Washington State Department of Transportation

Memorandum

May 5, 2008

TO: D. Tak, Kelso Design Office, S-5

FROM: T.M. Allen / M.P. Mulhern
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Geotechnical Services Division
Fax (360) 709-5585

SUBJECT: SR 4, MP 50.18 to 50.24 MT-0072 (Group 22)
State-Wide Risk Reduction Rock Slope Scaling Program
Geotechnical Recommendations

INTRODUCTION

A state-wide risk reduction scaling program was implemented by WSDOT in 2006. The program is meant to reduce rockfall until a permanent slope stabilization project under the P3 Unstable Slope Program can be programmed and constructed. This memorandum presents our findings and mitigation recommendations for a rockslope located on SR 4 between MP 50.18 to 50.24, approximately 10 miles west of Kelso/Longview, Washington (Figure 1).

GEOTECHNICAL ASSESSMENT

Our geotechnical site assessment consisted of taking photographs of the slope, conducting Maintenance interviews, measuring slope heights, lengths, and detailing risk reduction work which includes tree removal, slope scaling, debris removal, rock anchors, and determining estimated quantities. Project stationing was field located with cloth tape and spray paint.

SITE CONDITIONS

This unstable slope is approximately 300-feet long and about 55-feet high with the existing slope oriented near-vertical (Figure 2). The ditch is 2- to 3-feet wide, and Maintenance indicates it is unable to contain the larger rockfall. Rockfall impacts both lanes of the highway at this location.

The lower portion of the slope is primarily composed of highly fractured, slightly weathered, strong basalt, while the upper portion of the slope consists of blocky basalt columns (Figure 2). The bedrock is mapped as the Frenchman Springs Member of the Columbia River Basalt Group. Block sizes range from a few inches in the lower portion of the slope to five feet in dimension in the upper portion of the slope. Observed rockfall

occurs as raveling failures in the lower portion of the slope and toppling-type failures in the upper basalt columns. The upper portion of the slope contains discontinuities that form adversely oriented toppling structures that are a potential source of structurally controlled slope instability. Many detached blocks were observed in the upper section of the slope during our site visit (Figures 3 and 4).

No groundwater was observed on the slope during our site assessment on January 23, 2007.

MITIGATION RECOMMENDATIONS

Partial mitigation measures that will reduce rockfall at this location consist of the following:

- Vegetation Removal,
- Slope Scaling with Debris Removal, and
- Installation of Type 1 Rock Dowels

Vegetation Removal

Vegetation removal should include removal of trees on steep exposed bedrock slopes and trees that are undermined due to rockfall activity. We estimate that approximately six trees will be removed during construction (Figures 3 and 4).

Slope Scaling with Debris Removal

Slope scaling limits are shown in Figures 3 and 4. Within these limits, typical rock scaling should be performed. Areas of intensive scaling have been identified as detached blocks A, B, C, D, and E in Figures 3 and 4. Scaling in these locations will consist of removing the detached blocks that we observed during our site visits.

We estimate that 40 crew hours will be required for slope scaling. Special Provisions for Slope Scaling are provided in Appendix B. Scaling will likely damage the highway surfacing, so provisions for its repair should be included in the contract.

We also estimate that approximately 150 cubic yards of rock debris will be generated during scaling operations. A Special Provision for Debris Removal Including Haul is provided in Appendix B.

Type 1 Rock Dowels

Following scaling and debris removal, Type 1 rock dowels should be installed at the locations shown in Figure 3. Type 1 rock dowels were designed for the larger unstable blocks that are unlikely to be removed during scaling operations. However, since scaling operations are often successful at removing blocks that were designed for reinforcement, we recommend that a WSDOT geotechnical specialist be contacted to reassess the slope following scaling operations to help the engineer determine the need for and placement of the proposed reinforcement.

