FOR CONTRACT NO.: 10-0S2404

INFORMATION HANDOUT

MATERIALS INFORMATION

FOUNDATION REPORT AND SUPPLEMENTAL FOUNDATION REPORT

ROUTE: 10-Tuo-108-58.8

M e m o r a n d u m

Flex your power!
Be energy efficient!

To: MR. GARY JOE
Branch Chief
Structure Design Branch 17
Office of Bridge Design Services

Attention: Mr. Ramon Reyes

Date: November 5, 2010

File: 10-TUO-108 PM 58.8
EA 10-0S2401
EFIS 1000000235
Soldier Pile Wall

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: Supplemental Foundation Report

1. Introduction

This report has been prepared to provide supplemental foundation recommendations to the foundation report titled "Geotechnical Recommendations" dated September 5, 2006, for the proposed slope repair along State Route 108 at PM 58.8 in Tuolumne County. A vicinity map is presented on **Plate No. 1**.

At the project location, erosion has occurred which has undermined the shoulder and could ultimately undermine the structural section of the highway if not addressed. A soldier pile wall is proposed to mitigate the erosion and to protect the roadway. The 9/5/2006 recommendations were based on a subsurface investigation consisting of two borings, and geotechnical calculations using data obtained from the subsurface investigation. The 9/5/2006 foundation report is attached in **Appendix A**.

For this supplemental report, additional fieldwork including a refraction seismic (RS) survey and a ground penetrating radar (GPR) survey was performed to assist in the determination of the bedrock profile along the proposed soldier pile wall line. The RS/GPR report is attached in **Appendix B**.

2. Refraction Seismic Survey and Ground Penetrating Radar Survey

The Geophysics and Geology Branch performed RS and GPR surveys on August 12, 2010. The surveys were performed along the southwestern (eastbound) edge of the existing roadway at the proposed wall location.

The RS/GPR surveys show that the depth to rock within the proposed wall limits varies from about 3 to 10 feet. However, the report indicates that due to site geometry, rock jointing and weathering, in fill of joints and the presence of buried pavement, the material found should not be considered to represent a continuous bedrock profile.

For the investigation for the 9/5/2006 foundation report, rock was encountered at a depth of 5 feet in boring B-3, which correlates with the RS/GPR survey. However, rock was encountered at a depth of 20 feet in boring B-2, which does not correlate with the RS/GPR survey, where rock is indicated at depth of 10 feet.

The RS/GPR report is attached in **Appendix B**.

4. Supplemental Foundation Recommendations

As the rock encountered in the RS/GPR survey is indicated as fractured / weathered and not competent rock, the depth to competent rock as found in the borings for the 9/5/2006 foundation report should be used. As such, it is the recommendation of this Office that the proposed soldier pile wall be constructed per the recommendations in the 9/5/2006 foundation report. There are no global stability concerns for the project site.

Table 1 summarizes the soil/rock properties as determined in the 9/5/2006 foundation report.

Table 1. Soil/Rock Properties

Soil			Rock		
Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)
115	0	25	125	3000	0

Additionally, the 9/5/2006 foundation report indicates that the minimum unbonded length of anchors is 15 feet.

If there are any questions or comments in regards to this report, please contact Ben Barnes at 916-227-1039.

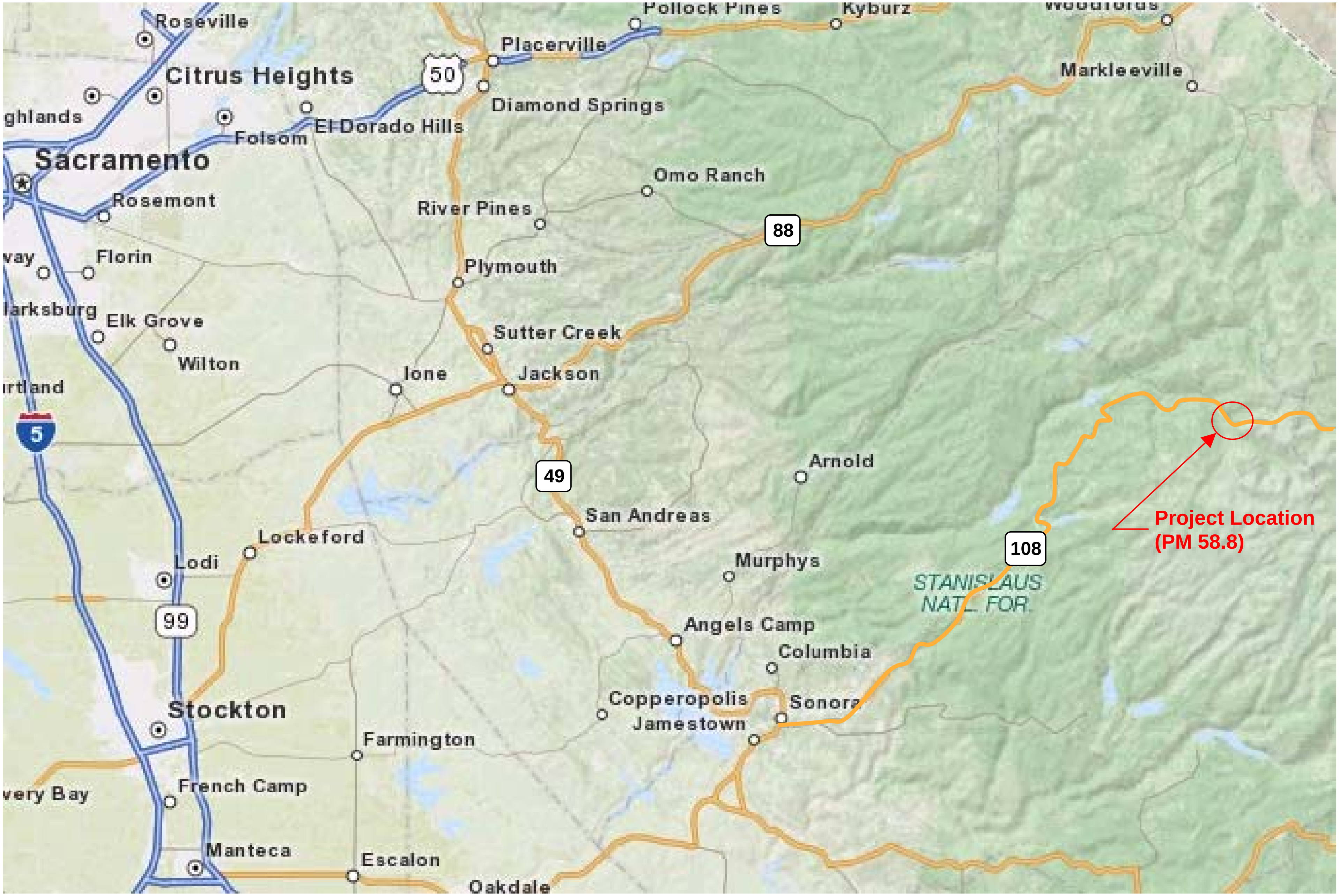
BENJAMIN M. BARNES, PE
Transportation Engineer
Office of Geotechnical Design – North
Branch E

REGISTERED PROFESSIONAL ENGINEER
BENJAMIN M. BARNES
No. 66090
Exp. 6/30/2012
CIVIL
STATE OF CALIFORNIA

<u>Attachments:</u>

Plate No. 1: Location Map
Appendix A: Geotechnical Recommendations (9/5/2006)
Appendix B: Depth to Bedrock Evaluation Highway 108 @ PM 58.8 (10/21/2010)

c: John Huang (Geotechnical Services, Geotechnical Design North)
Caroline Reyes (District 10 Project Manager)
Mark Willian (Geotechnical Services, Corporate Unit)
Dave Dhillon (D10 District Materials Engineer)
Rebecca Harnagel (DES Office Engineer, Office of PS&E)
Structure Construction R.E. Pending File



Division of Engineering Services Geotechnical Services Office of Geotechnical Design - North	EA: 10-0S2401	LOCATION MAP	Plate No. 1
	November 2010	10-TUO-108 PM 58.8 FOUNDATION REPORT	

APPENDIX A

Geotechnical Recommendations
September 5, 2006
State Route 108 Slope Repair
EA 10-0M2401
10-TUO-108 PM 58.8

Memorandum

Flex your power!
Be energy efficient!

