

DESERT VARNISH (PERMEON™) EVALUATION

Final Report

SPR 306.211

by

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16. Abstract In 1998, ODOT mitigated a rock fall hazard on the Historic Columbia River Highway. Loose rock was removed from the overhanging cliff while the sandstone near the base of the cliff was covered with shotcrete to prevent erosion. The shotcrete was then coated with desert varnish to hide the new-looking concrete face. The desert varnish was intended to help blend the project into the surrounding environment in this area of high tourist traffic. The project was completed in the summer of 1999. The desert varnish was applied without any problems. It continues to darken with age so that the shotcrete blends in well with the natural cliff. This report documents the application and inspections of the results.			
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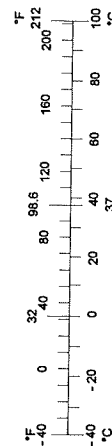
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<u>AREA</u>				
in ²	square inches	645.2	millimeters squared	mm ²
ft ²	square feet	0.093	meters squared	m ²
yd ²	square yards	0.836	meters squared	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	kilometers squared	km ²
<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	meters cubed	m ³
yd ³	cubic yards	0.765	meters cubed	m ³
NOTE: Volumes greater than 1000 L shall be shown in m ³ .				
<u>MASS</u>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<u>AREA</u>				
mm ²	millimeters squared	0.0016	square inches	in ²
m ²	meters squared	10.764	square feet	ft ²
ha	hectares	2.47	acres	ac
km ²	kilometers squared	0.386	square miles	mi ²
<u>VOLUME</u>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	meters cubed	35.315	cubic feet	ft ³
m ³	meters cubed	1.308	cubic yards	yd ³
<u>MASS</u>				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
<u>TEMPERATURE (exact)</u>				
°C	Celsius temperature	1.8C + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

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This report does not constitute a standard, specification, or regulation.

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1.0 INTRODUCTION

“Desert varnish” is the name given to the brown to black coating that forms on stable rock surfaces in certain arid regions of the world. Natural desert varnish can be found in the Sahara Desert, the outback of Australia and the cold dry desert of Antarctica. It also appears in arid high-altitude mountains in Germany as well as on mountains in Colorado and Montana. No one has observed the natural formation of desert varnish, as it is an extremely slow geological process that may take up to 200,000 years to form.

In order to restore the natural appearance of rocky cliffs after construction, an artificial form of desert varnish was synthesized. Initially, the laboratory-created desert varnish was applied to projects in mountainous areas in Arizona, to comply with visual impact laws. The desert varnish was used because reseeding and other reclamation efforts were not feasible.

Concrete support structures can also be colored with desert varnish to blend in with the surroundings. The varnish has been used successfully on retaining walls, dams, irrigation ditches, and cliffs stabilized with shotcrete.

In 1995, the Oregon Department of Transportation (ODOT) used the artificial desert varnish on a slope stabilization project on US 101 near Port Orford. The slope was shaped and reinforced with rock bolts and the bottom portion was covered with shotcrete. Because this scenic area attracts tourists from all over the world, desert varnish was applied to the shotcrete to make it more aesthetically appealing. After 5 years the varnish is still working well. It has given the gray shotcrete a marbled-brown appearance similar to other coastline cliffs in the area (*Hofmann 1995, Brooks 1998*).

A rock fall mitigation project on the Crown Point Highway was completed in 1998. After the loose rocks were removed manually, the base of the cliff was covered with shotcrete. Because the project is in the Columbia River Gorge National Scenic Area and is visited by many tourists, the shotcrete was colored with desert varnish to make it blend with the surroundings.

This report covers the application of desert varnish to the Crown Point Highway project and its appearance after two years of service.

1.1 STUDY OBJECTIVE AND METHODOLOGY

The objective of this project was to evaluate the effectiveness of an artificial desert varnish, PERMEON™, in producing a weathered, natural appearance when applied to shotcrete. This report documents the usefulness of desert varnish in achieving the visual quality objective of visual subordination. The term “visually subordinate” is defined in the Columbia River Gorge National Scenic Area Management Plan as follows:

“A description of the relative visibility of a structure where that structure does not noticeably contrast with the surrounding landscape, as viewed from a specified vantage point (generally a key viewing area, for the Management Plan). As opposed to structures that are fully screened, structures that are visually subordinate may be partially visible. They are not visually dominant in relation to their surroundings.” (*Columbia River Gorge Commission 1991*)

Photos were taken by the principal investigator at two weeks, one month, six months, eleven months and twenty-one months after application of the desert varnish. Landscape architects from ODOT and the US Forest Service were asked to review and evaluate the photos after eleven and twenty-one months.