We estimate that 50 lineal feet of Type 1 rock dowels are needed. For each rock dowel location, the minimum total length in feet is indicated in Figure 3. Special Provisions and a detail of a Type 1 rock dowel are provided in Appendix B. Note that epoxy resins are no longer accepted for rock dowel construction.

CONSTRUCTION CONSIDERATIONS

Poison Oak

This unstable slope is in an area containing poison oak. Contractors should take the necessary precautions before and during work on this slope.

Traffic

Full roadway closures will be required to perform scaling operations. We anticipate that these closures will be accomplished with short-duration work windows on the order of 20 to 30 minutes in length. Single-lane closures will also be required for installation of the Type 1 rock dowels.

Drilling

We anticipate difficult drilling conditions due to the variable rock characteristics and quality. Transitions between good quality and poor quality rock combined with the presence of some highly fractured material may result in difficult drilling and problems keeping borings open for insertion of the steel.

Geotechnical Inspection

We request that a geotechnical specialist from our office be contacted to assess the slope prior to the completion of scaling to help the engineer determine whether or not additional scaling is required.

If you have questions regarding the information presented in this memorandum, then please contact Mike Mulhern at (360) 709-5583 or Doug Anderson at (360) 709-5427.

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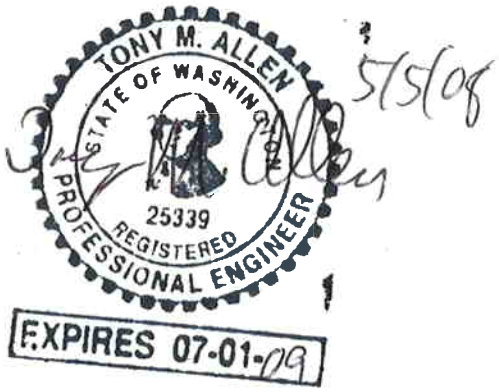

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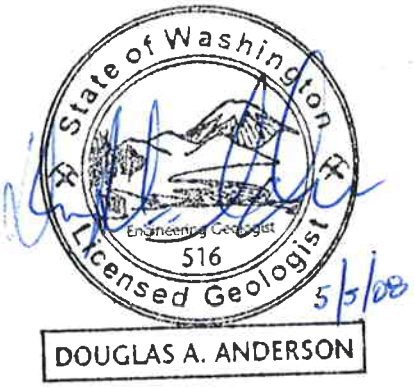