To: **MR. LOU DONADA**
Senior Design Engineer, Branch H
Central Region

Attention: Mr. Peter Kang

Date: September 5, 2006

File: 10-TUO-108
KP 94.6 (PM 58.8)
10-0M2401

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: Geotechnical Recommendations

This memorandum serves to provide geotechnical recommendations for the proposed slope repair along State Route 108 at KP 94.6 in Tuolumne County. At this location erosion has occurred which has undermined the shoulder and could ultimately undermine the structural section of the highway if not addressed. Our recommendations are based on field reconnaissance, a subsurface investigation consisting of two borings, geotechnical calculations using data obtained from the subsurface investigation, and Departmental standards. For the preparation of this memorandum we reviewed the Earth Retaining Structures Reference Manual written by the Federal Highway Administration dated April 1999, and the Department's Standard Plans dated July 2004.

At the project location, the highway is aligned in an east-west direction and is constructed in a cut and fill slope section. The depth of fill placed on the southern side of the highway is approximately 4 meters. The depth of fill on the northern side of the highway may vary from 0 to 1 meter. The northern slope above the roadway is composed mainly of two massive walls of rock standing vertical with an approximately 40-meter wide debris chute between them. The debris chute has a slope of approximately 1:1. The southern slope below the highway is inclined at 1:1 or steeper and is at least 60 meters to the bottom. It appears that the road was built over the debris chute as it can be seen on both sides of the highway. The soil on the eroding slope consists of silty sand with cobbles and boulders. A small stable rock outcropping is also situated on the south side of the highway. The width of the eroded section is approximately 40 meters. Maintenance has performed repairs to the eroded section including the addition of asphalt to build up and retain the shoulder.

The side hill fill is gradually failing by surficial erosion likely caused by snow melt and storm water runoff. The shoulder has been eroded away and the slope begins at the edge of pavement. It is our understanding that the addition of a new 0.60-meter wide shoulder is desired. The soil/rock borings (B-2 and B-3) were performed in the eastbound lane. Boring B-2 was performed 1.4 m from the centerline and was drilled to a final depth of 12.5 m. Boring B-2 consisted of 6.1 m of very loose to loose silty sand and sand overlying at least 6.4 m of granitic rock. Boring B-3 was performed 2.1 m from the centerline and was drilled to a final depth of 7.9 m. Boring B-3 consisted of 1.5 m of loose silty sand overlying at least 6.4 m of granitic rock. The boring logs are presented in the Appendix at the end of this report. Based on the depth to solid foundation material found in the soil/rock borings, this Office recommends the use of a soldier pile wall to regain the lost shoulder. Other alternatives were considered, however, due to the depth to solid foundation material and the desire to keep one lane of the highway open during construction, these alternatives would not be feasible as they would require the removal of both lanes.

The cross sections that were forwarded to our Office contained stationing that did not correspond with the layout. Therefore, it is uncertain which cross section is nearest to the slope failure. However, based on the soil/rock borings, the height of the soldier pile wall would range from approximately 6.1 meters near Boring B-2 to 1.5 meters near Boring B-3.

A soldier pile wall consists of piles typically set at 1.8 to 3 meter spacing and lagging which spans the distance between the piles. The lagging is used to retain the soil and transmit the lateral earth pressure to the piles. The most common pile used is the HP-pile or a pile with wide flange sections. The lagging is typically timber or prefabricated concrete. The piles would be installed and concreted into pre-drilled holes. The wall is built from the top down where the soil is excavated one level at a time, placing the lagging as the excavation proceeds. A waler, if necessary, is then attached to the piles and tie back anchors are installed and attached to the waler. Typically a waler and anchors are used for wall heights greater than 4 meters. This sequence is continued until the desired height of the wall is reached. A cross section of a soldier pile wall is presented as Figure No. 1.

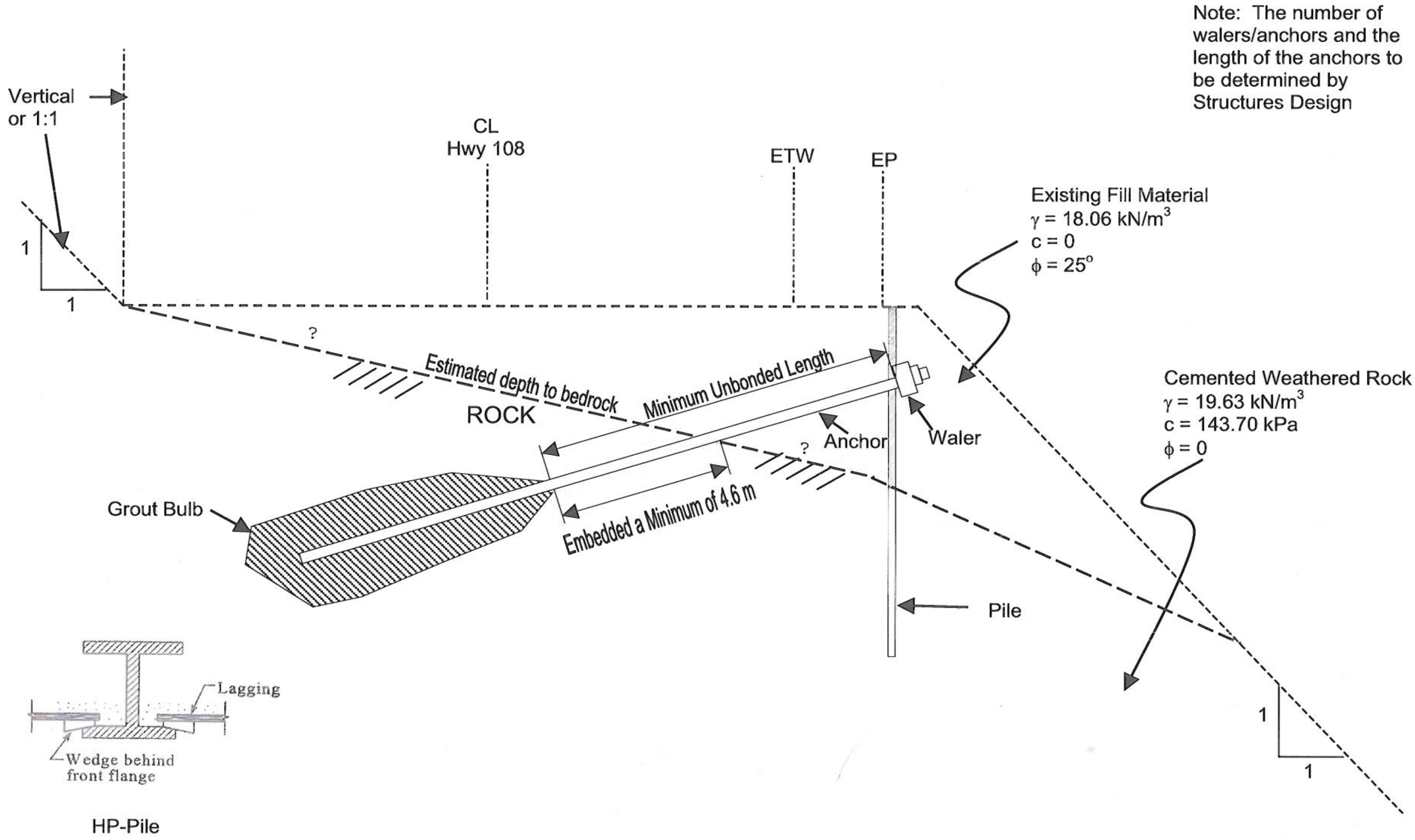
The following soil properties are recommended for design and are based on the two borings performed at the site. For design purposes, the existing fill material has a unit weight (γ) of 18.06 kN/m^3, cohesion (c) of 0 kPa, and a friction angle (ϕ) of 25°. The cemented weathered rock has a unit weight of 19.63 kN/m^3, cohesion of 143.70 kPa, and a friction angle of 0 °. A minimum unbonded length of the anchors is 4.6 meters into the weathered bedrock (See Figure No. 1). The wall height will vary from approximately 1.5 meters on the western end of the wall to 6.1 meters on the eastern end of the wall. An elevation view complete with wall height approximations of the soldier pile wall is presented as Figure No. 2. Mr. Overcomer Hor from the Office of Design and Technical Services should be contacted at (916) 227-8482 regarding the design of the soldier pile wall.

