CITY OF PRESCOTT
ARIZONA

Purchasing Division

201 N. Montezuma Street
Prescott, Arizona 86301
(928) 777-1408

ADDENDUM NUMBER ONE

FOR THE

CONSTRUCTION MANAGER AT RISK (CMAR) EFFLUENT & WASTEWATER PIPELINES & SR89 IMPROVEMENTS

DATE OF ADDENDUM: August 7, 2025

TO ALL BIDDERS BIDDING ON THE ABOVE PROJECT:

The following addendum shall be made part of the Project Specifications and Contract Documents. All other provisions of the Contract Documents remain unchanged. The Bidder shall acknowledge receipt of this Addendum by signing below and returning this form with the bid package. The contents of this Addendum shall be given full consideration in the preparation of the Bid.

Request for Information

Question: Is a project Geotechnical report available that can be shared?

Response: Yes. The current project Geotechnical information is provided as part of this addendum.

Question: Details are difficult to review on the roll-plots on the SR89 website. Are the roll-plots available as a PDF for more convenient reviewing?

Response: Yes. A PDF copy of each of the three (3) alternate roadway design roll-plots are provided as part of this addendum.

- END -

City of Prescott Public Works Department

Gwen Rowitsch

Digitally signed by Gwen Rowitsch
Date: 2025.08.08 08:49:44 -07'00'

Gwen Rowitsch, Public Works Director   Date

Acknowledgement: (must be signed and turned in with the bid documents)

Company Name

Signature of Company Official   Date

ENGINEERING & TESTING CONSULTANTS INC.

April 10, 2025

Kimley-Horn & Associates, Inc.
Attn: Mr. Andrew Baird
7740- N. 16th St., STE 300
Phoenix, Arizona 85020

SUBJECT: GEOTECHNICAL EXPLORATION FOR SR89 EFFLUENT AND WASTEWATER PIPELINE IMPROVEMENTS, PRESCOTT, AZ

Dear Mr. Baird:

Engineering & Testing Consultants, Inc., (ETC) has completed the geotechnical soil exploration for the subject project referenced above.

The purpose of the exploration was to determine existing pavement structure, soil sampling, and general subsurface soil and rock conditions along the proposed utility alignment, at the locations indicated.

This report presents the results of our exploration, including review of the project information provided to us, a discussion of the site conditions, subsurface soil conditions, and test results and presents our recommendations for utility trench excavation, earthwork/backfill, and pavement structural section.

Boring Location Maps are presented as Figures 1 and 2. Boring logs are included in Appendix A.

PROJECT AND SITE CONDITIONS

We understand the project limits are generally from the roundabout at Willow Lake Road to the roundabout at Phippen Trail.

The pipeline improvements may include roadway widening to accommodate two lanes in each direction with a median. If roadway widening is not performed, the existing traffic flow with one lane in each direction will be maintained.

The existing pavement surface appears to be in relatively good condition. However, the chip seal application makes it more difficult to determine the current degree of pavement distress.

Intact granite rock is exposed adjacent to the road throughout the project limits and located immediately adjacent to the road through several areas.

SUBSURFACE SOIL CONDITIONS

ETC performed 10 exploratory test borings at select locations throughout the project roadway.

The borings were drilled to determine general subsurface soil and rock conditions, and to collect soil samples for laboratory analysis. If subsurface soils encountered during construction differ significantly from those discussed herein, ETC should be contacted to review the recommendations made in this report.

The exploratory test borings were drilled to depths of approximately 9 to 10 feet below existing grade, or to auger refusal on rock.

In general, the test borings encountered approximately 6 to 9.5 inches of asphaltic concrete, which includes the chip seal surface layer. The bottom 2.5 to 4.5 inches of asphaltic concrete (AC) is much older or weathered and much weaker AC.

A specific aggregate base course layer was not identified in borings B-3 through B-7, or it consisted more of a granular select material. Where a distinct base course was identifiable, it was typically found to be approximately 5 to 6 inches in thickness, and the upper subgrade soils were typically very granular.

It is noted that the existing pavement structure encountered is not sufficient for support of the traffic loading conditions. Recommended pavement section alternatives are provided herein. The thickness of the existing asphaltic concrete, and the weathered and/or older lower asphaltic concrete encountered throughout is not suitable for use of an overlay to achieve adequate structural support.