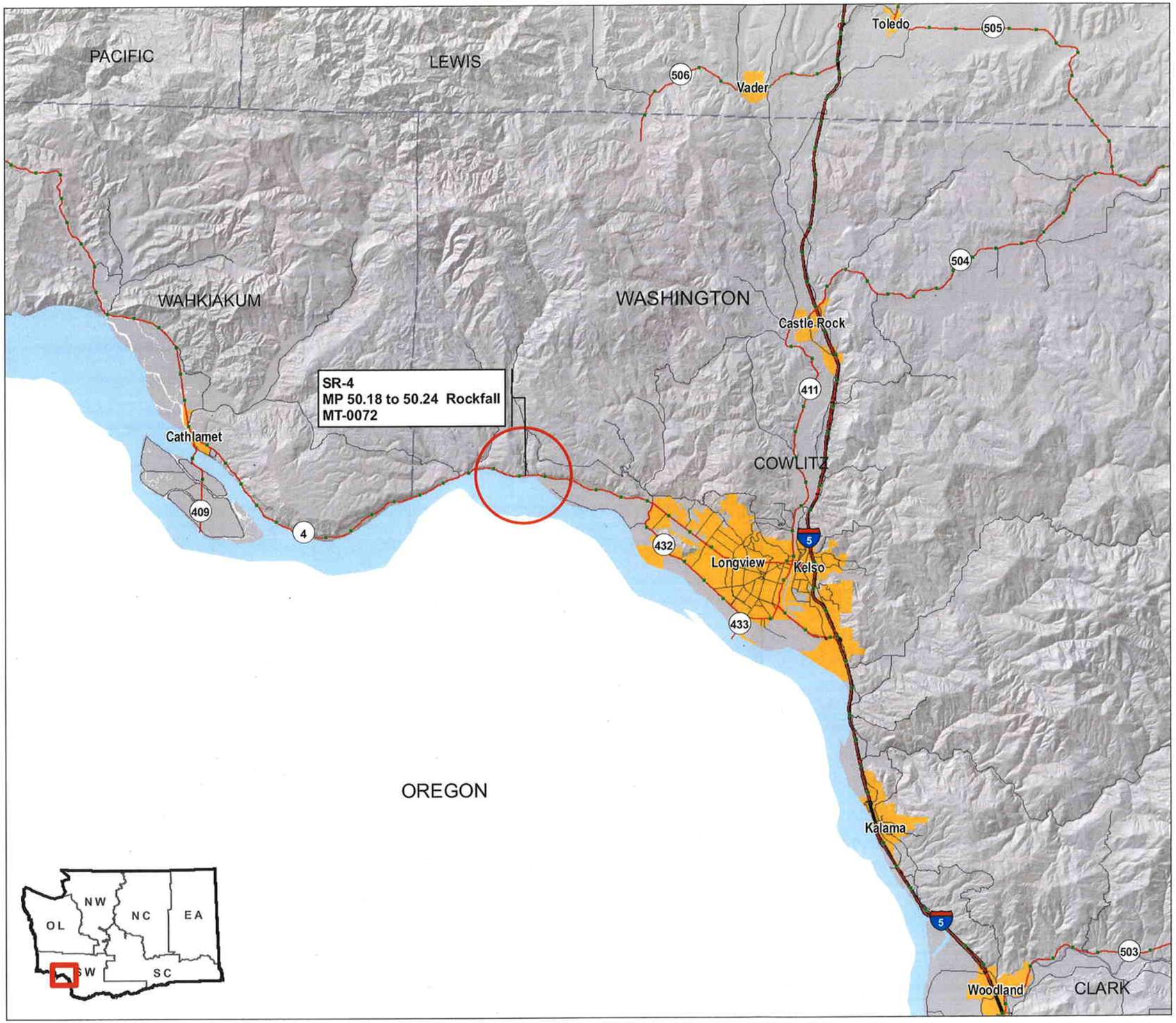
APPENDIX A

Figures

FIGURE 1: SITE VICINITY

SR-4 VICINITY MP 50.18 TO 50.24 ROCKFALL

JOB# MT-0072



LEGEND

- Risk Reduction Scaling Program Slopes
- Milepost Markers

State Routes

- Interstate
- US Route
- State Route
- Ramps
- Proposed Route
- Local Road
- County Boundary Lines
- Incorporated Cities

N

MILES
0 1 2 4 6 8

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1 INCH EQUALS 20,000 FEET

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DATE	MARCH 17, 2008

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FIGURE 2: A photograph showing the unstable slope on SR 4 vicinity MP 50.18 to 50.24