If you have any questions regarding these recommendations, please contact Michael Engelmann at (916) 227-7153.

MICHAEL ENGELMANN, P.E.
Transportation Engineer – Civil
Geotechnical Design – North

REGISTERED PROFESSIONAL ENGINEER
MICHAEL J. ENGELMANN
No. 65300
Exp. 9/30/07
CIVIL
STATE OF CALIFORNIA

c: Q Huang
D Dhillon (E-copy)
GDN File



CALTRANS
Division of Engineering Services
Geotechnical Services
Office of Geotechnical Design - North

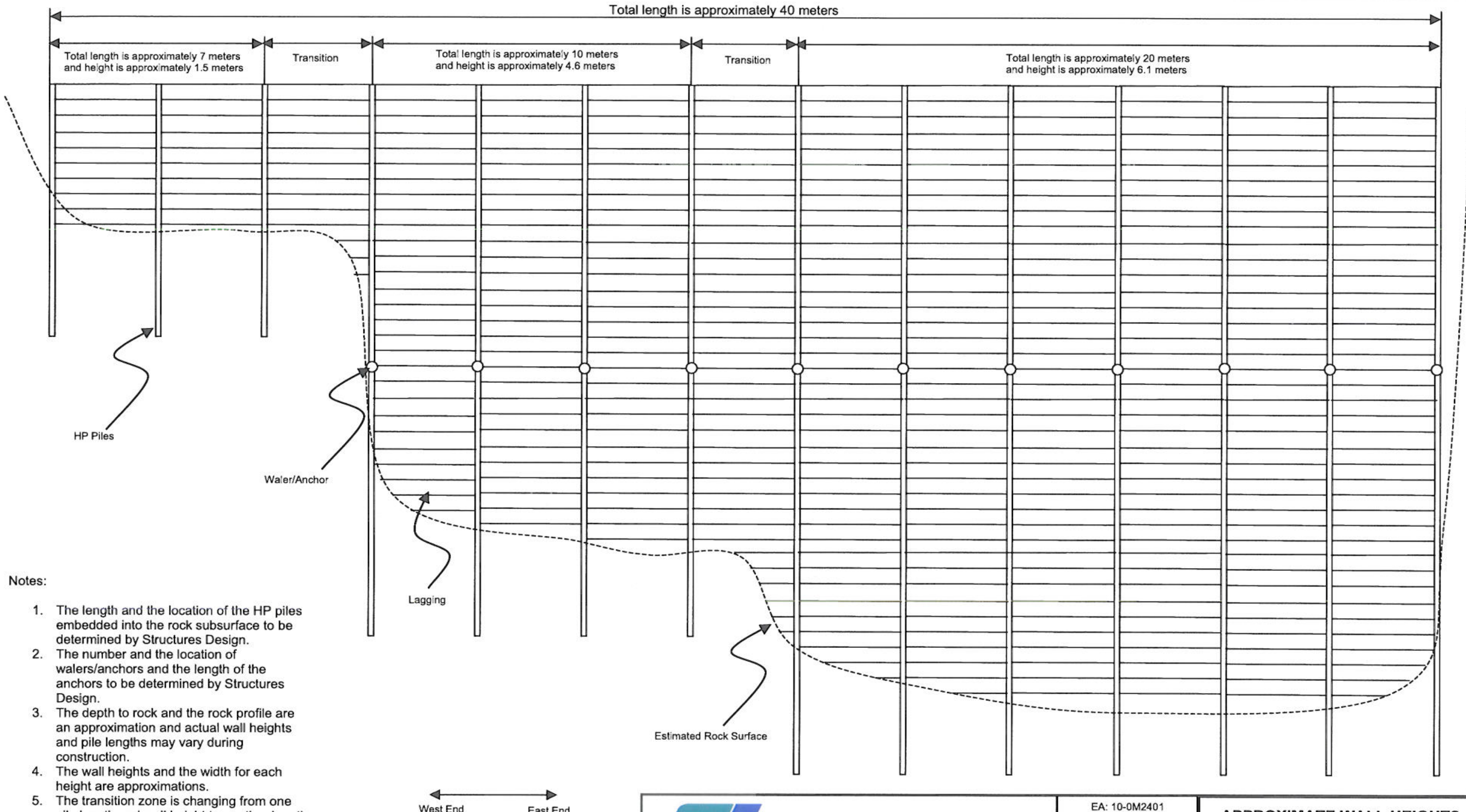
EA: 10-0M2401

Date: August 2006

CROSS SECTION (Soldier Pile Wall)

Figure No. 1

10-TUO-108 KP 94.6 (PM 58.8)
SLOPE PROTECTION PROJECT



Notes:

1. The length and the location of the HP piles embedded into the rock subsurface to be determined by Structures Design.
2. The number and the location of walers/anchors and the length of the anchors to be determined by Structures Design.
3. The depth to rock and the rock profile are an approximation and actual wall heights and pile lengths may vary during construction.
4. The wall heights and the width for each height are approximations.
5. The transition zone is changing from one pile length and wall height to another length and height. The location of transition will be determined during construction.