Granite rock was encountered in six of the borings, at depths ranging from 2.5 to 6 feet in borings B-2, B-4 through B-7, and B-9. Auger refusal on rock varied from 4.5 feet in boring B-7 to 7 feet in borings B-5 and B-6.

Some subsurface water was encountered in areas. Where encountered, the water appeared to be perched on top of the lower granite stratum.

Most of the borings encountered varying depths of sand with low percentages of fines. The sand strata will not easily stand vertical in excavations without collapse or sluffing of sidewalls. Therefore, shoring or sloped sidewalls per all OSHA trenching criteria is critical.

Loose and/or wet soil strata will be encountered in areas at varying depths throughout the project area. It is noted that loose, wet clayey soil was encountered at a depth of 4.5 feet in the southern boring, B-1. Boring B-3 encountered very weak or loose to medium dense clayey soils at a depth of 3.5 feet.

Medium to high plasticity Clayey Sand (SC) was encountered throughout the locations explored at varying depths with medium and high clayey fines contents. Some layers of Sandy Clay (CL and CH) were also encountered in some areas. A subsurface soil layer with increased gravel or other rock pieces was often encountered at depths of 2 to 2.5 feet in several borings.

As discussed herein, granite rock was encountered. The Contractor should expect excavations to require heavy equipment and other special excavation methods and rock removal techniques.

The subsurface soils in areas should also be expected to be unstable and prone to sidewall collapse/sluffing, especially within the cohesionless sands and in areas of seeping water.

Subsurface water was encountered in some areas. Subsurface water is expected to be much more prevalent during seasons of inclement weather, perched on top of the lower rock stratum. The Contractor should be prepared to dewater excavations for utility line installation and backfill. This may include temporary sump pits excavated laterally off the trench alignment and other dewatering measures. Buoyancy forces may also need to be considered by the design engineer.

A more detailed description of the existing pavement structure and subgrade soil conditions encountered at each boring location is included in the boring logs attached in Appendix A. A Boring Location Map is presented as Figure 1.

LABORATORY

Atterberg limits, gradation, and moisture content laboratory tests were performed for representative soil samples collected during the field operation. A summary of the laboratory test results is presented below in Table 1. Laboratory testing was performed in accordance with applicable ASTM standards.

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Boring	Depth (feet)	Liquid Limit (%)	Plasticity Index	Moisture Content (%)	Fines Content (%)	Gravel Content (%)	Unified Soil Classification
B – 1	3.5 – 9	50	28	19.3	32	2	SC
B – 3	1 – 3.5	---	Non-plastic	4.4	11	24	SP-SM
	3.5 – 5.5	44	24	17.3	39	2	SC
B – 4	¾ – 2	---	Non-plastic	4.0	9	27	SP-SM
B – 8	2 – 4.5	---	Non-plastic	5.5	16	5	SM
B – 10	5 – 7	36	18	11.6	29	1	SC

Corrosivity

The clayey site soil collected from boring B-1 was tested for corrosion potential testing to buried pipeline. These type of high plasticity clayey soils are typically found to meet the criteria for being corrosive to ductile iron pipe. It is noted that granular soils also encountered are often found not to be corrosive.

Resistivity and pH testing were performed to evaluate the soil corrosivity. A summary of the test results is presented below in Table 2.

Using the 10 point scale developed by the American Water Works Association, Standard C105-05, and ASTM A888, Appendix X, resistivity values less than 1,500 ohm-cm add 10 points to the 10-point scale, indicating that the soil is corrosive to ductile iron pipe, and protection is recommended.

The same specifications also state that pH values between 4 and 8.5 do not contribute to the corrosion potential of the soil.

TABLE 2
PH & RESISTIVITY TEST RESULTS

Boring	Depth (feet)	pH	Resistivity[1] (Ohm-cm)
B – 1	3.5 – 9	7.47	946

[1] Note: Saturated (ASTM G57).

Using the above referenced standards, the resistivity of the soils tested meet the 10-point criteria for corrosivity potential, *indicating that that the site soil tested is corrosive to ductile-iron pipe, and protection is recommended.*

TRENCH EXCAVATION

Some waster was noted, perched on top of the lower rock stratum. Subsurface water is expected to be much more prevalent during seasons of inclement weather. Where encountered, water in trench excavations will require dewatering.