JOB MT-0072 S.R. 4

SR 4 Vicinity MP 50.18 to MP 50.24 Rockfall

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DATE 4/2008

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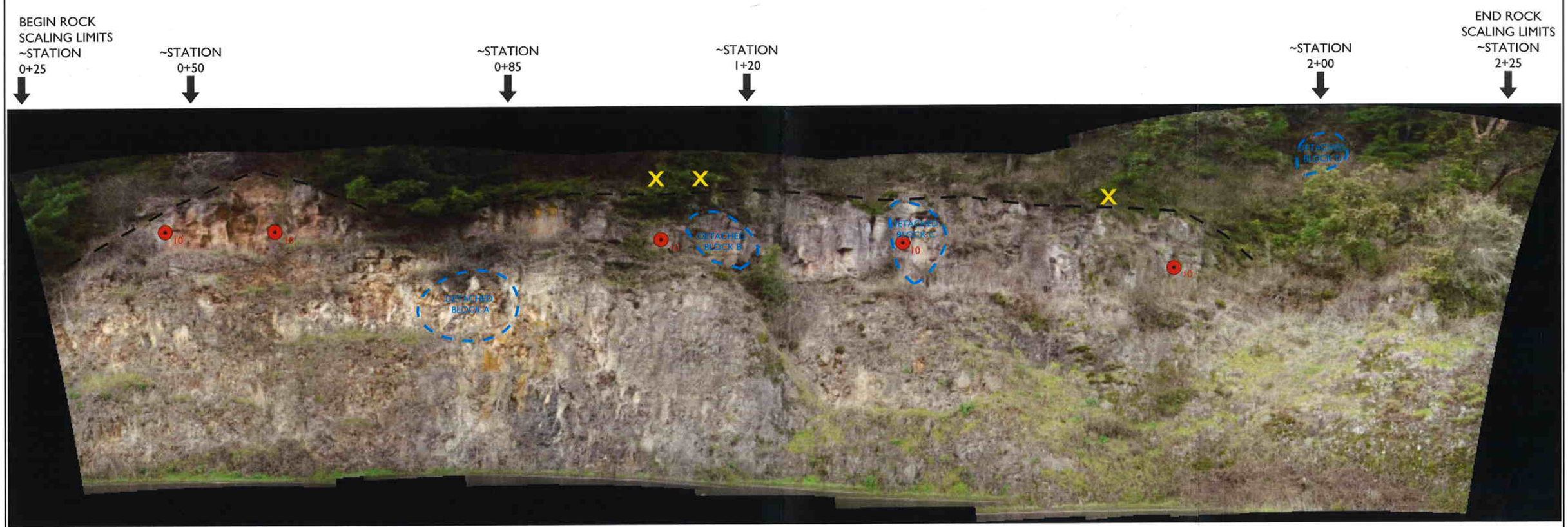

LEGEND

- 10 Type I Rock Dowels (Minimum Dowel Length In Feet)
- X Tree Removal (3 On This Figure)
- Slope Scaling Limits
- Areas of Intense Scaling

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FIGURE 3: RISK REDUCTION MITIGATION DESIGN

SR 4 MITIGATION MEASURES

SR-4 SRMP 50.18 - 50.24 JOB # MT-0072

NOT TO SCALE

PROJECT MANAGER	MIKE MULHERN
PREPARED BY	JEFF FISHER
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DATE	MAY 6, 2008
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LEGEND

X Tree Removal (4 On This Figure)

- - - Areas of Intense Scaling

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FIGURE 4: RISK REDUCTION MITIGATION DESIGN

SR 4 MITIGATION MEASURES

SR-4 SRMP 50.18 - 50.24 JOB # MT-0072

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APPENDIX B

Special Provisions

(******)
SLOPE SCALING

Description
This work shall consist of the manual removal of vegetation and loose rock and soil on the slope at the locations shown in the Plans or as directed by the Engineer. The Contractor shall provide all materials, equipment, and labor necessary to perform this work.

Submittals
Not less than 2 weeks prior to commencing rock scaling, the Contractor shall provide to the Engineer:

A. The Contractor shall provide written evidence that the rock slope scaling foreman and scalers have performed satisfactory work in similar capabilities for sufficient length of time to be fully qualified to perform their duties. The foreman shall have not less than 1500 hours of demonstrated experience as a scaler. The scalers shall have not less than 1000 hours of demonstrated experience on similar projects.

B. The Contractor shall submit a detailed work plan for each rock slope to be scaled. The plan shall include:

   1. The proposed construction sequence and schedule.

   2. The type of equipment and tools to be used.

   3. The number of scaling crews to be employed on the project. (A scaling crew is defined as one qualified foreman and two qualified scalers.)