CANTRANS Division of Engineering Services Geotechnical Services Office of Geotechnical Design - North	EA: 10-0M2401 Date: August 2006	**APPROXIMATE WALL HEIGHTS**
	10-TUO-108 KP 94.6 (PM 58.8) SLOPE PROTECTION PROJECT	Figure No. 2

APPENDIX

Logs of Test Borings

GRAPHIC SYMBOLS

Bulk Sample	Auger
Rock Core	Diamond Core
Modified California Sampler	Rotary
Standard Penetration Sampler	California Sampler
Shelby Tube	Water Level - 1st Reading
	Water Level - 2nd Reading
Vane Shear	Water Level - 3rd Reading

TESTING

CONS	Consolidation (Cal Test 219)	RQD	Rock Quality Designation (ASTM D6032)
UU	Unconsolidated Undrained Triaxial (Cal Test 230)	CP	Compaction Test (Cal Test 216)
CU	Consolidated Undrained Triaxial (Cal Test 230)	PERM	Permeability (Cal Test 220)
DS	Direct Shear (ASTM D3080)	COR	Corrosivity Testing (Cal Test 532/643)
UC	Unconfined Compression (Cal Test 221)	GRAD	Gradation Analysis (Cal Tests 202/203)
LL	Liquid Limit-% (Cal Test 204)	EP	Expansion Pressure (Cal Test 354)
PI	Plasticity Index-% (Cal Test 204)	OC	Organic Content-% (ASTM D2974)
PP	Pocket Penetrometer	SE	Sand Equivalent (Cal Test 217)
TV	Pocket Torvane		

SOIL GRAIN SIZE

U.S. STANDARD SIEVE		12"		3"		3/4"		4		10		40		200			
	BOULDERS		COBBLES		GRAVEL COARSE		GRAVEL FINE		SAND COARSE		SAND MEDIUM		SAND FINE		SILT		CLAY
SOIL GRAIN SIZE (in mm)		300		75		19		4.75		2		0.425		0.075		0.005	

GENERAL NOTES

1. Logs represent general subsurface conditions observed at the point of exploration on the date indicated.
2. In general, USCS designations presented on logs were established by visual methods only; therefore, actual designations (based on laboratory tests) may vary.
3. No warranty is provided as to the continuity of soil conditions between individual sample locations.
4. Lines separating strata on the logs represent approximate boundaries only; actual transitions may be different or gradual.
5. Pocket penetrometer values reported on the logs under shear strength are actual values as recorded in the field. (To be used in analysis, the pocket penetrometer value should be divided by two)

Department of Transportation
Division of Engineering Services
Geotechnical Services
Office of Geotechnical Design - North

EA: 10-0M2401
Date: 7-31-06

BORING LOG LEGEND

10-TUO-108 / KP 94.63 (PM 58.8)

Slope Protection Project

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

Department of Transportation
Division of Engineering Services
Geotechnical Services
Office of Geotechnical Design - North

EA: 10-0M2401
Date: 7-31-06

SOIL CLASSIFICATION SYSTEM

10-TUO-108 / KP 94.63 (PM 58.8)

Slope Protection Project

SYMBOLS

SEDIMENTARY　　METAMORPHIC　　IGNEOUS

DEGREE OF WEATHERING

Descriptor	Criteria
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric
Slightly weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 25.4 mm into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Intensely weathered	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

FRACTURING & FOLIATION (BEDDING)

Fracturing Descriptor*	Foliation (Bedding) Descriptor	Thickness/Spacing Criteria
Unfractured	Massive	None observed
Very slightly fractured		Greater than 3 m
	Very thickly foliated	Between 1 m and 3 m
Slightly fractured	Thickly foliated	Between 300 mm and 1 m
Moderately fractured	Moderately foliated	Between 100 mm and 300 mm
Intensely fractured	Thinly foliated	Between 30 mm and 100 mm
Very intensely fractured	Very thinly foliated	Between 10 mm and 30 mm
	Laminated (or intensely foliated)	Less than 10 mm (3/8")

*Note: Spacing criteria for fracturing can refer to general or average recovery length of core measured along core axis; for other exposures, the criteria is distance measured between fracture (size of blocks).

RELATIVE HARDNESS

Descriptor	Criteria
Extremely hard	Core, fragment, or exposure cannot be scratched with knife or sharp pick; can only be chipped with repeated hammer blows.
Very hard	Cannot be scratched with knife or sharp pick. Core or fragment breaks with repeated heavy hammer blows.
Hard	Can be scratched with knife or sharp pick with difficulty (heavy pressure). Heavy hammer blow required to break specimen.
Moderately hard	Can be scratched with knife or sharp pick with light or moderate pressure. Core or fragment breaks with moderate hammer blow.
Moderately soft	Can be grooved 2 mm (1/16") deep by knife or sharp pick with moderate or heavy pressure. Core or fragment breaks with light hammer blow or heavy manual pressure.
Soft	Can be grooved or gouged easily by knife or sharp pick with light pressure, can be scratched with fingernail. Breaks with light to moderate manual pressure.
Very soft	Can be readily indented, grooved or gouged with fingernail, or carved with a knife. Breaks with light manual pressure.

Equipment: CME 75	Station/KP: 94.6	Boring ID.: B-2
Hammer: Safety semi-automatic drop (140#/ 30")	Offset Distance/Line: 1.4mRt./Route 108	Date Completed: 7-26-06
Drilling Method: Rotary wash, open-ended punch core bit	North/East:	Hole Diameter: 95mm
Sampling Method: SPT, Core	Ground Surface Elevation: ~2048.9m	Total Depth: 12.5m
Notes:	~Depth to GW/date measured: None Encountered on 7-26-06	Logged By: Mengelmann

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	Graphic Log	Description	Sample Type	Sample Number	Sample Blows	Blows per Foot	Recovery (%)	RQD (%)	w/c (%)	Dry Density (kN/m³)	Shear Strength (kPa)	Drilling Method/ Casing	Remarks
2048.61	0.30	1		ASPHALT CONCRETE SILTY SAND (SM): light brown, dry, fine to medium sand, with rock fragments.											
2048.30	0.61	2													
2048.00	0.91	3				1									
2047.70	1.22	4													
2047.39	1.52	5													
2047.09	1.83	6													
2046.78	2.13	7		Well-graded SAND (SW): loose, grayish brown, moist, medium to coarse sand.		2	1 3 2	5							
2046.48	2.44	8													
2046.17	2.74	9													
2045.87	3.05	10													
2045.56	3.35	11													
2045.26	3.66	12		with rock fragments.		3	2 2 3	5							
2044.95	3.96	13													
2044.65	4.27	14													
2044.34	4.57	15													
2044.04	4.88	16													
2043.73	5.18	17		becomes very loose.		4	2 2 2	4							
2043.43	5.49	18													
2043.12	5.79	19													
2042.82	6.10	20													
2042.51	6.40	21		GRANITIC ROCK: gray with rust at the fractures, intensely weathered, moderately hard, very intensely fractured.		5			100	0					
2042.21	6.71	22				6			100	47					
2041.90	7.01	23		becomes moderately weathered, hard, intensely to moderately fractured.											
2041.60	7.32	24													
2041.29	7.62	25													
2040.99	7.92	26													
2040.68	8.23	27		becomes moderately to slightly weathered, moderately fractured.		7			100	70					
2040.38	8.53	28													
2040.08	8.84	29													
2039.77	9.14	30													
2039.47	9.45	31													
2039.16	9.75	32				8			100	75					
2038.86	10.06	33													
2038.55	10.36	34													
2038.25	10.67	35													
2037.94	10.97	36													
2037.64	11.28	37		becomes intensely fractured.		9			100	40					
2037.33	11.58	38													
2037.03	11.89	39													
2036.72	12.19	40													
2036.42	12.50	41													
2036.11	12.80	42		Bottom of Hole at 12.50 m (41.0 ft) on 7-26-06											