2.0 PROJECT DESCRIPTION

2.1 PROJECT LOCATION AND ENVIRONMENT

The desert varnish was applied to the shotcrete used on the base of the cliff near Dabney State Park. This park is located east of Portland, Oregon along the Sandy River on the Crown Point Highway at milepost 4.1 (see Figure 2.1). The roadway has been designated as a National Scenic Route and is used by many tourists.

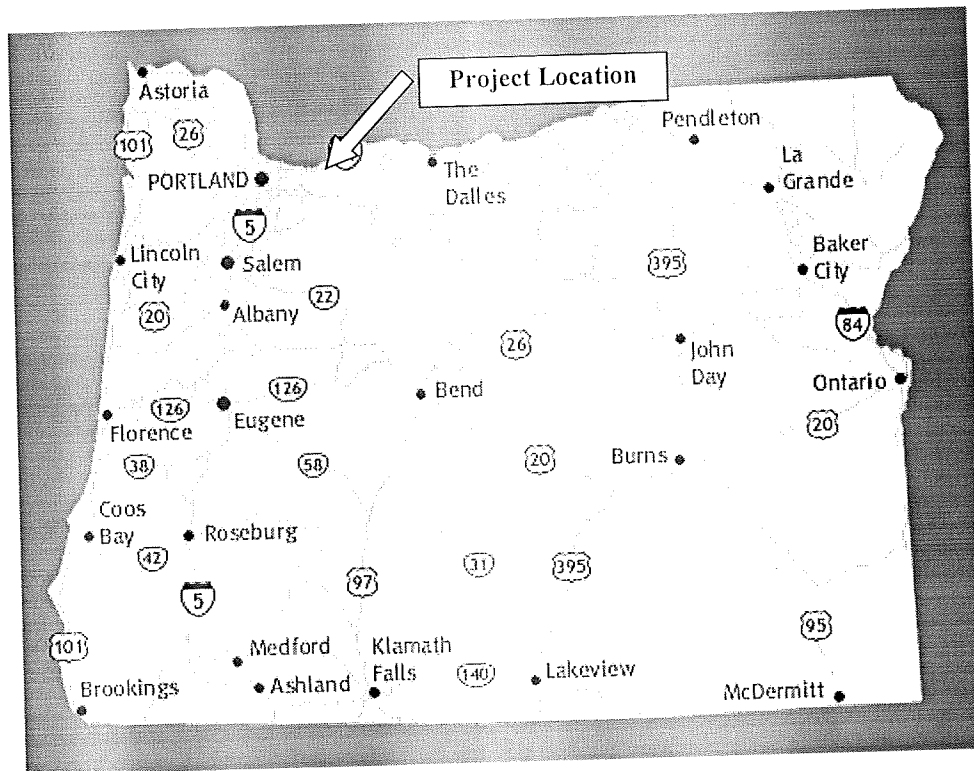


Figure 2.1: Project vicinity map

A cross section of the cliff is included in Appendix A. Located in the north Willamette Valley, the annual rainfall is about 114 cm (45 in). The winters are mild with only a few freeze-thaw cycles. The mean January temperature is 4 °C (39 °F), while the mean July temperature is 21 °C (69 °F).

3.0 CONSTRUCTION

Application of the desert varnish was delayed for several months due to wet weather. (Desert varnish must be applied to a dry surface.) On July 14, 1999, final preparations were made, as there was no rain forecast for the next 24 hours, with only a 20% chance of light showers late on the night of July 15. The contractor prepared the surface by pressure washing the shotcrete, which had been applied the prior year and had some natural buildup of dirt and minerals.

3.1 APPLICATION

The morning of July 15, the desert varnish application went smoothly, with about 76 linear meters (250 ft) completed by 10:00 a.m. The weather was sunny and warm. Traffic was routed one-way in the eastbound lane. The base of the newly cut rock slope was then about 7.6 m (25 ft) from the passing cars. Because of the low height to be sprayed and low wind conditions, the chance of overspray hitting passing cars was not a problem. Traffic was light and the delay due to the one-way travel was very short.