Intact granite rock is exposed adjacent to the road throughout the project area. Granite rock was encountered at depths ranging from 2.5 to 6 feet in borings B-2, B-4 through B-7, and B-9. Auger refusal on rock varied from 4.5 feet in boring B-7 to 7 feet in borings B-5 and B-6. Rock should be expected in areas at shallower depths, in other locations not explored.

Cohesionless sands are present that can be unstable in trench excavations. Special attention shall be given to providing adequate control of surface water drainage near open excavations. Vehicles, equipment, stockpiles or other surcharge loads shall not be located near the top of open trenches. Workers shall be adequately protected from sloughing soil conditions and provided with safe ingress and egress.

Shoring, sloping, benching, etc, of temporary slopes used for construction should be excavated in strict compliance with the Federal Register, Volume 54, No. 209 (October 1989), the United States

Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR, Part 1926 to maintain stability of excavation sidewalls.

UTILITY BACKFILL

Quad City Specifications for bedding material states that the sum of the percent fines and the plasticity index shall not exceed a value of 22, with 100% passing a 1-in. sieve, and a maximum plasticity index of 10.

As shown in Table 1, some zones of relatively clean sands, where encountered, may meet the required criteria for use as bedding and shade material.

If potential bedding/shade materials are encountered that are desired for use as bedding, ETC recommends that the Contractor create stockpiles of the screened material for testing and approval prior to use. This will require the contractor to sort soil types and separate them into separate stockpiles for general trench backfill and bedding/shading backfill.

The native materials encountered should be suitable for use as trench backfill above the pipe shading, provided that the material is screened to remove any rock pieces 3 inches or larger in size.

Backfill compaction shall be completed on moisture-conditioned soil by mechanical methods, in accordance with MAG Standards. Water consolidation shall not be used.

PAVEMENT STRUCTURAL SECTION

High plasticity clayey soils were encountered by the borings in some areas, at depths of 3 feet or more below existing pavement surface elevations. Any clay soils, if exposed at subgrade elevation, shall be removed to a minimum depth of 12 inches below the bottom elevation of the pavement structure, or the bottom elevation of the ABC. The removed clay soil, if encountered, shall be replaced with on-site or imported, low plasticity granular soil approved by the engineer.

Yearly traffic volumes provided to us include a total daily traffic volume of 23,032 in 2026, increasing to 39,624 in 2046.

For traffic composition we have assumed volumes of 0.5% Tractor and Trailer, 5% Tractor-Semi Trail, 5% medium trucks, 5% RV/buses, and 24% light trucks with a 40/60 directional split. We have also used an 80% design lane for the option with two lanes in each direction.

Using the above traffic data and assumptions, ETC has determined a 20-year design lane ADT of 14,520vpd, with a 20-year ESAL of 2.08×10^7.

Utilizing the references noted herein, and the field and laboratory test results, ETC has utilized a Subgrade Resilient Modulus (Mr) for design of approximately 16,700psi for medium high plasticity clayey sands (SC).

Based upon the traffic data and assumptions discussed herein, and the soil subgrade testing data provided, the recommended pavement sections provided in Tables 3 and 4 were determined using design methods outlined in the Asphalt Institute's "Thickness Design - Asphalt Pavements for Highways and Streets," (MS-1) 9th ed., and other selected design parameters from ADOT's " Pavement Design Manual" based upon AASHTO design guidelines.

The recommended pavement sections discussed herein are expected to function with periodic maintenance or overlays when the subgrade, base, and pavement are constructed in accordance with accepted construction standards.

ETC recommends the structurally equivalent pavement sections presented below in Table 3 for roadway improvements with one lane in each direction (existing width).

TABLE 3
PAVEMENT STRUCTURAL SECTIONS
(ONE-LANE IN EACH DIRECTION)

Location	Alternative	Asphaltic Concrete Thickness (inches)	Aggregate Base Thickness (inches)	Prepared Subgrade Thickness (inches)
State Route 89 Willow Lake Road Round-a-Bout to North	1	6	16	8
	2	7	13	8
	3	8	10	8

ETC recommends the structurally equivalent pavement sections presented below in Table 4 for roadway improvements that will include road widening with two lanes in each direction.

TABLE 4
PAVEMENT STRUCTURAL SECTIONS
(TWO-LANES IN EACH DIRECTION - WIDENING)

Location	Alternative	Asphaltic Concrete Thickness (inches)	Aggregate Base Thickness (inches)	Prepared Subgrade Thickness (inches)
State Route 89 Willow Lake Road Round-a-Bout to North	1	6	15	8
	2	7	12	8
	3	8	9	8

The recommended pavement sections discussed herein are expected to function with periodic maintenance or overlays when the subgrade, base, and pavement are constructed in accordance with MAG construction standards with City of Prescott modifications. Efficient surface water and drainage must be provided and maintained to help mitigate moisture infiltration into the subgrade.

