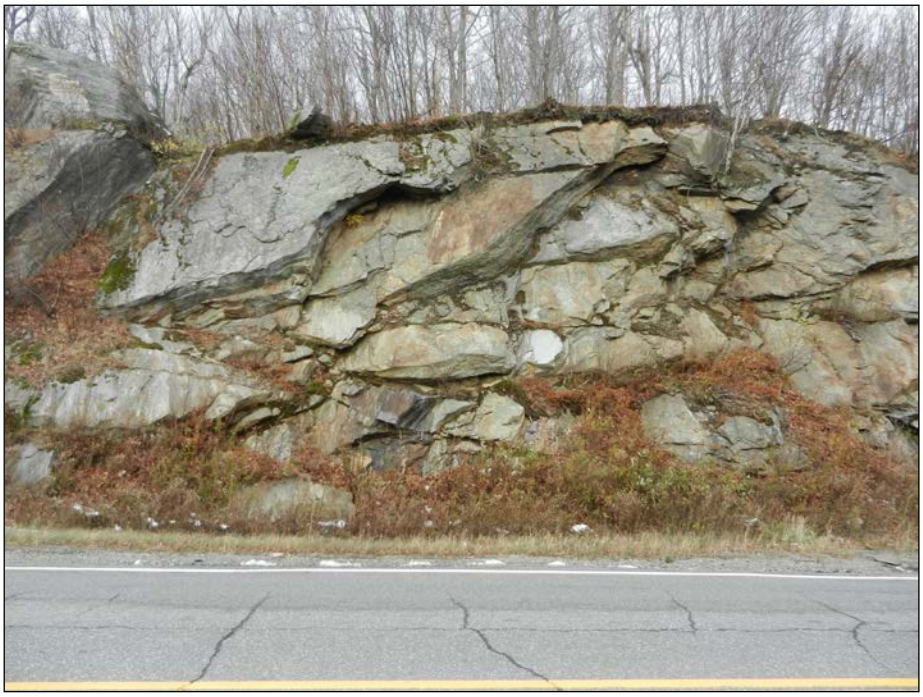
CONDITIONS:
This road here has little to no shoulder room. At least one lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
High Scaling	**5 Days (50 Hours)**	**$431,000**	**835**
Machine Scaling	**2 Days (20 Hours)**		
Rock Dowels	**700 Lin. ft**		
Drains in Rock (including drains for shotcrete)	**700 Lin. ft**		
Shotcrete	**120 cy**		

*Quantities and estimated cost come from current conceptual plans for the project and may not represent final estimated quantities and cost.

Rock Cut Number	**0149**
Maintenance District	9
Highway	VT-105
Mile	3.66
Town	JAY
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	461
AADT (2012)	680
Posted Speed Limit	50
Date Last Inspected	07/29/2015
Inspectors	ET, RM
Total RHR Score	**366**



SLOPE DESCRIPTION:
This slope is 29 ft tall and 461 ft long. The slope consists of schist that dips directly toward the roadway. The primary modes of failure are plane failure along foliation as well as wedge failure along the intersections of the joints and foliation. Two jointing plane sets act as release surfaces which allow large slabs of rock to slide along foliation planes. The slope is moderately vegetated and is dry. This slope is a currently programmed project (Jay STP 034-2(16)).

REMEDIATION OPTIONS:
The suggested remediation option for this rock cut is to cut the slope back on a 1V:1H (45°) slope. In addition to cutting the slope back, a more effective rockfall catchment ditch could be constructed.

Anchoring the large slabs of schist into the slope using rock doweling is also feasible; however, the advantages of eliminating the potential for further rockfall by excavation outweigh the future maintenance issues that rock doweling would produce.

CONDITIONS:
Remediation of the slope will require the closure of both lanes of traffic during blasting. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
Cutting Slope back to 1V:1H **Rockfall Catchment Ditch**	**3,500 cy** **300 cy**	**$134,000**	**366**

*Quantities and Estimated Cost come from current conceptual project plans. These values may not reflect final estimated quantities and cost.

Rock Cut Number	**0150**
Maintenance District	9
Highway	VT-5A
Mile	1.84
Town	WESTMORE
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	5,280
AADT (2012)	930
Posted Speed Limit	50
Date Last Inspected	07/28/2015
Inspectors	ET, MG
Total RHR Score	**888**

SLOPE DESCRIPTION:
This site is 1,000 feet high and 5,280 feet long. The slope consists of granite, quartzite, and phyllite. The primary failure types are toppling and raveling. This slope is heavily vegetated, is wet, and has an active talus slope. The site produces annual rockfalls and icefalls. Mitigation of this site is considered not feasible due to the overall size of the slope.

REMEDIATION OPTIONS:
Not applicable to this site.

CONDITIONS:
Not applicable to this site.

Rock Cut Number	**0156**
Maintenance District	9
Highway	VT-5A
Mile	3.33
Town	WESTMORE
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	340
AADT (2012)	930
Posted Speed Limit	50
Date Last Inspected	07/28/2015
Inspectors	ET, MG
Total RHR Score	**685**

SLOPE DESCRIPTION:
This slope is 170 feet high and 340 feet long. The slope consists of granite, quartzite, and phyllite. The primary failure types are toppling and plane failure. The slope is heavily vegetated, is wet, and has large overhangs. This slope experiences occasional rockfalls. In 2002 the slope was thoroughly high scaled and thirty-two rock dowels were installed. Additional high scaling was performed in 2006.

REMEDIATION OPTIONS:
Remediation for this slope will consist of periodic high scaling of the slope and installation of rock dowels as needed, to anchor loose rocks.

CONDITIONS:
Stop and Go traffic will be needed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel**	**5 Days** **400 Lin. ft**	**$108,000**	**158**

Rock Cut Number	**0159**
Maintenance District	4
Highway	I-91
Mile	56.06
Town	WINDSOR
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	5,280
AADT (2012)	13,000
Posted Speed Limit	65
Date Last Inspected	07/15/2015
Inspectors	ET, RM
Total RHR Score	**459**

SLOPE DESCRIPTION:
This is a very long (5,280 feet), high (80feet) rock cut that has well defined planar jointing dipping toward the roadway at about 50 degrees. The cut was constructed on a 70 degree angle and large slabs slide out of the cut. The slope is moderately vegetated and dry. The District reports that this rock cut has produced many rockfalls in the past.