   4. Debris removal and disposal plan generated from the scaling work.

   5. Provisions to protect adjacent facilities.

Work shall not begin until the Engineer has approved the appropriate submittals in writing.

Materials
Slope scaling will be done with the use of scaling bar, portable hydraulic wedges, air pillows, hand drills, splitters, Boulder Buster™ or other mechanical means. Other hand tools in addition to scaling bars may be used provided they have demonstrated effectiveness to perform the required work by approval of the Engineer.

Construction Requirements
All trees and brush within 20 feet of the slope crest shall be flush cut and the root wad left intact.

Work shall proceed according to the work plan and schedule submitted by the Contractor prior to commencement of work. The size of the crew, defined as a foreman and two qualified scalers, shall be maintained at all times.

Slope scaling shall start at the top of the slope and work shall proceed down slope, removing loose rock and soil as the work progresses. Tree and brush removal shall be included as Slope Scaling. Unless otherwise directed by the Engineer, all trees within 20 feet of the slope crest shall be flush cut and the root wad left intact. Tree falling shall be completed prior to performing other scaling work.

The extent of the slope scaling will be determined by the Engineer and/or be specified in the Plans.

All rock, debris, and vegetive material produced by the scaling operation shall be removed by the Contractor and hauled to a site specified in the contract. See Special Provision **DEBRIS REMOVAL INCLUDING HAUL**.

Measurement

Slope scaling will be measured by the crew hour.

Debris removal will be by the cubic yard in the hauling conveyance at the point of removal from the roadway. See Special Provision **DEBRIS REMOVAL INCLUDING HAUL**.

Payment

Payment will be made in accordance with Section 1-04.1, for the following Bid item included in the proposal:

"Slope Scaling", per crew hour.

The unit contract price per crew hour for "Slope Scaling" shall be full pay for performing the work as specified.

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DEBRIS REMOVAL INCLUDING HAUL

Description

This work consists of removing existing debris from the roadway or material generated from slope scaling, mechanical scaling, and/or trim blasting operations.

Construction Requirements

The Contractor shall remove all existing and slope scaling-, mechanical scaling -, and/or trim blasting-related debris within the project limits and as directed by the Engineer. The Contractor shall also haul and place debris at a specified location.

Measurement

Debris removal will be measured by the cubic yard in the hauling conveyance at the point of removal from the roadway.

Payment

Payment will be made in accordance with Section 1-04.1 for the following bid item that is included in the proposal:

"Debris Removal Including Haul", per cubic yard.

The unit contract price per cubic yard for "Debris Removal Including Haul" shall be full pay for performing the work described including furnishing the equipment, materials, and labor required to load, haul, and place the debris at the specified location.

(******)
TYPE 1 ROCK DOWEL

Description
This work shall consist of the installation of untensioned Type 1 rock dowels at the locations and orientations designated in the Plans or by the Engineer. The Contractor shall select and construct the dowels to carry a 25 kip design load and supply all materials, equipment, and labor to test and install the dowels. The Engineer will designate the orientation and minimum length of the dowel required.

Submittals
Not less than two weeks prior to commencing the rock doweling, the Contractor shall submit in writing to the Engineer for approval:

The Contractor shall provide written evidence that the foreman and drill operator have performed satisfactory work in similar capacities elsewhere. The foreman shall have installed a minimum of 3000 linear feet of untensioned and/or tensioned rock anchors on a minimum of 5 projects over 5 years, and the drill operator shall have installed a minimum of 1000 linear feet of untensioned and/or tensioned rock anchors on a minimum of 3 projects over 5 years.

The Contractor shall submit a detailed plan for the rock doweling to include:

1. The proposed construction sequence and schedule.

2. The proposed drilling method and equipment.

3. The proposed drill hole diameter.

4. The proposed anchor steel/tendon, couplers, bearing plate, anchor unit, flat washer, and beveled washer specifications including manufacturer's data sheets, catalog cuts and mill certificates.