Department of Transportation
Division of Engineering Services
Geotechnical Services
Office of Geotechnical Design - North

EA: 10-0M2401	**B-2**	
Date: 7-31-06		
Drafted By: MEngelmann		
10-TUO-108 / KP 94.63 (PM 58.8)		1 of 1
Slope Protection Project		4

Equipment: CME 75	Station/KP: 94.6	Boring ID.: B-3
Hammer: none	Offset Distance/Line: 2.1mRt./Route 108	Date Completed: 7-27-06
Drilling Method: Rotary wash, open-ended punch core bit	North/East:	Hole Diameter: 95mm
Sampling Method: Core	Ground Surface Elevation: ~2047.6m	Total Depth: 7.9m
Notes:	~Depth to GW/date measured: None Encountered on 7-27-06	Logged By: MEngelmann

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	Graphic Log	Description	Sample Type	Sample Number	Sample Blows	Blows per Foot	Recovery (%)	RQD (%)	w/c (%)	Dry Density (kN/m^3)	Shear Strength (kPa)	Drilling Method/ Casing	Remarks
2047.25	0.30	1		ASPHALT CONCRETE: black. SILTY SAND (SM): brown, dry, fine sand.											
2046.95	0.61	2													
2046.64	0.91	3													
2046.34	1.22	4													
2046.03	1.52	5													
2045.73	1.83	6		GRANITIC ROCK: pinkish gray, very intensely weathered, soft, very intensely fractured.		1			100	0					
2045.42	2.13	7		becomes intensely to moderately weathered, intensely to moderately fractured.		2			100	55					
2045.12	2.44	8													
2044.81	2.74	9													
2044.51	3.05	10													
2044.20	3.35	11													
2043.90	3.66	12		becomes slightly weathered to fresh, very hard, slightly fractured.		3			100	100					
2043.59	3.96	13													
2043.29	4.27	14													
2042.98	4.57	15													
2042.68	4.88	16													
2042.37	5.18	17		becomes fresh, extremely hard, very slightly fractured.		4			100	100					
2042.07	5.49	18													
2041.76	5.79	19													
2041.46	6.10	20													
2041.15	6.40	21													
2040.85	6.71	22		becomes slightly weathered, very hard, moderately fractured.		5			100	87					
2040.54	7.01	23													
2040.24	7.32	24													
2039.93	7.62	25													
2039.63	7.92	26													
2039.33	8.23	27		Bottom of Hole at 7.92 m (26.0 ft) on 7-27-06											
2039.02	8.53	28													
2038.72	8.84	29													
2038.41	9.14	30													
2038.11	9.45	31													
2037.80	9.75	32													
2037.50	10.06	33													
2037.19	10.36	34													
2036.89	10.67	35													
2036.58	10.97	36													
2036.28	11.28	37													
2035.97	11.58	38													
2035.67	11.89	39													
2035.36	12.19	40													
2035.06	12.50	41													
2034.75	12.80	42													

Department of Transportation Division of Engineering Services Geotechnical Services Office of Geotechnical Design - North	EA: 10-0M2401 Date: 7-31-06 Drafted By: MEngelmann	**B-3**
	10-TUO-108 / KP 94.63 (PM 58.8)	1 of 1
	Slope Protection Project	**5**

APPENDIX B

Depth to Bedrock Evaluation
Highway 108 @ PM 58.8
October 21, 2010

Memorandum

Flex your power!
Be energy efficient!

To: Mr. Qiang Huang
Senior M&R Engineer
Department of Transportation

Date: October 21, 2010

File: 10_TUO_108_PM 58.8

EA: 10-0S2401
Project: 1000000235

Attention: Ben Barnes

From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES-MS#5

Subject: Depth to Bedrock Evaluation Highway 108 @ PM 58.8

Introduction

This memo documents the results of a refraction seismic survey to assist in evaluation of depth to bedrock for a purposed soldier pile wall to be constructed at this location. A Ground Penetrating Radar (GPR) survey was also conducted to assist with interpretation of the subsurface. Figure 1 shows the approximate location of the investigation line. Figure 2 is the processed model of our findings and Table 1 summarizes the information.

Results and Discussion

The site is located in the Stanislaus National Forest along a very narrow, steep and winding portion of Highway 108 (the Quedeporca Grade), directly above the Deadman Creek campground of the Stanislaus National Forest. This portion of RTE 108 occupies the original 1860s alignment of the historic Mono Toll Road, portions of which approach a 26% grade.

The site includes old pavement, fill and sidecast material below the roadway that is unstable. Granitic bedrock, where exposed, appears competent. Two debris chutes noted during our investigation appear to be active, with evidence of multiple previous attempts to stabilize the road grade. Granitic bedrock is expected to be encountered at fairly shallow depths along the existing roadway within the northeastern (westbound) lane, with the fill and debris prism thickening toward the outboard (eastbound) side. Material within the prism is predominantly soil and fill consisting of decomposed granitics, colluvium and sidecast debris, with old pavement sections, metal debris, and granitic blocks up to 4.5 m (15 feet) on their longest dimension. Granitic boulders over 1.5 meters (5 feet) on their longest dimension will require reduction for removal. Those boulders may present difficulties during pile driving (i.e., pile refusal on boulders instead of bedrock), as well as for construction of temporary access roads. Anomalously slow material was noted where competent bedrock was anticipated. Due to site geometry, rock jointing and weathering, in-fill of joints and the presence of buried pavement, the profile of this anomalously slow material should not be considered to represent a continuous bedrock profile. Across this profile, undetected, in-filled joints of unknown depth are expected to be encountered, with various degrees of weathering of the rock surface. Based on surface observations, the granitics below the weathered zone and between joints are expected to be competent, but were not defined by this survey.

Field data were acquired on August 12, 2010. The geometry of the site limited our options for investigation (Figure 1). We ran a seismic refraction line and a GPR profile along the southwestern (eastbound) edge of the existing roadway in an attempt to differentiate between loose slide material and bedrock below it (Figure 2, Plates 1 and 2). Bedrock is visible below and above the roadway. The roadway itself appears to be constructed within several active and inactive debris chutes bounded by granitic bedrock.

Comparison of the refraction seismic data to the collinear GPR profiles (Plates 1 and 2) reveals surprising agreement within the upper 2 meters (6.5 feet). The GPR signal attenuates to background below 2 m due to the lossy nature of the fill, so total thickness of the fill prism is not completely defined by GPR. At various locations above the refractor, GPR reflections demonstrate characteristics associated with repaired fill prisms, such as boulders or rubble and buried pavement. In addition, the GPR data reveal some shallow bedrock contacts not defined by the refraction model.

We anticipated bedrock seismic velocity should be much faster than loose slide debris lying above it. However, results revealed only a single, shallow refractor with velocity of about 600 m/sec. (1970 ft/sec., see Figure 2). Velocity of the fill and colluvial material overlying the refractor was measured at 320m/sec., (1050 ft/sec.). From observations of rock exposures, the measured seismic velocity for the refractor, if associated with granitic bedrock under the profile, appears to be anomalously slow. Correlation of the seismic profile with the GPR data does not lead to the conclusion of a spurious model, but neither can this velocity zone be interpreted as consisting of intact rock. It is highly likely that the velocity unit identified by the refractor does not represent homogeneous bedrock and is instead originating from a heterogeneous surface comprised of granitic bedrock, compacted fill or colluvium, and possibly even buried pavement.