REMEDIATION OPTIONS:
Option 1: Lay the slope back to 1.5V:1H. The upper slope angle is estimated to be 20 degrees and as such, a 50 degree cut would produce a 90 foot high cut. Since it would be very expensive ($6 million) and not practical to cut all 5,000 feet of the slope, for estimate purposes it is assumed that 1,000 feet of slope would be laid back.
Option 2: Remove loose and unstable rock by utilizing high scaling techniques, remove overhangs with trim blasting and utilize pattern bolting.

CONDITIONS:
If Option 1 is chosen, it would involve a barrel closure and the construction of crossovers.
If Option 2 is chosen it would require one lane closure and the use of temporary netting and a temporary Rock Catchment Fence.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

OPTION 1

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Lay 1,000 feet of Slope back to 1.5V:1H	**57,000 cy**	**$1,250,000**	**2,723**

OPTION 2

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling Trim Blasting Pattern Bolting	**60 Days 5,000 cy 3,000 Lin. ft.**	**$1,580,000**	**3,453**

Rock Cut Number	**0160**
Maintenance District	5
Highway	I-89
Mile	54.61
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,400
AADT (2012)	25,500
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**390**

SLOPE DESCRIPTION:
This rock cut is 50 feet high and 1,400 feet long. The slope consists of phyllitic green schist, quartzite, and greenstone. The primary failure type is toppling failure. The slope is heavily vegetated at the top, is dry, and has overhangs. The District has reported that this rock cut has produced many rockfalls in the past.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of loose and unstable rock utilizing high scaling and machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling**	**10 Days** **3 Days (30 Hours)**	**$116,000**	**297**

Rock Cut Number	**0161**
Maintenance District	5
Highway	I-89
Mile	64.90
Town	WATERBURY
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	161
AADT (2012)	25,700
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	TE, ET
Total RHR Score	**234**

SLOPE DESCRIPTION:
This rock cut is 34 feet high, 161 feet long and is composed of schist. The primary failure types are wedge failure and toppling failure. The slope is moderately vegetated at the top, is dry, and has overhangs. A detached block leaning on intact rock on the northern section of the rock cut was observed in 2015 (red circle in second photo). This site has experienced rockfalls in the past.

REMEDIATION OPTIONS:
Remediation of this rock cut will consist of blasting the cut to a shallower, more stable angle (45°).

CONDITIONS:
This is an interstate highway. Both lanes of traffic will need to be closed during blasting. Detours may include the use of crossovers.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blast slope to 1V:1H	**1,000 cy**	**$51,000**	**218**

Rock Cut Number	**0162**
Maintenance District	7
Highway	I-91
Mile	116.93
Town	RYEGATE
Cut Location	OUTSIDE
Travel Direction	NB
Length (ft)	970
AADT (2012)	5,100
Posted Speed Limit	65
Date Last Inspected	08/28/2015
Inspectors	ET, MG
Total RHR Score	**234**

SLOPE DESCRIPTION:
This slope is 54 feet high and 970 feet long. The slope consists of quartzite and greenschist. Basalt dikes were observed cutting through the greenschist. The primary failure type is plane failure and raveling. The stereonet plot also shows the potential for toppling failure. The slope is heavily vegetated at the top, is dry, and has overhangs. Very large overhangs were observed at Mile Marker 116.90. A possible bench was located at Mile Marker 117.00. This bench could allow future rockfalls to launch into the roadway. This site has caused few rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and trim blasting of overhangs.

CONDITIONS:
This is Interstate highway. One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Trim Blasting**	**5 Days** **60 cy**	**$62,000**	**265**

Rock Cut Number	**0176**
Maintenance District	8
Highway	VT-108
Mile	1.08
Town	CAMBRIDGE
Cut Location	BOTH SIDES
Travel Direction	NB & SB
Length (ft)	4,224
AADT (2012)	1,500
Posted Speed Limit	40
Date Last Inspected	08/7/2015
Inspectors	ET, MG

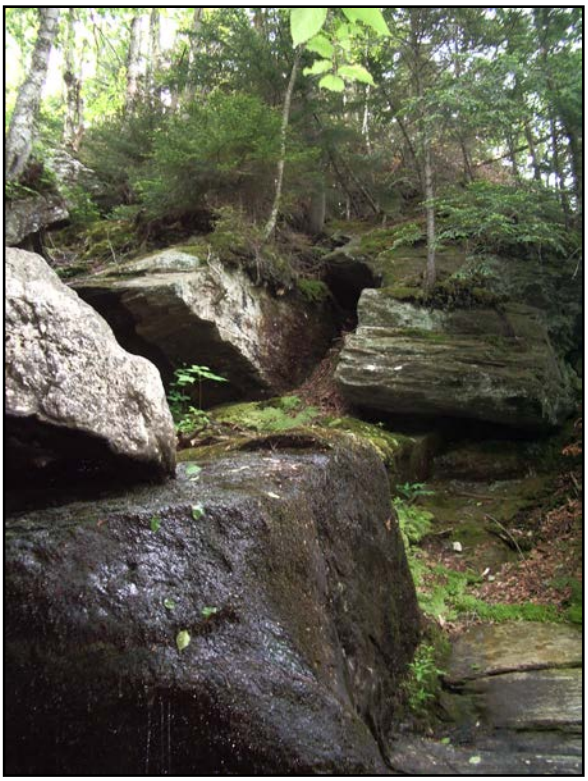
Total RHR Score **836**

SLOPE DESCRIPTION:
This slope ranges from 500 feet high to 800 feet high and is 4,224 feet long. The slope consists of schist. The primary failure type is plane failure, wedge failure, and raveling. The slope is heavily vegetated, has enormous overhangs, and is wet. This site has caused many rockfalls in the past. The roadway is closed during the winter months. Mitigation of this natural area would require expensive and extensive mitigation measures.

REMEDIATION OPTIONS:
Not applicable for this natural area.

CONDITIONS:
Not applicable for this natural area.