EARTHWORK

High plasticity clayey soils were encountered by the borings in some areas, typically at depths of 3 feet or more below existing pavement surface elevations. Any unsuitable high plasticity clayey soils, if exposed at subgrade elevation, shall be removed to a minimum depth of 12 inches below the bottom elevation of the pavement structure, or the bottom elevation of the ABC. The removed clay soil, if encountered, shall be replaced with on-site or imported, low plasticity granular soil approved by the engineer.

Unsuitable high plasticity clayey soils that would require 12 inches of removal and replacement, if encountered, shall be determined using the Subgrade Acceptance Criteria specified below.

The Plasticity Index (PI) (AASHTO T90) and the percent passing the No. 200 Sieve (Minus 200) (Arizona Test Method 201) when used in the equation below shall give a value of X that does not exceed **88** for determination of acceptable subgrade soils.

$$X = (\text{Minus } \#200) + 2.83 * (PI)$$

Less than adequate subgrade soils, if encountered, will require removal of the unsuitable clayey soil within 12 inches of finished subgrade elevation and replacement with better quality soils that do meet the minimum subgrade X-value found elsewhere on-site.

The areas where fill is required must be stripped of all debris, loose, wet, or other unstable soils. The exposed ground surface shall be scarified, moisture conditioned and compacted prior to fill placement. All subbase fill required to bring the structured areas up to subgrade elevation should be placed in horizontal lifts not exceeding 8 inches compacted thickness. Soils shall be compacted in accordance with the criteria in Table 5.

TABLE 5
SOIL COMPACTION CRITERIA
ASTM D698

Operation		Moisture Content	Degree of Compaction
I	**Pavement Subgrade, utility backfill, and other soils within the roadway prism**		
	A. Aggregate Base Course	±2 % of Optimum	Minimum of **98%** of Maximum Dry Density
	B. Granular Soils	±2 % of Optimum	Minimum of **95%** of Maximum Dry Density
	C. Clayey Soils	-3% to +2% of Optimum	Minimum of **95%** of Maximum Dry Density

ETC recommends the observation of the site grading operation with sufficient tests to verify proper compaction.

The lower rock stratum in areas and anticipate subsurface water conditions will require special excavation methods and dewatering for excavations within the project area.

As discussed herein, the Contractor should be prepared to provide dewatering of excavations as needed for underground utility line installation and bedding/backfill placement within utility trenches. This may include temporary sump pits to pump from that may be excavated laterally off the main trench alignment. Dewatering may require multiple well/pump points and/or cut-off trenches from which to pump accumulated water and lower the local water table.

Unstable Subgrade

In any areas where loose/soft subgrade soils are encountered that cannot be stabilized with conventional compaction methods, if encountered, we recommend a minimum over-excavation depth of 12 inches. 12 inches of coarse, clean sound gravel may be used to stabilize the exposed ground surface, such as "track-out rock" or "leach rock."

In any areas where subgrade movement is relatively minor, as determined by the engineer, subgrade reinforcement with geogrid and separation filter fabric may be utilized to help provide a more stable construction platform, and to mitigate concentrated loads on weak subgrade soils.

Geogrid reinforcement, if used, would include the installation of a geogrid layer on the compacted, ground surface. ABC should then be placed and compacted on top of the geogrid layer. If needed, ETC recommends geogrid reinforcement meet minimum Type 2 criteria in MAG Section 796.2.4, such as Tensar TX-160, or BX-1200. It is noted that additional support would be provided by a stronger geogrid product, such as Tensar NX-750 or stronger geogrid. At least 12 inches of overlap shall be provided between adjacent geogrid layers. In addition, a separation geotextile filter fabric shall be placed between the geogrid and the prepared subgrade. ETC recommends MAG Section 796.2.2 Class B specifications for the fabric layer.

Geosynthetics, if used, shall be placed in accordance with MAG Section 306 and the manufacturer's installation guidelines. This will require special grading procedures to limit the pumping action of the underlying soil; such as light construction equipment, pushing the ABC in front of the equipment rather than driving directly onto the geogrid, and ensuring the subgrade is relatively flat before installing the fabric and geogrid reinforcement, which may require pinning.