For rock, seismic velocity can be significantly affected by jointing, fracturing and infilling of joints and fractures by unconsolidated material. The effects of such defects may dominate seismic velocity measurements by increasing raypath travel time via increased tortuosity and by the presence of low-velocity weathered rinds and soil infilling of the defects. Refraction seismic methods are poorly suited for detection of those features and can yield low velocity measurements despite the presence of high-velocity blocks within the subsurface. Several factors in particular appear to contribute to the apparent slow material velocity at this site: 1) presence of jointing normal to the profile alignment, 2) depth and aperture of the joints, and 3) rock weathering and soil fill within the joints. The refraction seismic method cannot accurately delineate the geometry of steep-sided contacts or step-like features with narrow apertures (e.g., joints and sinkholes) due to the presence of edge diffractions. The sides and bottoms of such features are therefore poorly defined, if at all. For this site, that means intact granitic blocks may be present and undetected (a conclusion supported by the GPR data). Such blocks may be unrippable, despite the low overall seismic velocity, and may require blasting or other mechanical means of reduction for excavation and removal.

At the site, exposed joints in the granitic exposures have nearly vertical dip and bear evidence of construction blasting at one location. Primary vertical jointing of the granitics is oriented roughly north-south (approximate azimuth 333 degrees), sub-parallel to the overall road alignment. Secondary vertical jointing is noted approximately 90 degrees to the primary (approximate azimuth 67-74 degrees). These joints appear to create zones of weakness, and the debris slides in the investigation area generally occupy these zones.

The first active debris chute, noted from 6-15 m on the seismic profile, includes hexagonal drill steel and old scraper blades set below the road grade, suggesting previous instability and attempts to stabilize this area. It appears to be bounded by two intersecting joints, with the debris chute occupying a zone of weakness developed within the intersection.

Bedrock between the first and second debris chutes (16.5-19.5 m on the seismic line) bears evidence of blasting during road construction. Field observations and GPR data suggest this bedrock exists under the road grade. Seismic refraction data indicate an anomalously low seismic velocity.

The second active debris chute was noted from 21-56.5 m and contains large granitic slabs (up to 4.5 m, or 15 feet, in length along dominant axis) and boulders in a loose matrix of colluvium and fill. Two joints appear to intersect at this location, producing a zone of weakness occupied by the debris chute. A fresh scarp was noted above road grade and appears to be progressing upslope. Local erosion and sliding is anticipated to continue in this area.

Granitic bedrock was encountered again at 57 m on profile, although the southwestern (eastbound) lane of the roadway appears to be constructed over debris and fill. Another joint, bearing 62 degrees, is noted at this location. There is evidence from aerial photographs that a joint intersection was present here and subsequently removed by erosion. The zone of weakness created by this joint intersection appears to establish a relatively inactive debris chute visible in the refraction profile.

The GPR profile extends beyond the end of the seismic line (65-100 m), and suggests bedrock is present under the roadway at relatively shallow depths.

Data Acquisition and Processing

Seismic refraction data were recorded using an EG&G Smartseis 24-channel seismograph with 14 Hz geophones. The profile consisted of two overlapping 36 meter long lines using 1.50 meter (5 feet) geophone spacing. The energy source employed was a hammer and striker plate. Refraction data from each shot were stored in the seismograph's memory. Both profile geometry and refraction data were backed-up to paper and floppy disk upon completion of the survey.

Interpretation of the survey results used the Generalized Reciprocal Method of refraction Interpretation (GRM; Palmer, 1980). This method can accommodate variation in refractor velocity and depth along the seismic line, is relatively insensitive to refractor dip (up to 20 degrees) and can accommodate hidden layer conditions (where supporting borehole data exist). Data interpretation used Viewseis, a commercially available computer program.

Profiles in this report are presented in terms of velocity units. A velocity unit is a three-dimensional unit which, due to its elastic properties and density, propagates seismic waves at a characteristic velocity or within a characteristic velocity range. Velocities denoted in this report and in the seismic refraction sections are expressed in meters per second. At least one velocity is present within a geologic unit. In addition, each zone of weathering or fracturing within that geologic unit can constitute its own velocity unit. Conversely, when two rock units (such as water saturated gravel and moderately weathered rock) propagate seismic waves at the same velocity and are adjacent to each other, both units would be part of the same velocity unit. Lastly, discontinuous velocities might result from variation in the degree of alteration in the form of physical and chemical weathering and should be considered in the interpretation of the data.

Ripping ability is based on unpublished Caltrans data for a Caterpillar D9 series bulldozer with a single-tooth ripper. These values are as follows:

Velocity, m/s (ft/s)	**Rippability**
<1050 (3450)	Easily Ripped
1050-1500 (3451-4900)	Moderately Difficult
1500-2000 (4901-6550)	Difficult Ripping
>2000 (6550)	Not Rippable

Different excavation equipment may experience different results. Penetrating efficacy of the ripping tooth is often more important in predicting ripping success than seismic velocity alone. Undetected blocks or lenses of high-velocity material may also be present within rippable zones, requiring blasting or other means of mechanical breakage for excavation.

Thank you for the opportunity to work on this project. If you have any questions or need additional assistance, please contact me at (916) 227-1307 or Mr. Bill Owen at (916) 227-0227.

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Reference

Palmer, D.; 1980 The generalized reciprocal method of seismic refraction interpretation, Society of Exploration Geophysicists, Tulsa Oklahoma, 104p.