Rock Cut Number	**0178**
Maintenance District	8
Highway	VT-108
Mile	1.75
Town	CAMBRIDGE
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	291
AADT (2012)	2,100
Posted Speed Limit	40
Date Last Inspected	08/7/2015
Inspectors	ET, MG
Total RHR Score	**638**



SLOPE DESCRIPTION:
This natural rock exposure is 52 feet high and 291 feet long. The slope is heavily vegetated and wet. There are numerous 4ft+ wide blocks with the potential to topple into the roadway sitting loosely on the slope as well as blocks with dilated joints sitting further up the slope. The southbound section of the slope is dry while the northbound section has flowing water. Primary failure types include toppling and raveling. The District has reported that this slope has produced occasional rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will be achieved by the removal of loose and unstable rock utilizing high scaling techniques with possible spot rock doweling and cable lashing.

CONDITIONS:
Traffic control can be set up by the closure of one lane with stop and go traffic. As an alternative, mitigation could be scheduled at a time of the year that this roadway would be closed to traffic (late fall or early spring).

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Spot Rock Doweling** **Cable Lashing**	**5 Days** **200 Lin. ft** **500 Lin. ft**	**$70,000**	**110**

Rock Cut Number	**0180**
Maintenance District	1
Highway	US-7
Mile	4.59
Town	DORSET
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	1,025
AADT (2012)	3,800
Posted Speed Limit	50
Date Last Inspected	06/10/2015
Inspectors	ET, RM
Total RHR Score	**286**

SLOPE DESCRIPTION:
This rock cut is 43 feet high, 1,025 feet long, and is composed of dolostone. Solution cavities were observed throughout the slope, especially in the sections with flowing water. The primary failure types are wedge failure, plane failure, and toppling failure. The slope has overhangs, is moderately vegetated at the top, and is wet. This site produces occasional rockfalls

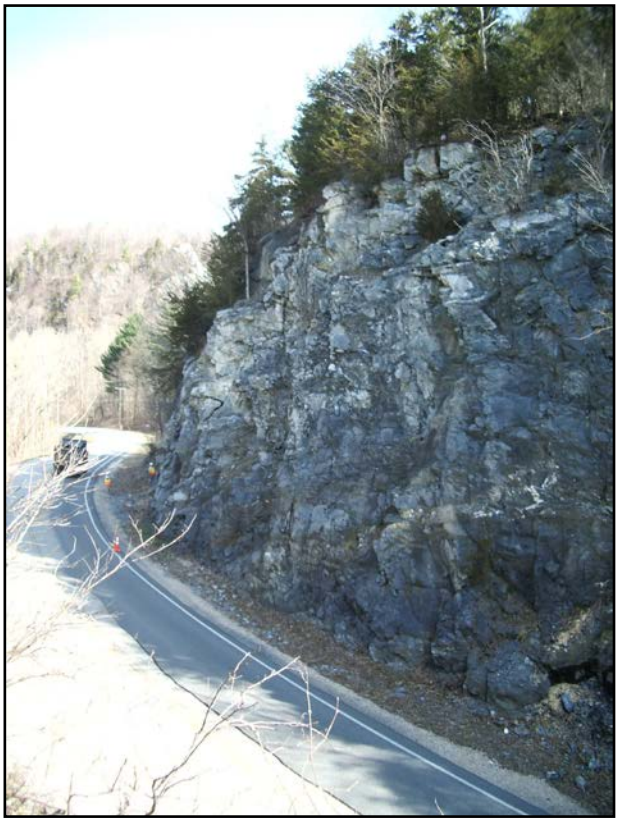
REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by performing extensive machine scaling of the slope.

CONDITIONS:
This rock slope lies on a section of US-7 with ample shoulder area. One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**5 Days (50 Hours)**	**$36,000**	**126**

Rock Cut Number	**0182**
Maintenance District	1
Highway	VT-346
Mile	2.27
Town	POWNAL
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	361
AADT (2012)	1,600
Posted Speed Limit	50
Date Last Inspected	06/10/2015
Inspectors	ET, RM
Total RHR Score	**343**



SLOPE DESCRIPTION:
This rock cut is 50 feet tall, 361 feet long and consists of meta-limestone. The primary failure types are raveling, plane failure, and toppling failure. The slope is moderately vegetated at the top and is wet. The District has reported that this rock cut produces occasional rockfalls.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and the installation of rock dowels.

CONDITIONS:
This rock cut lies on a curve within the roadway and because of this; both lanes of traffic will need to be closed during remediation. Stop and go traffic will be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**5 Days** **300 Lin. ft**	**$113,000**	**329**

Rock Cut Number	**0187**
Maintenance District	2
Highway	VT-30
Mile	4.28
Town	DUMMERSTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	1,357
AADT (2012)	6,400
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, MB
Total RHR Score	**382**

SLOPE DESCRIPTION:
This rock cut is 42 feet tall and 1,357 feet long. This is a heavily vegetated slope with predominantly plane type failures. The slope consists of schist that is heavily weathered in some areas. Recent rockfall that spilled into the shoulder of the roadway was observed in 2015.

REMEDIATION OPTIONS:
Due to the low height of the rock cut, remediation can be achieved by removing loose and unstable rock by machine scaling the rock cut face and trim blasting of select overhangs.

CONDITIONS:
The paved area here is wide (40-feet) and it is expected that one-way alternating traffic could allow work to be completed without much disruption to the traveling public.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **Trim Blasting**	**80 Hours** **100 cy**	**$55,000**	**144**

Rock Cut Number	**0193**
Maintenance District	2
Highway	VT-30
Mile	5.00
Town	TOWNSHEND
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	762
AADT (2012)	3,000
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, MB

Total RHR Score **332**

SLOPE DESCRIPTION:
This rock cut is 58 feet tall and 762 feet long. The slope consists of garnet schist and amphibolite. The primary failure type is plane failure. The slope is heavily vegetated at the top, has overhangs, and is wet. Portions of this cut serve as benches to launch rock into the roadway. Also, there are some seemingly loose blocks on the slope. The District has reported that this site has produced rockfalls and icefalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques, machine scaling the face of the slope, trim blasting overhangs, and the installation of rock dowels.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Trim Blasting** **Rock Dowel**	**20 Days** **5 Days (50 Hours)** **100 cy** **900 Lin. ft**	**$376,000**	**1133**

Rock Cut Number	**0202**
Maintenance District	3
Highway	VT-103
Mile	3.49
Town	SHREWSBURY
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	377
AADT (2012)	5,300
Posted Speed Limit	50
Date Last Inspected	06/11/2015
Inspectors	ET, MB
Total RHR Score	**268**

SLOPE DESCRIPTION:
This slope is 27 feet tall and 377 feet long. The slope consists of gneiss. The primary failure type is plane failure. The slope is moderately vegetated, has overhangs, and is dry. This site was upgraded from a "B" in 2011 at the request of the District.