LIMITATIONS

The figures and recommendations in this report were prepared in accordance with accepted professional engineering principles and soil mechanics practices. We make no other guarantee or warranty, either implied or expressed. If during subsequent planning and construction, conditions are different than as indicated, this firm should be notified for evaluation.

This report is not a bidding document. Any contractor reviewing this report must draw his own conclusions regarding site conditions and specific construction techniques to be used on this project.

For your use. If you have any questions, please contact us at (928) 778-9001.

Sincerely,

ENGINEERING & TESTING CONSULTANTS, INC.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 37900
MICHAEL PHILIP WILSON
Date Signed 4/10/25
ARIZONA, U.S.A.

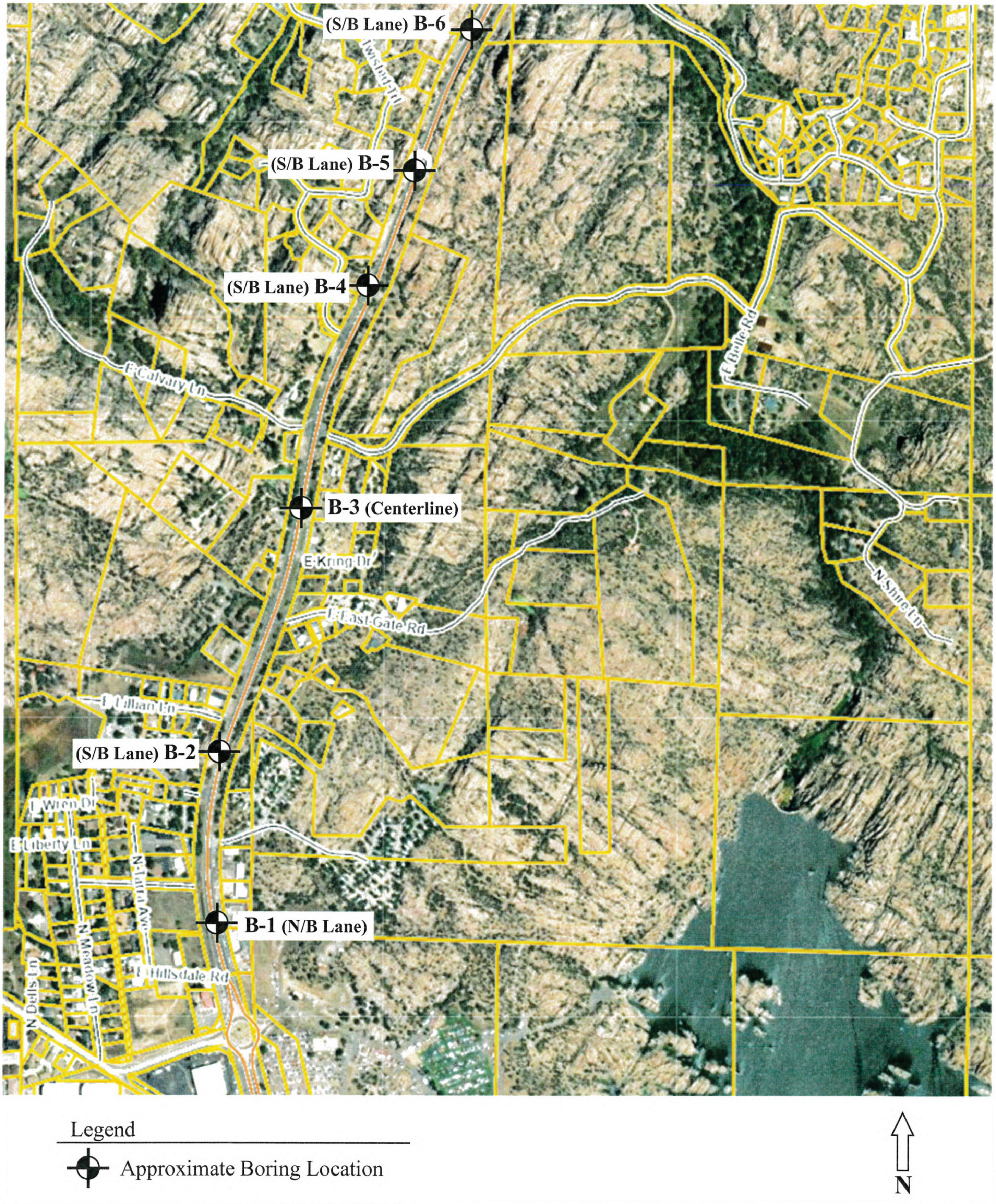
Registered Professional Engineer (Civil)
CERTIFICATE NO. 26853
RICHARD G. KELLEY
Date Signed 4/10/25
ARIZONA, U.S.A.