The PERMEON™ (desert varnish) had been mixed with water in a 1:5 solution, 75.7 liters (20 gal) of PERMEON™ to 378.5 liters (100 gal) of water. The mix was carried in the back of a pickup truck in a 946-liter (250-gal) tank. A compressor was used to pressurize the spray to about 14 kg/cm² (200 psi). (see Figure 3.1) The sub-contractor, Livingston, Inc., used a 61 m (200 ft) hose and an agricultural type handheld nozzle to spray the shotcrete-coated cliff.



Figure 3.1: Spraying equipment to apply desert varnish

Jill Livingston, who was doing the desert varnish application, was an experienced operator. She said that the desert varnish color can range from almost black to a light tan, depending on the

concentration of PERMEON™ and the number of coats to be made. The solution was sprayed on until saturation, when it started to run off the shotcrete. At this saturated value, the desert varnish was intended to match the light brown of the rocks above.

The application went very well, with no complaints about overspray. Application was completed with materials on hand and no breakdowns occurred.

3.2 MATERIAL DESCRIPTION

When first applied, the PERMEON™ mixture does not have a tint, and the shotcrete returns to its original light gray color as it dries. The coloration process is activated by exposure to ultraviolet light from sunshine. The formulation for this project was selected by spraying test bricks and leaving them for the required exposure time. Because some of the cliff above the shotcrete was darker, additional coats could be required, but because it takes at least a week for the PERMEON™ color to develop, another trip would be required to achieve a darker coloration.

The material safety data sheet for the PERMEON™ indicates that it contains salts of manganese and iron with trace elements chlorine, copper, zinc and phosphoric oxides. (See Appendix B). At the concentrations used, Jill Livingston said the mixture would not kill roadside vegetation or affect fish in nearby streams with running water. She cautioned, however, that still water such as small fishponds should be covered when PERMEON™ is applied nearby.

3.3 POSSIBLE PROBLEMS

Two possible problems were noted: water running over the cliff in a few areas from a local land owner's irrigation effort on the hill above the site (see Figure 3.2), and mineral stains from an unknown source appearing on some of the rocks just above the shotcrete. It was decided that these two areas should be closely monitored.



Figure 3.2: Dark streaks on shotcrete caused by irrigation water from above

Also noted were some cracks in the shotcrete running vertically up the cliff. Some of these cracks extended from weep-hole to weep-hole. These were considered to be potential break points for the shotcrete. Near the top of the desert varnish, there were areas of overhang which could also be breaking points.

4.0 EVALUATIONS

Jeanette Kloos, ODOT's Historic Columbia River Highway Coordinator, monitored the project as principal investigator. Photographs and inspections were taken at two weeks, one month, six months, eleven months, and a final inspection was conducted after twenty-one months. Photographs were compared and evaluated for the aesthetic value of the desert varnish application. A construction report was written soon after the initial inspection was completed.

4.1 POST CONSTRUCTION INSPECTION

After two weeks, half of the shotcrete with the desert varnish was starting to blend well with the surrounding cliff. The section west of the Sandy River Bridge was well matched, as shown in a comparison of Figures 4.1 and 4.2. East of the bridge, the section was still lighter than the cliff, as shown in Figures 4.3 and 4.4. This section was closely monitored, with the expectation that it would darken with age. After six months, the lighter patches were no longer noticeable. Figures 4.5 through 4.8 show the sections West and East of the Sandy River Bridge at one- and six-month intervals respectively.



Figure 4.1: Shotcrete before application of desert varnish - West of Sandy River Bridge



Figure 4.2: Shotcrete 2 weeks after application of desert varnish - West of Sandy River Bridge



Figure 4.3: Shotcrete before application of desert varnish - East of Sandy River Bridge



Figure 4.4: Shotcrete 2 weeks after application of desert varnish - East of Sandy River Bridge