REMEDIATION OPTIONS:
Remediation of this slope will consist of blasting the slope back to 45º.

CONDITIONS:
Closure of both lanes of traffic will be needed during blasting. Stop and go traffic as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blast Slope Back to 45º	**2,700 cy**	**$98,000**	**366**

Rock Cut Number	**0213**
Maintenance District	4
Highway	VT-107
Mile	2.04
Town	STOCKBRIDGE
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	1,800
AADT (2012)	2,700
Posted Speed Limit	50
Date Last Inspected	04/24/2015
Inspectors	TE, ET
Total RHR Score	**274**

SLOPE DESCRIPTION:
The rock cut here is relatively low (15 feet) however the natural slope above it rises at 25º to 40º and continues for almost 2,000 feet. Wedge failures have produced gulleys that are eating into the slope and migrating up slope. This rock cut was remediated in 2012 as project Stockbridge ER022-1(26). Remediation consisted of high scaling and machine scaling of the slope as well as the installation of rock bolts and pinned netting.

Small amounts of rock were observed reaching the shoulder of the roadway in 2015. The rock seems to be coming from the soil slope and raveling from the slope face. Pieces of rock were also observed passing through the netting as well.

It is expected that the rock slope will deteriorate overtime and further maintenance in the form of high scaling and possible rock dowel installation will be needed in the future. The slope will continue to be monitored.

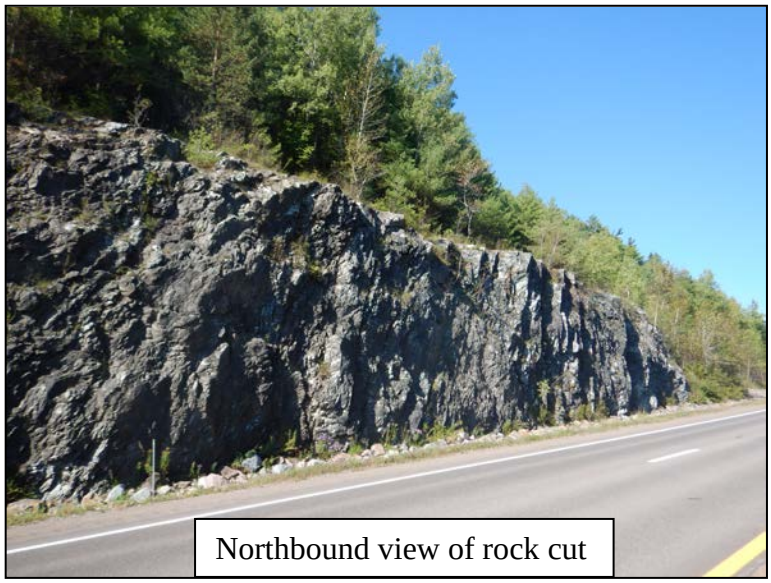
REMEDIATION OPTIONS:
Stabilization of unstable rock by installing rock dowels and the removal of loose rock from the slope face utilizing high scaling techniques.

CONDITIONS:
This rock cut exists on a curve in the roadway on VT-107. One lane of traffic will need to be closed during remediation and a temporary rockfall catchment fence will need to be put up during scaling operations. Stop and go traffic can be used as needed.

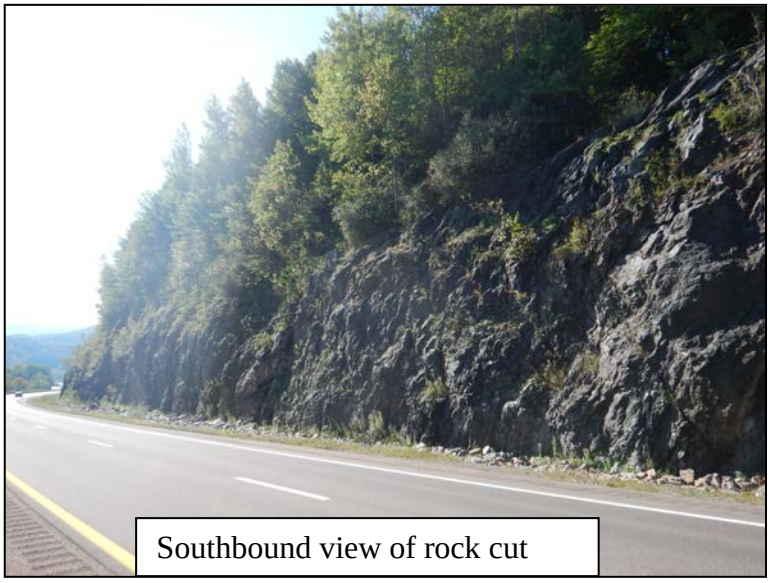
GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowels**	**5 Days** **250 Lin. ft**	**$142,000**	**518**

Rock Cut Number	**0217**
Maintenance District	5
Highway	I-89
Mile	80.10
Town	WILLISTON
Cut Location	RIGHT
Travel Direction	SB
Length (ft)	831
AADT (2012)	29,300
Posted Speed Limit	65
Date Last Inspected	08/21/2015
Inspectors	ET, MB
Total RHR Score	**431**



Northbound view of rock cut



Southbound view of rock cut

SLOPE DESCRIPTION:
This 45 feet high, 831 feet long rock slope is made of phyllite and quartzite. The primary failure type here is wedge failure along the intersection of foliation and jointing. Though this slope has an adequate ditch to contain minor rockfall events, the size of blocks at the southbound end will easily overwhelm the ditch. Flowing water was noticed at the southbound end of the slope as well.

REMEDIATION OPTIONS:
Remediation of this slope will consist of the removal of overhangs by trim blasting, spot rock doweling, and the removal of loose and unstable rock by high scaling the slope. The water issue at this site can be addressed by blasting a notch within the rock slope and installing a drainage inlet at the base.