Michael P. Wilson, P.E.
Project Engineer

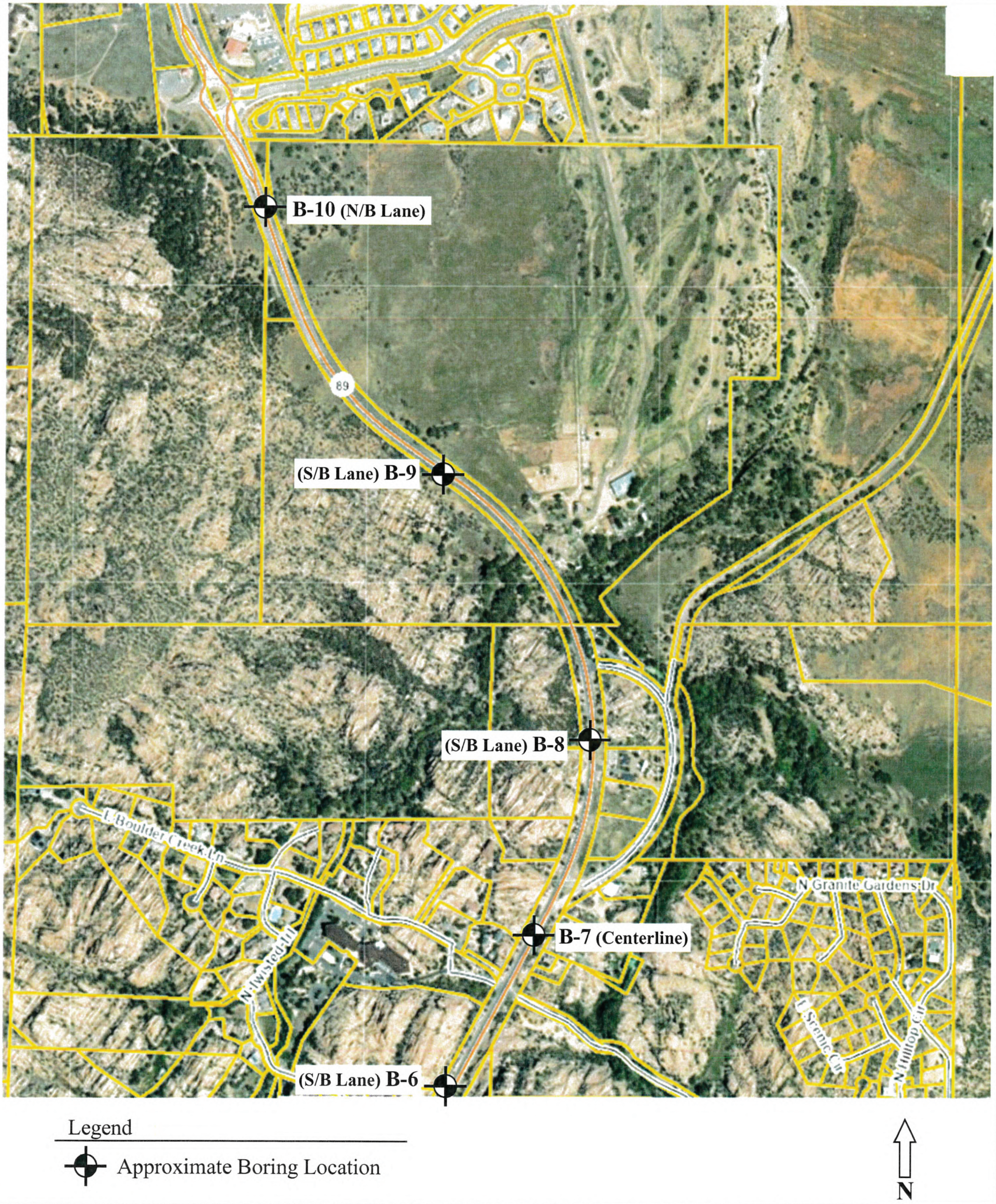
Reviewed by: Richard G. Kelley, P.E.
Project Manager