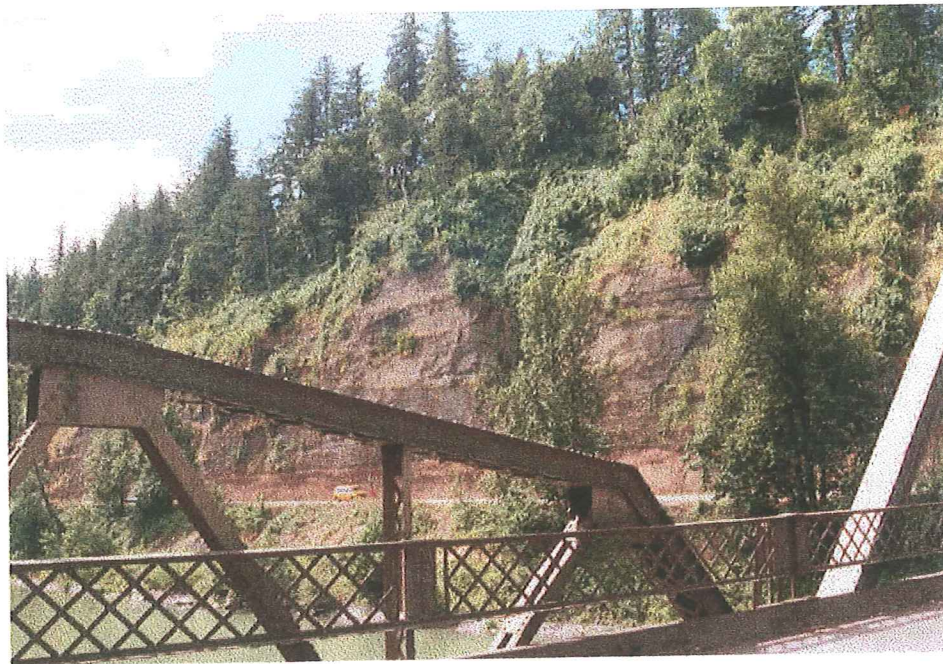


Figure 4.5: Shotcrete one month after application of desert varnish - West of Sandy River Bridge



Figure 4.6: Shotcrete one month after application of desert varnish - East of Sandy River Bridge



Figure 4.7: Shotcrete 6 months after application of desert varnish - West of Sandy River Bridge



Figure 4.8: Shotcrete 6 months after application of desert varnish - East of Sandy River Bridge

4.2 ELEVEN MONTH INSPECTION

Approximately eleven months after application – on June 14, 2000 – the dark brown shade of the desert varnish remained on most of the shotcrete. Figures 4.9 and 4.10 show that the coloring is consistent with the surrounding slopes, as the desert varnish begins to develop a naturally weathered appearance.



Figure 4.9: Shotcrete 11 months after application of desert varnish - West of Sandy River Bridge



Figure 4.10: Shotcrete 11 months after application of desert varnish - East of Sandy River Bridge

4.3 TWENTY-ONE MONTH INSPECTION

A final inspection of the desert varnish at Dabney State Park was made on April 24, 2001. Figures 4.11 and 4.12 show that the shotcrete applied with desert varnish completely blends into the natural view. Jurgen Hess, Landscape Architect and Environmental Planning Staff Officer with the Columbia River Gorge National Scenic Area commented that the desert varnish had a positive mitigating effect on the shotcrete at Dabney State Park. Mr. Hess went on to state that he noticed a significant decrease in contrast between the shotcrete and surrounding slopes over the twenty-one months the project area was monitored and that the project meets the visual subordinate requirements of the Columbia River Gorge Scenic Area Management Plan. Figures 4.13 through 4.18 provide additional evidence of how the desert varnish naturally weathered and blended into the natural surroundings over time.



Figure 4.11: Shotcrete 21 months after application of desert varnish - West of Sandy River Bridge