CONDITIONS:
This rock slope lies on I-89. Closure of at least one lane of traffic will be needed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Trim Blasting **Rock Dowels** **High Scaling**	**300 cy** **400 Lin. ft** **10 Days**	**$197,000**	**457**

Rock Cut Number	**0222**
Maintenance District	5
Highway	US-2
Mile	4.58
Town	MIDDLESEX
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	270
AADT (2012)	2,300
Posted Speed Limit	50
Date Last Inspected	05/21/2015
Inspectors	TE, ET

Total RHR Score **213**

SLOPE DESCRIPTION:
This rock cut is 55 feet tall and 270 feet long. The slope consists of greenstone and phyllitic quartzite. The primary failure type is raveling and toppling failure. The slope is heavily vegetated at the top, has overhangs, and is dry. This site has produced rockfalls in the past.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose and unstable rock by utilizing high scaling techniques and machine scaling.

CONDITIONS:
This rock cut lies on US-2 and one lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **High Scaling**	**5 Days (50 Hours)** **2 Days**	**$52,000**	**244**

Rock Cut Number	**0233**
Maintenance District	7
Highway	I-91
Mile	141.70
Town	LYNDON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	419
AADT (2012)	4,600
Posted Speed Limit	65
Date Last Inspected	07/29/2015
Inspectors	ET, RM
Total RHR Score	**313**

SLOPE DESCRIPTION:
This rock cut is 42 feet tall and 419 feet long. The slope consists of meta-limestone with scarce heavily weathered sulfide zones. The primary failure type is raveling. The slope is moderately vegetated at the top, has large overhangs, and is wet.

REMEDIATION OPTIONS:
Remediation of this slope consists of the removal of loose and unstable rock by utilizing high scaling techniques, machine scaling the face of the slope, installing rock dowels, and drilling drain holes within rock.

CONDITIONS:
This is an interstate highway and remediation will require the closure of one lane of traffic.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Rock Dowel** **Rock Drains**	**5 Days** **5 Days (50 Hours)** **300 Lin. ft** **200 Lin. ft**	**$129,000**	**412**

Rock Cut Number	**0234**
Maintenance District	7
Highway	I-91
Mile	142.55
Town	LYNDON
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	975
AADT (2012)	4,600
Posted Speed Limit	65
Date Last Inspected	07/29/2015
Inspectors	ET, RM
Total RHR Score	**421**

SLOPE DESCRIPTION:
This rock cut is 60 ft tall and 975 ft long. This is a very wet slope with large overhanging masses of meta-limestone. District 7 reports that this rock exposure sheds rock frequently and that some of these rockfall events have resulted in rock reaching the roadway.

REMEDIATION OPTIONS:
This slope is a current project (Lyndon IM 091-3(51)). Planned remediation consists of the removal of loose and unstable rock by utilizing high scaling techniques, trim blasting overhangs, installation of rock anchors, and ditch catchment modifications.

CONDITIONS:
This is interstate highway with decent shoulder room. Remediation will require closure of one lane of traffic. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity*	Estimated Cost*	Cost/Score Ratio
High Scaling **Trim Blasting** **Rock Anchor Installation** **Ditch Catchment Modification**	**160 Hours** **475 cy** **120 Lin. ft** **1,200 cy**	**$456,000**	**1083**

*****Quantities and Estimated Cost reflect current planned project estimates and may not represent final quantities and cost.

Rock Cut Number	**0240**
Maintenance District	8
Highway	VT-108
Mile	1.29
Town	CAMBRIDGE
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	230
AADT (2012)	1,500
Posted Speed Limit	40
Date Last Inspected	08/07/2015
Inspectors	ET, MG
Total RHR Score	**531**

SLOPE DESCRIPTION:
This slope is 118 feet tall and 230 feet long. The slope consists of soil and chlorite-mica schist. The primary failure type is toppling. The slope is heavily vegetated, has overhangs, and is wet. There was a rockfall here on October 22, 2007 that closed the roadway.

Jersey barrier has been installed at the base of this slope in order to help prevent rock and soil from reaching the roadway. Damage of the Jersey barrier was noted during the 2015 evaluation.

REMEDIATION OPTIONS:
Remediation will consist of the removal of loose rock utilizing high scaling techniques, rock dowel installation, and drilling drain holes within rock.

CONDITIONS:
This rock slope lies on VT-108 in Smugglers Notch. Remediation will require closure of both lanes of traffic, resulting in a difficult detour. This roadway is closed within the winter months and is reopened in the spring. Remediation can begin in early spring and opening of the roadway can be delayed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Rock Dowel** **Drain Holes in Rock**	**30 Days** **600 Lin. ft** **400 Lin. ft**	**$406,000**	**765**

Rock Cut Number	**0252**
Maintenance District	2
Highway	VT-30
Mile	5.17
Town	TOWNSHEND
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	515
AADT (2012)	3,000
Posted Speed Limit	50
Date Last Inspected	06/19/2015
Inspectors	ET, MB

Total RHR Score **401**

SLOPE DESCRIPTION:
This rock cut is 62 feet tall, 515 feet long and consists of garnet bearing schist and gneiss. The dominate failure types are planar failure and toppling; also the stereonet plot shows potential for wedge failure. This cut sits close to the roadway (7 feet from pavement to toe of slope), and has large overhangs. This site has produced rockfalls in the past and at least two accidents have been reported because of it.

REMEDIATION OPTIONS:
Remediation will consist of installation of rock dowels and the removal of loose and unstable rock by utilizing high scaling and machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Power lines lie in front of the rock slope.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Rock Dowels **High Scaling** **Machine Scaling**	**400 Lin. ft** **5 Days** **5 Days**	**$127,000**	**317**

Rock Cut Number	**0260**
Maintenance District	1
Highway	VT-313
Mile	5.45
Town	ARLINGTON
Cut Location	RIGHT
Travel Direction	WB
Length (ft)	774
AADT (2012)	2,600
Posted Speed Limit	40
Date Last Inspected	06/10/2015
Inspectors	ET, RM

Total RHR Score **295**

Westbound view of rock cut

SLOPE DESCRIPTION:
This rock cut is 24 feet tall, 774 feet long, and consists of meta-limestone. The primary failure type is raveling; also the stereonet shows the potential for planar failure and wedge failure. This cut sits close to the road (5 ft from edge of pavement to toe of slope) and is heavily vegetated. The thick vegetation hides much of the rock cut and because of this, the full degree of hazard here is unknown.