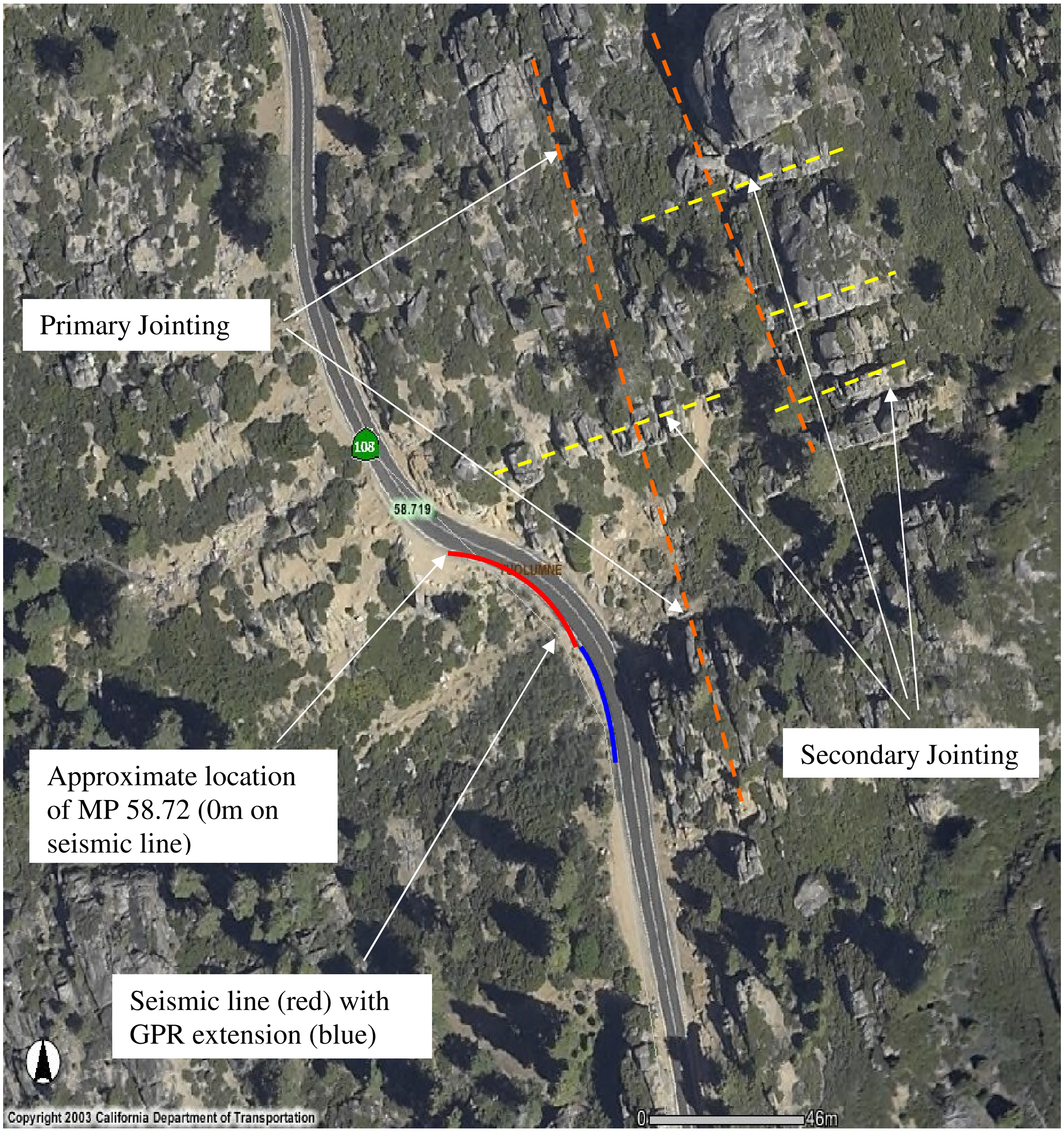

Figure 1. Aerial photo showing location of the site on Highway 108, regional geologic trend of granitic outcrop and its jointing, and location of the seismic line.

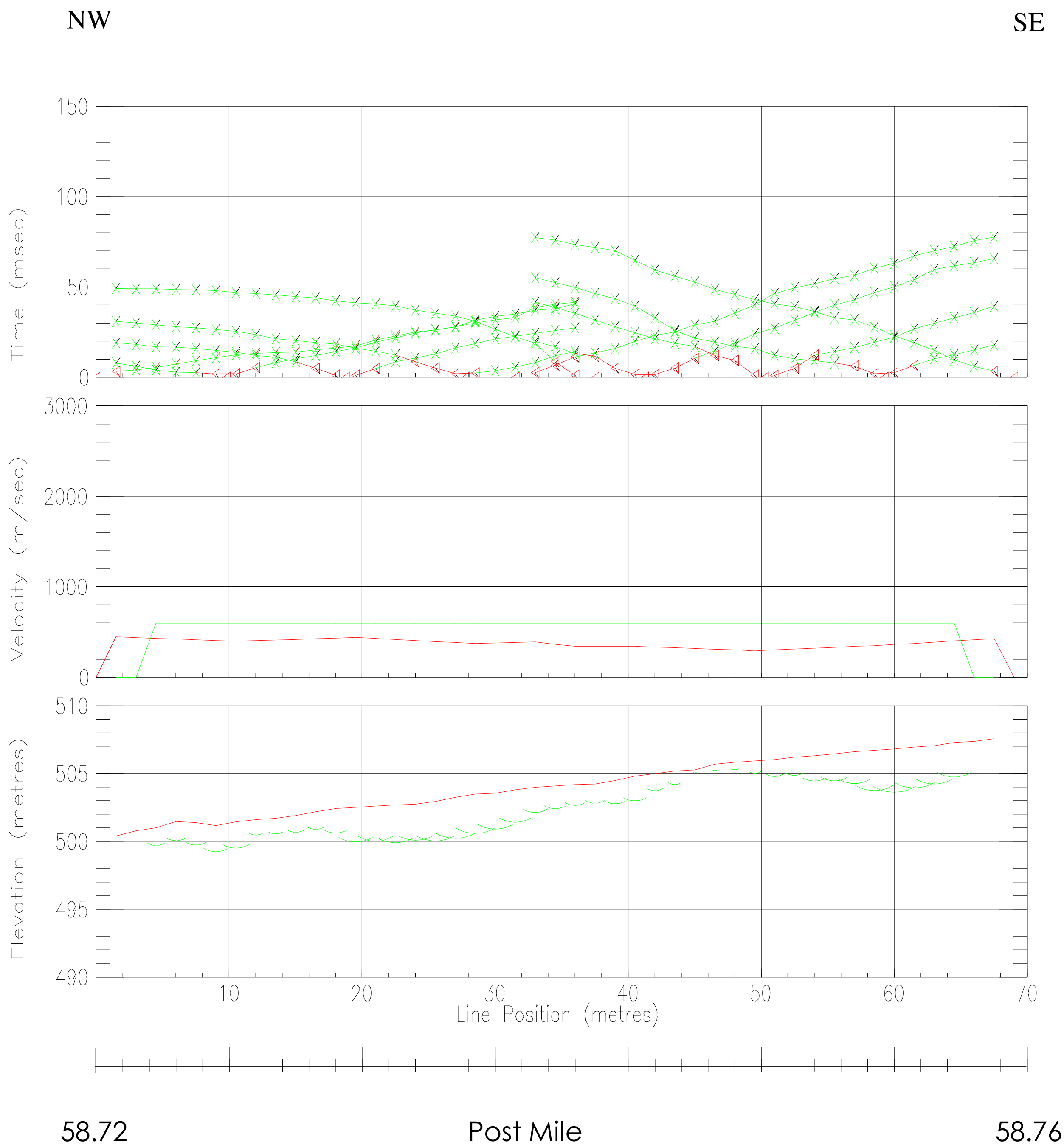

Figure 2. Travel time curve, velocity model and depth section for the seismic line. Model does not support the existence of bedrock as large intact blocks below the refractor. Post mile stationing is approximate. See text for discussion.