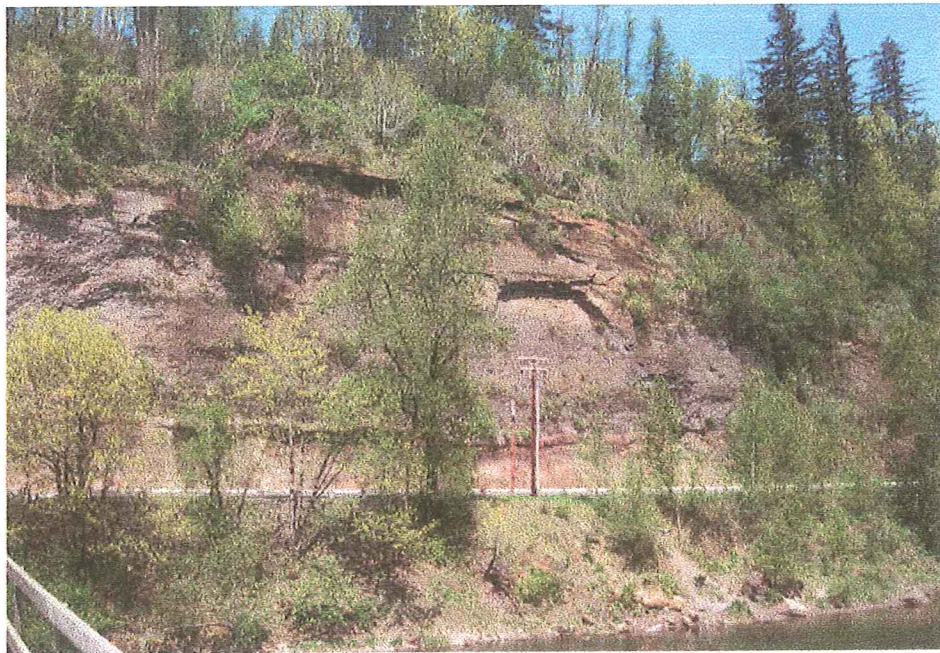


Figure 4.12: Shotcrete 21 months after application of desert varnish - East of Sandy River Bridge



Figure 4.13: Close-up view of shotcrete before application of desert varnish - West of Sandy River Bridge



Figure 4.14: Close-up view of shotcrete 2 weeks after application of desert varnish - West of Sandy River Bridge

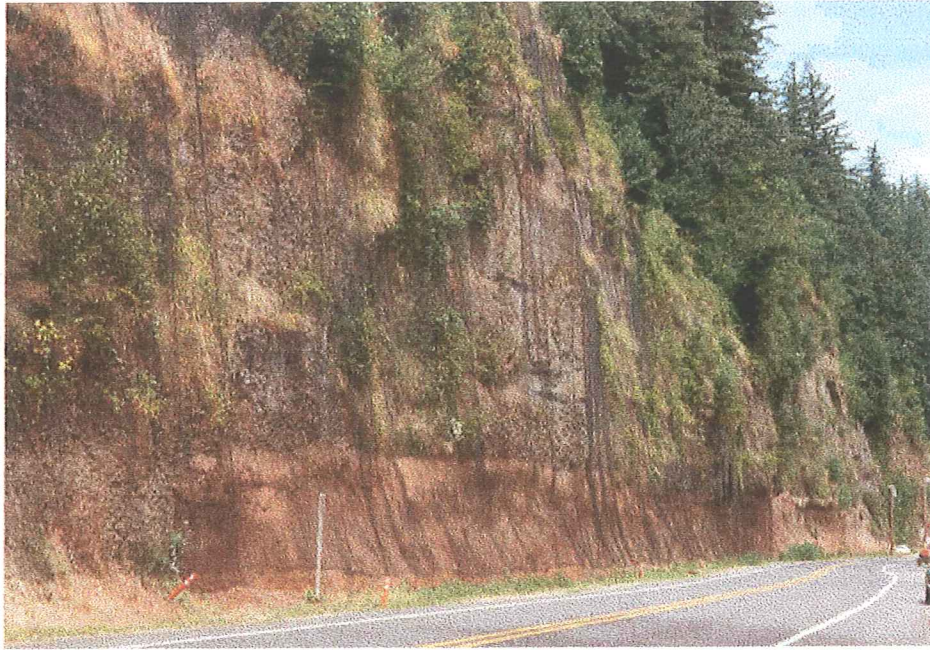


Figure 4.15: Close-up view of shotcrete one month after application of desert varnish - West of Sandy River Bridge