5. The proposed cement grout mix design including manufacturer's data sheets and catalog cuts and the procedures for placing the grout.

6. The proposed construction method for upwardly inclined anchors.

7. The proposed corrosion protection for the rock dowel system. This shall include written certification and statement of manufacturer's compliance for corrosion-resistant bar coating.

8. The calibration data for each load cell, test jack, pressure gauge and master pressure gauge to be used in the proof testing. An independent testing laboratory shall have performed the calibration tests within 60 calendar days of the date submitted.

9. The proposed stressing procedures and stressing equipment to proof test the dowels.

Work shall not begin until the Engineer has approved the appropriate submittals in writing.

Materials

All rock bolts, including anchorage, bearing plates, couplers, corrosion protection, and other appurtenances, shall be products of a manufacturer regularly engaged in the manufacturing of materials for the construction of rock dowels.

Dowels shall be fabricated from deformed steel bars in general compliance with WSDOT Standard Specification 9-07. Anchor bar steel shall not be precut at the factory to lengths shown in the Plans, but rather be delivered in bulk lengths and field cut to the appropriate length. Anchor bar steel shall be provided with either fusion-bonded epoxy coating or hot dip galvanizing for corrosion protection. Epoxy coating shall be applied in accordance with ASTM A 934 and shall have a minimum thickness of 10 mils plus or minus 2 mils. Patching material, compatible with the epoxy coating and inert in cement grout, shall be supplied with each shipment. Extreme care shall be taken in the handling of epoxy-coated bars to prevent coating damage and embrittlement. Field handling procedures for epoxy-coated bars shall be in general accordance with ASTM D 3963 including providing padding between contact points during storage and lifting and covering coated bars to minimize ultraviolet exposure. Hot dip galvanizing shall comply with ASTM A 153 and shall have a minimum thickness of 3.9 mils.

Each rock dowel shall be fitted with a bearing plate and nut. These anchorage devices shall be capable of developing 95 percent of the minimum guaranteed ultimate tensile strength of the pre-stressing steel. The anchorage devices shall conform to the static strength requirements of Section 4.3 of the Post-Tensioning Institute "Recommendations for Prestressed Rock and Soil Anchors". The bearing plate shall be of mild steel, not less than 0.25 inches in thickness and not less than 4 inches square. A minimum 8 inch-square bearing plate shall be used for rock surfaces that are very weak and/or highly weathered, or where anchoring through and bearing against shotcrete. The plate shall have a central hole large enough to fit easily over the dowel while maximizing the average bearing surface for the washer and the nut. Spherical seating of the nut is not required. Beveled washers shall be used to accommodate non-perpendicular installations.

Cement grout shall be a proven, non-shrink material capable of permanently developing the bond and internal strength necessary for the required dowel capacity. The use of epoxy or polyester resin as bonding agents is not allowed. If requested by the Engineer, a sample of the cement grout shall be provided for testing.

Corrosion protection paint shall conform to Section 9-08.2 for Formula A-9-73 - Galvanizing Repair Paint, High Zinc Dust Content.

Construction Requirements

Work shall proceed according to the plan and schedule submitted by the Contractor prior to the commencement of the work.

The Engineer shall specify the location, orientation, and minimum length of each rock dowel. The rock dowel shall be installed within five degrees of the specified angle. Unless otherwise specified, the angle of installation shall be perpendicular to the rock

face and inclined slightly downward. If the axis of the rock dowel is not close to perpendicular to the rock face or within the angle provided by the beveled washer, or the rock beneath the bearing plate is not sound, a bearing pad approved by the Engineer shall be constructed at no additional cost to the State, so that the rock dowel is not bent when tensioned. In all cases, at least three quarters of the bearing plate shall be in contact with the rock face.