Attachments: Figures 1 & 2
Appendix A

cc: ETC File No. 12825



Engineering & Testing Consultants		**FIGURE 1** **BORING LOCATION MAP** SR89 Effluent & Wastewater Pipeline Improvements Prescott, AZ	ETC
Drawn by: others Project No: ETC 12825	Date: 01/27/25 Page No:		



Engineering & Testing Consultants	**FIGURE 2** **BORING LOCATION MAP** SR89 Effluent & Wastewater Pipeline Improvements Prescott, AZ
Drawn by: others Date: 01/27/25 Project No: ETC 12825 Page No:	

APPENDIX A

FIELD EXPLORATION

GENERAL NOTES

DESCRIPTIVE SOIL CLASSIFICATION:

Soil Classification is based on the Unified Soil Classification System and ASTM Designations D-2487 and D-2488. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine grained soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: Clays, if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse grained soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their consistency. Example: Lean clay with sand, trace gravel, stiff (CL); silty sand, trace gravel, medium dense (SM).

CONSISTENCY OF FINE-GRAINED SOILS:

N-Blows/ft.	Consistency
0-2	Very Soft
3-4	Soft
5-8	Medium
9-16	Stiff
17-32	Very Stiff
33+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS:

N-Blows/ft.	Relative Density
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
50+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL:

Description Term(s) (of Components Also Present in Sampling)	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY:

Major Component of Sampling	Size Range
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES:

Description Term(s) (of Components Also Present in Sampling)	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

KEY TO CLASSIFICATION
(Unified Soil Classification System)

TERMS & SYMBOLS

UNIFIED SOIL CLASSIFICATION SYSTEM*

				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]	GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12 % fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H,]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-graded sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12 % fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
FINE-GRAINED SOILS 50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12 % fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15 % sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15 % gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30 % plus No. 200, predominantly sand, add "sandy" to group name.

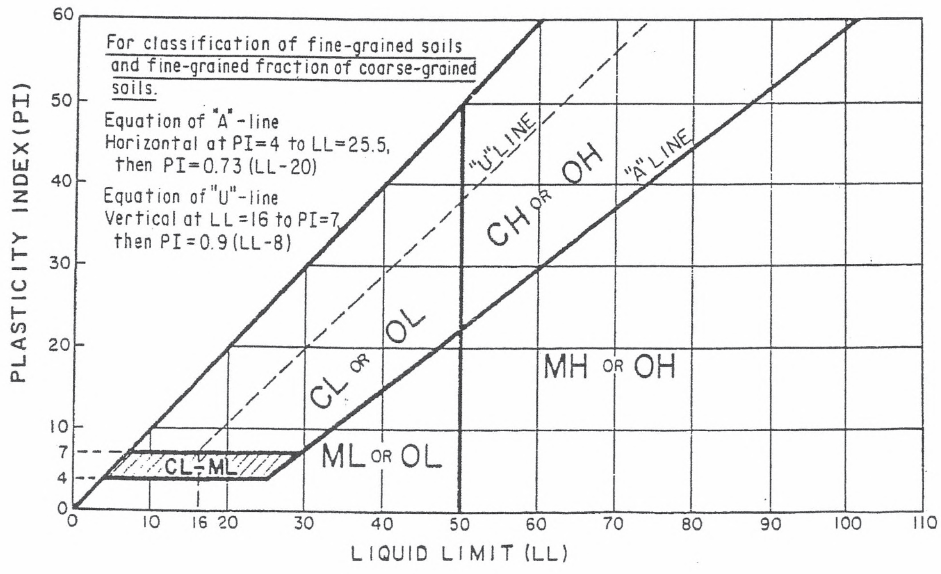
[M] If soil contains ≥ 30 % plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.


For classification of fine-grained soils and fine-grained fraction of coarse-grained soils.