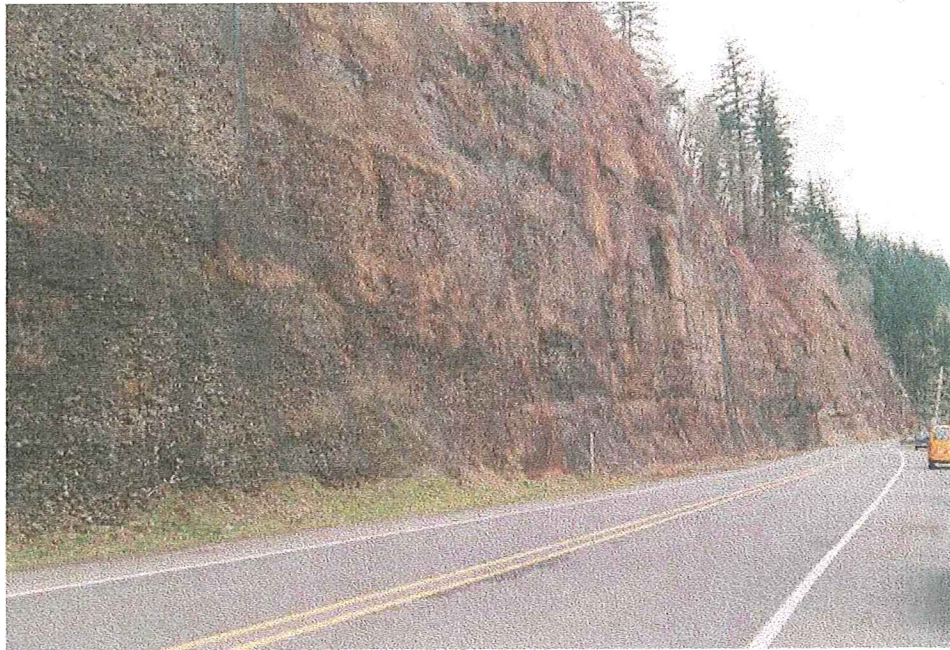


Figure 4.16: Close-up view of shotcrete 6 months after application of desert varnish - West of Sandy River Bridge



Figure 4.17: Close-up view of shotcrete 11 months after application of desert varnish -
West of Sandy River Bridge

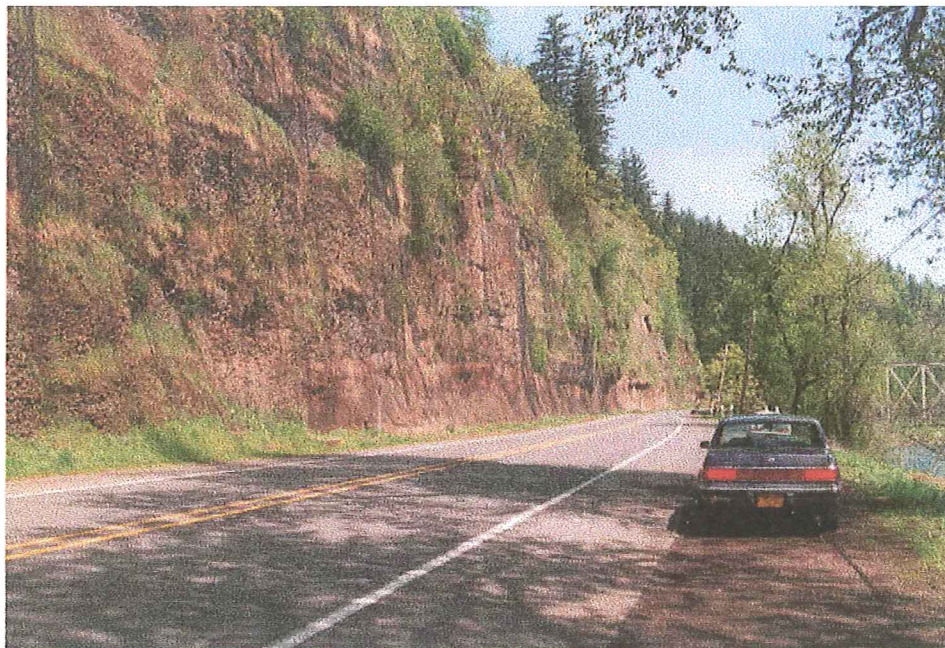


Figure 4.18: Close-up view of shotcrete 21 months after application of desert varnish -
West of Sandy River Bridge

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were made from this study:

1. The application of desert varnish successfully changed the grayish-white color of shotcrete to a light-brown color that mitigated the visual impacts of construction in this scenic area. In addition, the treatment met the requirements of the Columbia River Gorge Scenic Area Management Plan to achieve a visual quality objective known as visual subordination.
2. It is recommended that application of the desert varnish be performed by a company with extensive experience in using the product. Knowledge and skill in the correct application rate is critical to achieving a color which blends well with the surrounding environment.
3. It should be noted that desert varnish does not provide a lasting coloring effect. Because of the continuous change in the desert varnish coloration, it is recommended that sections applied with this treatment be periodically monitored for changes in coloration as the natural weathering process occurs.

6.0 REFERENCES

Brooks, Eric. *Desert Varnish: Rocky Point Viaduct. Final Report.* Oregon Department of Transportation, Research Unit. November 1998.

Columbia River Gorge Commission. *Management Plan for the Columbia River Gorge National Scenic Area.* Glossary. October 1991.

Hofmann, Kaaren. *Desert Varnish: Rocky Point Viaduct. Construction Report.* Oregon Department of Transportation, Research Unit. January 1996.