The dowels shall be handled and stored in such a manner as to avoid damage or corrosion of the coating and the steel. Damage to the dowel steel as a result of abrasion, cuts, nicks, welds, and weld splatter will be cause for rejection. The dowels shall be protected from dirt, rust, and harmful substances. A light coating of rust on the steel is acceptable. If heavy corrosion or pitting is noted, the Engineer will reject the rock dowel.

Prior to installation all mill scale, flaking rust and grease shall be removed from the steel. The entire length of the rock dowel shall be encapsulated in cement grout for a second level of corrosion protection. All exposed parts of the dowel, bearing plate and nut on the surface shall be painted with approved corrosion protection paint or epoxy patching compound.

The use of hand drills for advancing the anchor hole is not allowed without written permission by the Engineer and demonstrated effectiveness by the Contractor.

The drill hole shall be sized to provide a minimum of 0.5 inches of grout cover around the bar. The Contractor shall flush the drill hole of all drill cuttings and debris with compressed air prior to the installation of the rock dowel. Holes drilled for rock dowels in which dowel installation is considered by the Engineer to be impractical shall be re-drilled at the Contractor's expense.

The grout equipment shall produce a grout free of lumps and undispersed cement. The pump shall be equipped with a pressure gauge near the discharge end to monitor grout pressures. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The grout shall be injected from the lowest point of the drill hole. The quantity of the grout and the grout pressures shall be recorded.

Centralizers shall be placed on the bar on 10-foot centers prior to grouting with a minimum of two centralizers per anchor. The lower centralizer should be located within one foot of the end of the bar/tendon. Sufficient grout will be placed in the drill hole to ensure full encapsulation of the dowel.

When the cement grout has reached final set, the Contractor shall install the bearing plate, washers and nut. The nut shall be torqued to a nominal 100 foot-pounds to insure proper seating against the rock face. The end of the completed rock dowel shall be trimmed to within 6 inches of the rock face.

At the discretion of the Engineer, up to 5 percent, but not less than three rock dowels, of the installed rock dowels shall be proof tested. The Contractor shall conduct the proof test, and the Engineer will interpret the results. The rock dowel shall be tensioned to 25,000 pounds with a calibrated hollow-ram hydraulic jack using a bar extension and coupler attached to the rock dowel and held for 10 minutes. If no loss of load occurs over this time period, the rock dowel is acceptable. The Engineer may require additional

proof of testing beyond the 5 percent maximum, if rock dowels fail the proof testing. All failed rock dowels shall be replaced with an additional rock dowel installed in a separate hole. No payment will be made for rock dowels that fail or for additional proof testing.

Measurement

Rock dowels will be measured per linear foot of rock dowel installed and accepted.

Payment

Payment will be made in accordance with Section 1-04.1 for the following bid items that are included in the proposal.