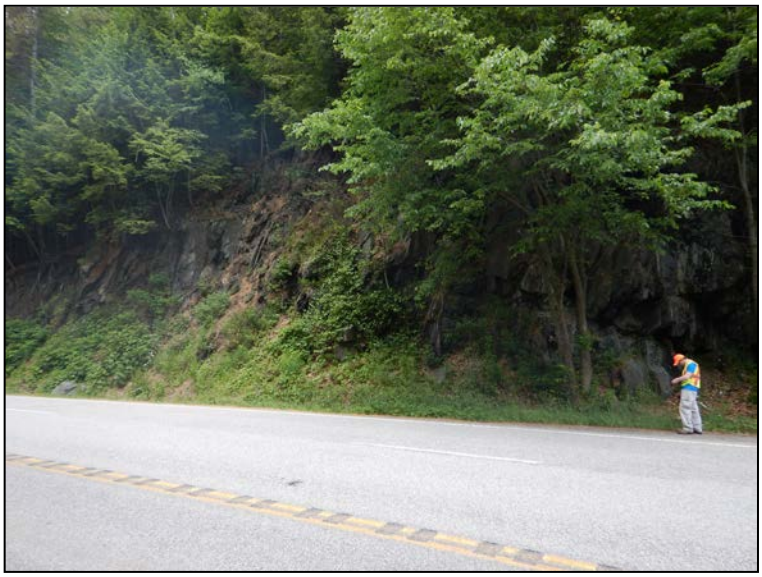
REMEDIATION OPTIONS:
Remediation of the rock cut will consist of extensive machine scaling of the slope.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**20 Days (200 Hours)**	**$127,000**	**431**

Rock Cut Number	**0888**
Maintenance District	3
Highway	VT-103
Mile	1.15
Town	CAVENDISH
Cut Location	RIGHT
Travel Direction	NB
Length (ft)	169
AADT (2012)	5,200
Posted Speed Limit	50
Date Last Inspected	06/18/2015
Inspectors	TE, ET



Total RHR Score **280**

SLOPE DESCRIPTION:
This rock cut is 42 feet tall, 169 feet long, and consists of banded amphibolite. The primary failure type is wedge failure. This cut is heavily vegetated and has overhangs scattered throughout its length. The highest portion of the slope consists of loose rock and soil that is eroding out of the slope.

REMEDIATION OPTIONS:
Remediation of the rock cut will consist of the removal of loose and unstable rock by utilizing high scaling techniques, machine scaling techniques, select rock doweling of blocks of rock, and the installation of Tecco Mesh along the soil erosion zone.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
High Scaling **Machine Scaling** **Rock Dowels** **Tecco Mesh**	**5 Days** **5 Days (50 Hours)** **200 Lin. ft** **100 ft^2**	**$105,000**	**375**

Rock Cut Number	**1860**
Maintenance District	5
Highway	VT-74
Mile	0.12
Town	CORNWALL
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	216
AADT (2012)	1,900
Posted Speed Limit	50
Date Last Inspected	05/29/2015
Inspectors	ET, TE
Total RHR Score	**329**

SLOPE DESCRIPTION:
This rock cut is 19 feet tall and 216 feet long. The slope consists of meta-limestone with karstic features. The primary modes of failure are toppling and raveling. The primary concern at this rock cut are the open joints and solution cavities that are continuing to weather and widen over time. As they widen, it is expected that the large blocks of rock will eventually topple out of the slope and they will easily reach the roadway, as there is an inadequate ditch here. The slope is dry and is moderately vegetated.

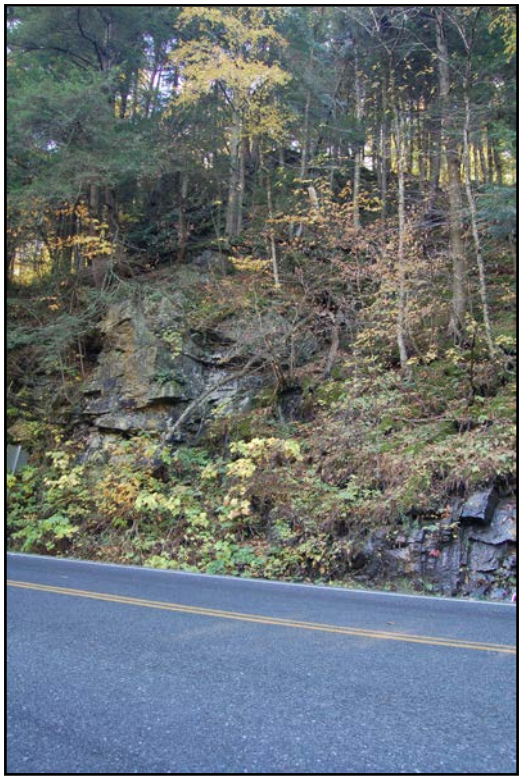
REMEDIATION OPTIONS:
The suggested remediation option for this rock cut is to remove the large blocks of weathered rock by machine scaling the slope.

CONDITIONS:
Remediation of the slope will require the closure of one lane of traffic. Stop and go traffic can be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**3 Days (30 Hours)**	**$14,000**	**43**

Rock Cut Number	**1931**
Maintenance District	5
Highway	VT-125
Mile	0.19
Town	RIPTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	290
AADT (2012)	1,900
Posted Speed Limit	40
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**405**



SLOPE DESCRIPTION:
This rock cut is 60 feet high and 290 feet long. The rock cut consists of gneiss. The dominate failure type is raveling; also, the stereonet plot shows the potential for wedge failure and planar failure along joint surfaces. This cut is heavily vegetated, wet, and resides on a curve in the roadway. This cut has been the source of rockfalls in this area in the past and was upgraded at the District's recommendation.