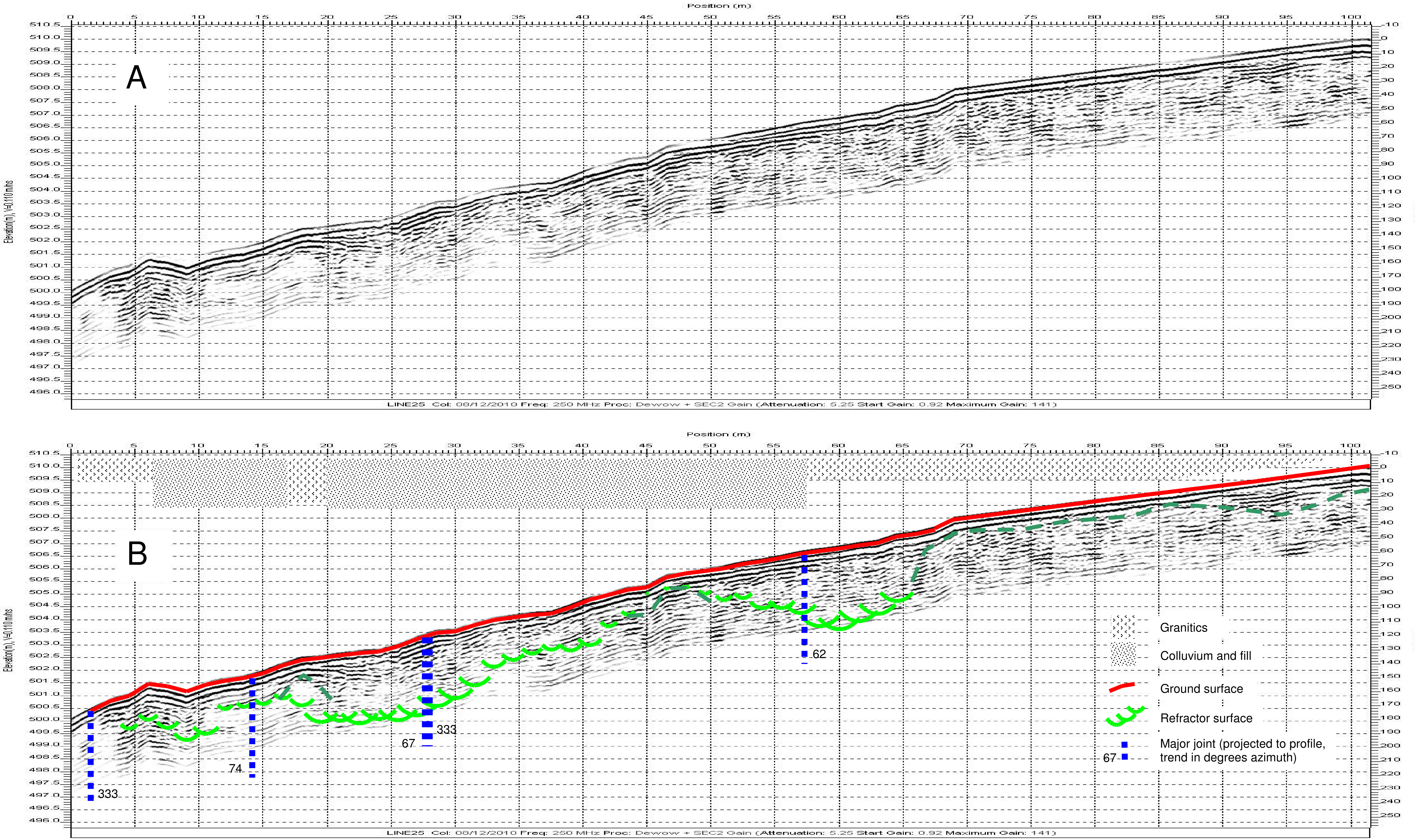

Plate 1. Correlation of GRM seismic and 250 MHz radar profiles. A) Original and B) interpreted sections. Material composition at top of (B) projected from observations of outcrop along the cut (westbound shoulder) and embankment (eastbound shoulder). GRM data terminates at 65 meters; dashed green lines represent interpreted base of colluvium and fill from GPR data.

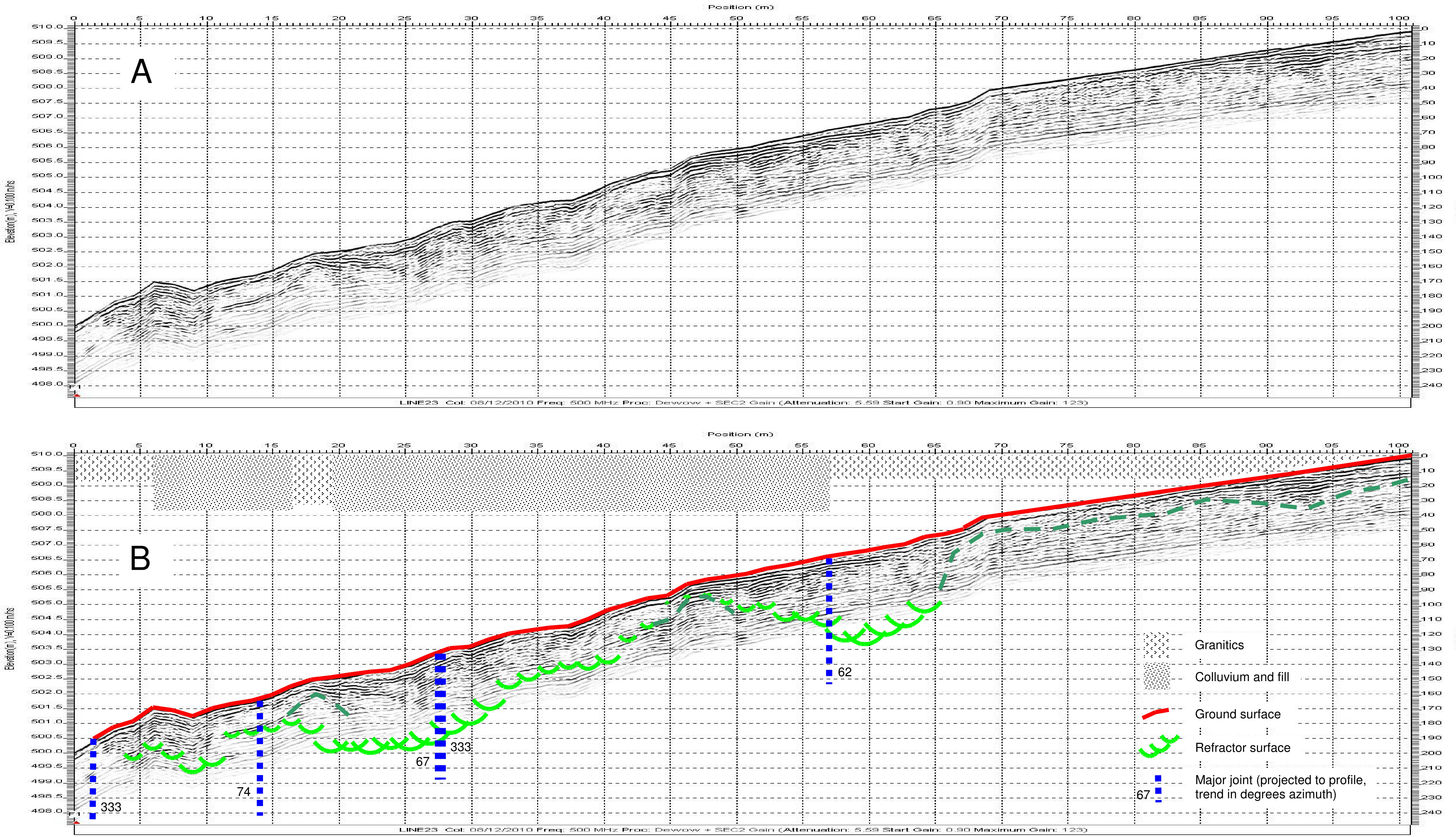

Plate 2. Correlation of GRM seismic and 500 MHz radar profiles. A) Original and B) interpreted sections. Material composition at top of (B) projected from observations of outcrop along the cut (westbound shoulder) and embankment (eastbound shoulder). GRM data terminates at 65 meters; dashed green lines represent interpreted base of colluvium and fill from GPR data.