APPENDICES

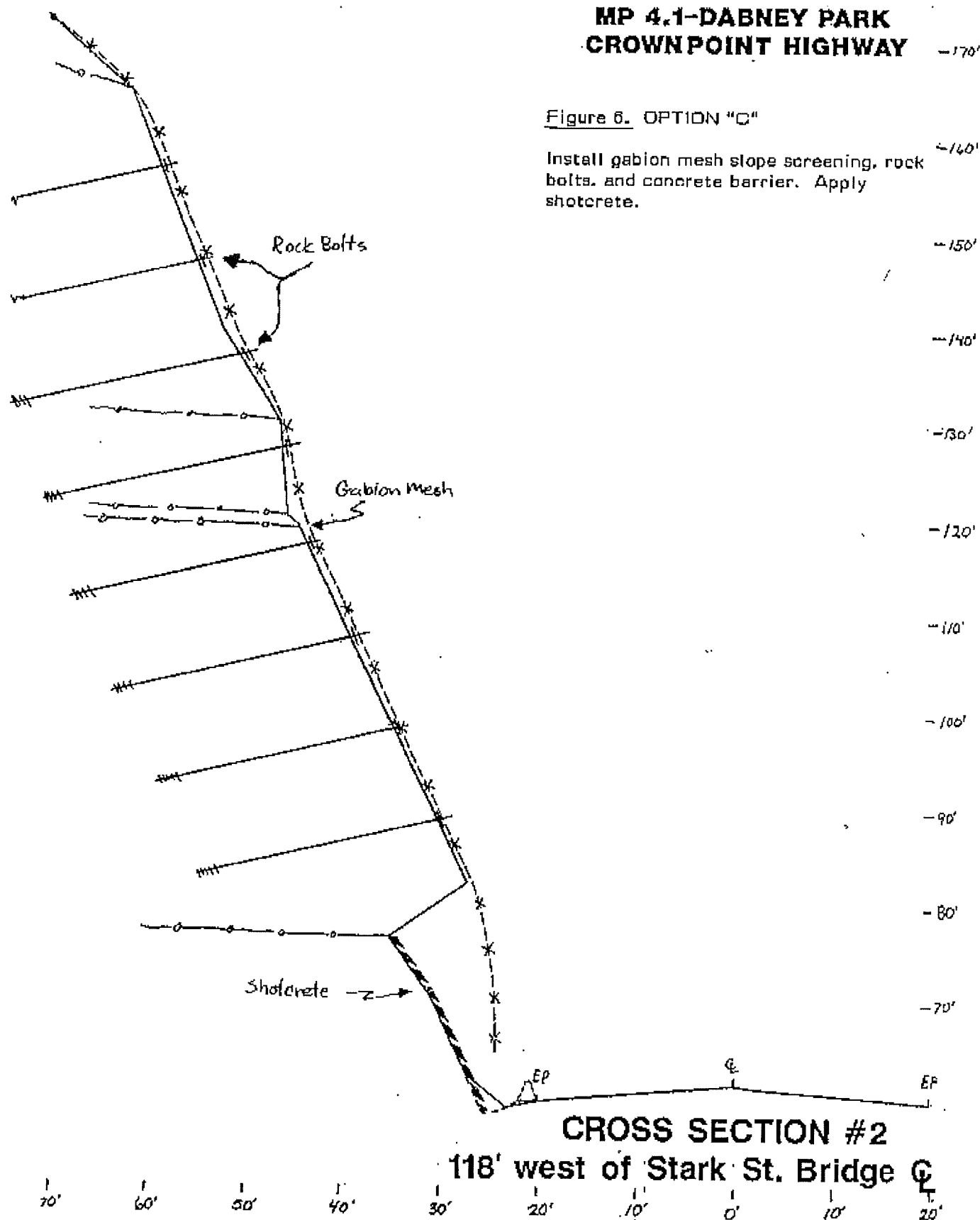
APPENDIX A: CROSS SECTION OF PROJECT AREA

MP 4.1-DABNEY PARK CROWNPOINT HIGHWAY

-170'

Figure 6. OPTION "C"

Install gabion mesh slope screening, rock bolts, and concrete barrier. Apply shotcrete.