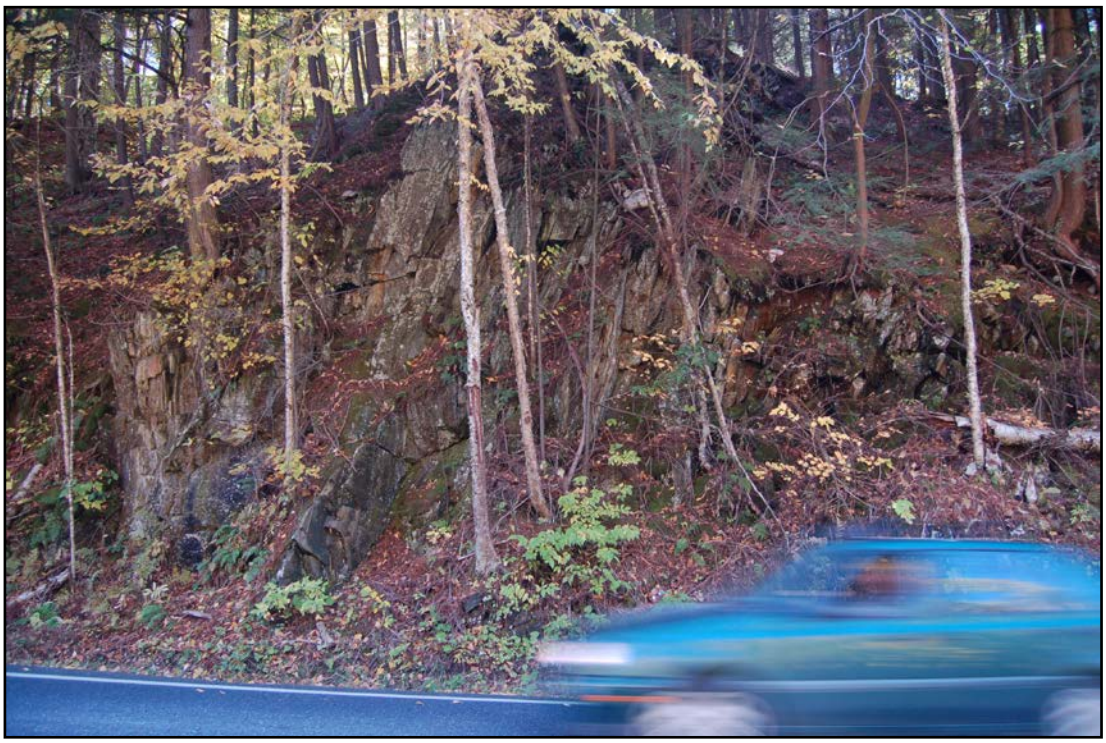
REMEDIATION OPTIONS:
Remediation for this slope will consist of the removal of loose and unstable rock by utilizing machine scaling techniques, the installation of rock dowels, and drilling drain holes within the rock.

CONDITIONS:
Closure of one lane of traffic is needed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling **Rock Dowel** **Drain Holes in Rock**	**3 Days (30 Hours)** **100 Lin. ft** **200 Lin. ft**	**$50,000**	**123**

Rock Cut Number	**1933**
Maintenance District	5
Highway	VT-125
Mile	0.32
Town	RIPTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	235
AADT (2012)	1,900
Posted Speed Limit	40
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**389**



SLOPE DESCRIPTION:
This rock cut is 35 feet high, 235 feet long, and consists of gneiss. The primary failure types are planar failure and wedge failure. The rock is broken up into numerous dilated joints. The slope sits extremely close to the roadway (2 ft from edge of pavement to toe of slope) and is heavily vegetated. This rock cut has a history of shedding rock into the roadway and it was upgraded to an "A" ranking at the District's recommendation.

REMEDIATION OPTIONS:
Remediation of this slope consists of the removal of loose and unstable rock utilizing machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**3 Days (30 Hours)**	**$22,000**	**57**

Rock Cut Number	**1937**
Maintenance District	5
Highway	VT-125
Mile	1.00
Town	RIPTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	95
AADT (2012)	1,900
Posted Speed Limit	40
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**302**

SLOPE DESCRIPTION:
This rock cut is 20 feet high, 95 feet long, and consists of gneiss. The dominate failure type is raveling. The slope sits extremely close to the roadway (2 ft from edge of pavement to toe of slope in some areas) and is heavily vegetated. Open fractures were observed on overhangs at the eastbound end of the rock cut.

REMEDIATION OPTIONS:
Remediation of this rock cut will consist of the removal of loose and unstable rock by utilizing machine scaling techniques.

CONDITIONS:
One lane of traffic will need to be closed during remediation. Stop and go traffic will be used as needed.

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Machine Scaling	**2 Days (20 Hours)**	**$13,000**	**43**

Rock Cut Number	**3665**
Maintenance District	5
Highway	VT-125
Mile	0.25
Town	RIPTON
Cut Location	RIGHT
Travel Direction	EB
Length (ft)	80
AADT (2012)	1,900
Posted Speed Limit	40
Date Last Inspected	05/29/2015
Inspectors	TE, ET
Total RHR Score	**243**

SLOPE DESCRIPTION:
This rock slope is 62 feet high and 80 feet long. The rock is made up of mica-schist. The primary failure types are wedge and raveling failure. This site sits up from the roadway and is heavily vegetated. It is essentially invisible while driving past it on the roadway. There is a large, dilated block in the middle of the slope.

REMEDIATION OPTIONS:
Remediation will consist of blasting the slope back to match the existing slope angle of 40°.

CONDITIONS:
Both lanes of traffic will need to be closed during blasting. Stop and go traffic will be used as needed

GROSS COST ESTIMATES:
Cost estimates include Engineering Design, Construction Management, Traffic Control, Mobilization and Clearing & Grubbing.

Mitigation Technique	Quantity	Estimated Cost	Cost/Score Ratio
Blast slope back to 40°	**5,000 cy**	**$165,000**	**679**

APPENDIX C

RHR SCORE ANALYSIS FOR SLOPES REMEDIATED 2011 - 2015

#0013 TOWNSHEND

Remediation Methods: Machine Scaling, High Scaling, Drains, and Rock Doweling.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	100	100	N/A
Paved Width Score	3	3	N/A
Rockfall History	9	0	Rockfall history is reset after remediation of slope
Accident History	9	0	Rockfall history is reset after remediation of slope.
Overhangs	27	27	Although doweling and scaling were performed, the slope still contains overhangs.
Rock Reach Roadway?	81	0	Rockfall history is reset after remediation of slope.
Average Vehicle Risk	3	4	Increased AADT increased vehicle risk.
% Decision Sight Distance	100	100	N/A
Block Size	81	81	Large blocks still remain on upper portions of slope. Those that are deemed unstable were bolted.
Block Shape	14	14	N/A
Geologic Factor	81	27	Doweling and scaling has reduced geologic score.
Ditch Effectiveness	100*	85	*Ditch effectiveness in 2011 was estimated to be zero, due to extremely small ditch width and depth. The ditch was modified in 2015 during remediation and new ditch measurements were obtained and ditch effectiveness was calculated.
Moisture Condition	9	3	Drains were installed to address moisture conditions.
TOTAL RHR SCORE	**617**	**444**	
Change in RHR Score	**173**		
% Change in RHR Score	**28%**		