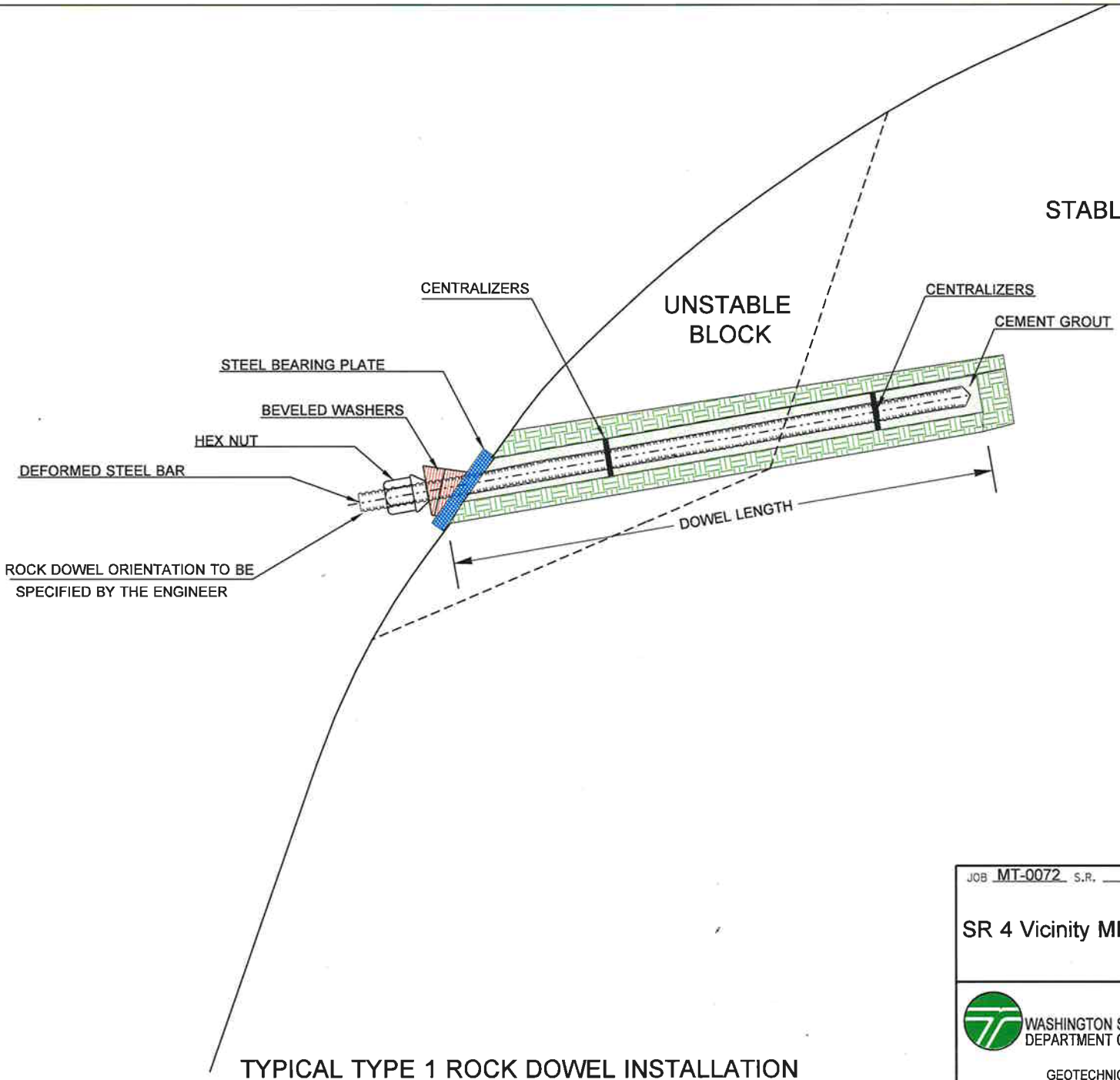
"Type 1 Rock Dowel", per linear foot.

The unit contract price per linear foot for "Type 1 Rock Dowel" shall be full pay for performing the work as specified. The cost for the performance and proof testing shall be included in the unit bid price for "Type 1 Rock Dowel". The unit contract price shall include grout-take up to 200 percent of the drilled hole volume calculated from the hole diameter and length.

"Grout Exceedance", by force account as provided in Section 1-09.6

For grout takes greater than 200 percent in any specific hole, the Contractor shall be reimbursed under bid item "**Force Account Grout Exceedance**". Wasted grout will not be measured for payment. For measurement of grout volume injected, the Contractor shall supply a meter or other method satisfactory to the Engineer.

To provide a common Proposal for all Bidders, the contracting Agency has entered an amount in the Proposal for "Force Account Grout Exceedance" to become a part of the Contractor's total Bid.



TYPICAL TYPE 1 ROCK DOWEL INSTALLATION

JOB MT-0072 S.R. 4

SR 4 Vicinity MP 50.18 to MP 50.24 Rockfall

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DATE 4/2008

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