**APPENDIX B: MATERIAL SAFETY DATA SHEET
FOR PERMEON™**

MATERIAL SAFETY DATA SHEET

SECTION I ***** PRODUCT IDENTIFICATION *****

TRADE NAME (AS LABELED) PERMEON
COMMON SYNONYMS: ARTIFICIAL DESERT VARNISH
CHEMICAL FAMILY: SOLUBLE CHEMICAL SALTS IN WATER

INGREDIENTS: IRON AND MANGANESE SALTS WITH TRACE
ELEMENTS INCLUDING Cl, PO₄, CU, ZN AND
INSOLUBLE MATTER.

MANUFACTURER'S NAME: ADVANCED CONCRETE TECHNOLOGIES
ADDRESS: 11622 NEWPORT AVENUE SANTA ANA CA 92705
PHONE: 714 731-0906
DATE PREPARED SEPTEMBER 1, 1992

***** PRECAUTIONARY LABELING *****

CERCLA RATINGS (SCALE 0-3)
HEALTH 2 FIRE 0 REACTIVITY 0

NFPA RATINGS (SCALE 0-4)
HEALTH 2 FLAMMABILITY 0 REACTIVITY 0

BAKER SAF-T DATA (SCALE 0-4)
HEALTH 1 FLAMMABILITY 0 REACTIVITY 0 CONTACT 0

PRECAUTIONARY LABEL STATEMENTS
AVOID CONTACT WITH EYES. USE WITH ADEQUATE VENTILATION
WASH AFTER HANDLING. SAFETY GLASSES RECOMMENDED.

SECTION II ***** HAZARDOUS COMPONENTS *****

NOT APPLICABLE - STABLE

SECTION III ***** PHYSICAL DATA *****

WATER SOLUTION - CLEAR TO BROWN COLOR

SECTION IV ***** FIRE AND EXPLOSION HAZARD DATA *****

NOT APPLICABLE

MATERIAL SAFETY DATA SHEET

PERMEON

PAGE 2 OF 2

SECTION V ***** PHYSIOLOGICAL EFFECTS *****

HEALTH INFORMATION AND FIRST AID PROCEDURES:
EYE EFFECTS: PRODUCT IN CONCENTRATED FORM MAY CAUSE
IRRITATION. IF IRRITATION PERSISTS, SEEK MEDICAL
ATTENTION.

SECTION VI ***** REACTIVITY *****

STABILITY: STABLE
DECOMPOSITION PRODUCTS: OXIDES OF IRON AND MANGANESE

SECTION VII ***** SPILL AND DISPOSAL PROCEDURES *****

WASH WITH WATER. MAY STAIN CONCRETE. DISPOSE IN
ACCORDANCE WITH LOCAL ENVIRONMENTAL REGULATIONS.

SECTION VIII ***** PROTECTIVE EQUIPMENT *****

VENTILATION: USE WITH ADEQUATE VENTILATION.
RESPIRATORY PROTECTION: NONE REQUIRED WITH ADEQUATE
VENTILATION.

EYE/SKIN PROTECTION: SAFETY GLASSES RECOMMENDED.

SECTION IX ***** STORAGE AND HANDLING *****

STORE IN COOL, DRY PLACE IN TIGHTLY CLOSED CONTAINERS.
OTHER PRECAUTIONS: USE GOOD PERSONAL HYGIENE. AVOID
INHALATION OF MISTS AND PROLONGED SKIN CONTACT.

SECTION X ***** TRANSPORTATION DATA *****

(TM) AND (R) DESIGNATED TRADEMARKS - PERMEON

THE INFORMATION PUBLISHED IN THIS MATERIAL SAFETY DATA SHEET HAS
BEEN COMPILED FROM OUR EXPERIENCE AND DATA PRESENTED IN VARIOUS
TECHNICAL PUBLICATIONS INCLUDING MATERIAL SAFETY DATA SHEETS
PROVIDED BY J.T. BAKER CHEMICAL COMPANY, FISHER SCIENTIFIC
CHEMICAL DIVISION AND JOHNSON MATTHEY CHEMICALS.

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Two possible problems were noted: water running over the cliff in a few areas from a local land owner's irrigation effort on the hill above the site (see Figure 3.2), and mineral stains from an unknown source appearing on some of the rocks just above the shotcrete. It was decided that these two areas should be closely monitored.



Figure 3.2: Dark streaks on shotcrete caused by irrigation water from above

Also noted were some cracks in the shotcrete running vertically up the cliff. Some of these cracks extended from weep-hole to weep-hole. These were considered to be potential break points for the shotcrete. Near the top of the desert varnish, there were areas of overhang which could also be breaking points.