#0062 ROYALTON

Remediation Methods: Emergency Machine Scaling of slope after rockfall event. Only zone of rockfall was scaled.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	12	12	N/A
Paved Width Score	7	7	N/A
Rockfall History	81	0	Rockfall history is reset after remediation of slope.
Accident History	0	0	N/A
Overhangs	27	27	N/A
Rock Reach Roadway?	81	0	Rockfall history is reset after remediation of slope.
Average Vehicle Risk	100	100	N/A
% Decision Sight Distance	2	2	N/A
Block Size	81	81	N/A
Block Shape	14	14	N/A
Geologic Factor	81	81	N/A
Ditch Effectiveness	83	83	N/A
Moisture Condition	3	3	N/A
TOTAL RHR SCORE	**572**	**410**	
Change in RHR Score	**162**		
% Change in RHR Score	**28%**		

#0077 BERLIN

Remediation Methods: Machine Scaling of slope.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	4	4	N/A
Paved Width Score	5	5	N/A
Rockfall History	9	0	Rockfall history is reset after remediation of slope
Accident History	0	0	Rockfall history is reset after remediation of slope.
Overhangs	27	9	Machine scaling removed most overhangs, 2 years later possible overhangs are starting to form.
Rock Reach Roadway?	0	0	Rockfall history is reset after remediation of slope.
Average Vehicle Risk	2	2	N/A
% Decision Sight Distance	50	50	N/A
Block Size	81	81	N/A
Block Shape	14	14	N/A
Geologic Factor	27	27	N/A
Ditch Effectiveness	0	0	N/A
Moisture Condition	0	0	N/A
TOTAL RHR SCORE	**219**	**192**	
Change in RHR Score	**27**		
% Change in RHR Score	**12%**		

#0079 BERLIN

Remediation Methods: High Scaling and installation of a Light Duty Rockfall Fence.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	100	100	N/A
Paved Width Score	6	6	N/A
Rockfall History	27	27	2015 History information from district shows no change from 2011 history information.
Accident History	0	0	N/A
Overhangs	81	27	Scaling removed the large overhangs present in 2012. 2015 visual inspection shows the presence of overhangs, not large overhangs.
Rock Reach Roadway?	81	0	Rockfall history is reset after remediation of slope.
Average Vehicle Risk	100	100	N/A
% Decision Sight Distance	1	1	N/A
Block Size	81	81	3-4 ft blocks were noted in the ditch next to slope. Few > 4ft blocks were observed on slope and are potentially unstable. Block size score remains the same as 2011
Block Shape	5	5	N/A
Geologic Factor	81	81	N/A
Ditch Effectiveness	27	15	Rockfall fence is light duty. It was not designed to contain large rockfall events which are possible at this slope. However the common rockfall occurrence of smaller amounts and sizes of rock is adequately contained by the fence. The ditch effectiveness was improved to 85% retention due to installation of the fence. Ditch effectiveness score was changed to 15.
Moisture Condition	3	3	N/A
TOTAL RHR SCORE	**593**	**446**	
Change in RHR Score	**147**		
% Change in RHR Score	**25%**		

#0109 RICHMOND

Remediation Methods: High Scaling, Rock Dowel Installation, Rock Drains, and Shotcrete application.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	55	55	N/A
Paved Width Score	7	7	N/A
Rockfall History	3	0	History tab is reset after remediation
Accident History	0	0	N/A
Overhangs	27	9	N/A
Rock Reach Roadway?	0	0	N/A
Average Vehicle Risk	100	100	N/A
% Decision Sight Distance	46	46	N/A
Block Size	81	27	N/A
Block Shape	14	14	N/A
Geologic Factor	81	9	Due to scaling, installation of rock dowels, and shotcrete application, the geologic factor is decreased.
Ditch Effectiveness	32	32	N/A
Moisture Condition	0	0	N/A
TOTAL RHR SCORE	446	299	
Change in RHR Score	147		
% Change in RHR Score	33%		

#0110 RICHMOND

Remediation Methods: High Scaling, Rock Dowel Installation, Rock Drains, and Shotcrete application.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	88	88	N/A
Paved Width Score	7	7	N/A
Rockfall History	3	0	History tab is reset after remediation
Accident History	0	0	N/A
Overhangs	27	9	High scaling reduced the number of overhangs.
Rock Reach Roadway?	0	0	N/A
Average Vehicle Risk	100	100	N/A
% Decision Sight Distance	46	46	N/A
Block Size	81	27	High scaling reduced the block size.
Block Shape	14	14	N/A
Geologic Factor	81	9	Due to scaling, installation of rock dowels, and shotcrete application, the geologic factor is decreased.
Ditch Effectiveness	7	7	N/A
Moisture Condition	3	3	N/A
TOTAL RHR SCORE	**457**	**310**	
Change in RHR Score	**147**		
% Change in RHR Score	**32%**		

#0213 STOCKBRIDGE

Remediation Methods: Machine Scaling, Rock Dowel Installation, and Secured Netting.

RHR Score Category	RHR Score Before Remediation	RHR Score After Remediation	Reasoning for change in score
Slope Height Score	2	2	N/A
Paved Width Score	21	21	N/A
Rockfall History	9	9	Occasional rockfalls occur but mostly retained by netting.
Accident History	0	0	N/A
Overhangs	27	9	Overhangs were scaled and bolted into place on slope.
Rock Reach Roadway?	81	81	N/A - small pieces of rock reach roadway
Average Vehicle Risk	20	29	Increased AADT
% Decision Sight Distance	39	39	N/A
Block Size	81	27	Scaling and rock bolting has reduced the maximum size of rocks that can reach roadway
Block Shape	5	5	N/A
Geologic Factor	81	27	Scaling , bolting, netting has reduced the geologic factor
Ditch Effectiveness	27	16	Clearing / grubbing of slope allowed for slope profile to be obtained and ditch effectiveness was then calculated
Moisture Condition	9	9	N/A
TOTAL RHR SCORE	**402**	**274**	
Change in RHR Score	**128**		
% Change in RHR Score	**32%**		