Equation of "A"-line
Horizontal at PI=4 to LL=25.5, then PI=0.73 (LL-20)

Equation of "U"-line
Vertical at LL=16 to PI=7, then PI=0.9 (LL-8)

Engineering & Testing Consultants, Inc.
•Subsurface Drilling •Geotechnical •Environmental Support

KEY TO CLASSIFICATION
(Unified Soil Classification System)

TERMS & SYMBOLS

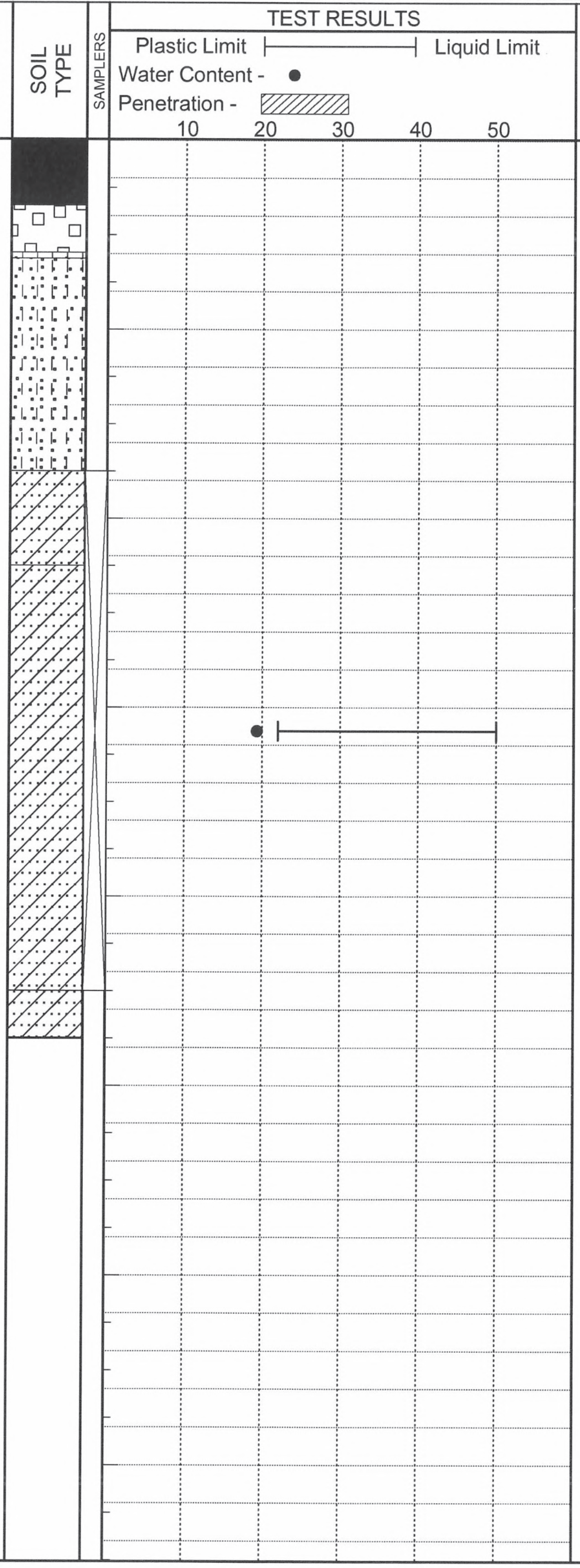
LOG OF BORING NO. B-1

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

DEPTH (feet)	Description	GROUP SYMBOL	Remarks
	5.5" ASPHALTIC CONCRETE (incl. chip seal)	AC	
	2.75" ASPHALTIC CONCRETE - Older/Weaker	AB	
2	6" BASE COURSE MATERIAL, some granite pieces	SP-SM	
	SAND WITH SILT, damp, some gravel, Medium Dense		
	Layers of Gravel/Cobble with Loose Pockets		
4	CLAYEY SAND, reddish-brown, very moist, High PI & Clay Fines, Loose to Medium Dense	SC	Mottled
6 8	CLAYEY SAND, dark brown, High PI & Clay Fines, very moist to wet, Loose	SC	
	Moist, Medium Dense		
10 12 14	Boring terminated at 9.5 feet depth.		

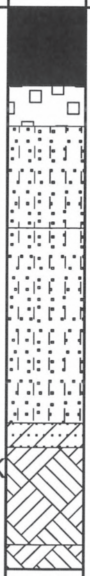


LOG OF BORING NO. B-2

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50



DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	6.75" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.75" ASPHALTIC CONCRETE - Older/weaker	AB				
	5" BASE COURSE MATERIAL	SP-SM				
2	SAND WITH SILT, damp, some gravel, Medium Dense					
	Some larger rock pieces & Loose to Medium Dense pockets					
4						
	CLAYEY SAND, moist, med-high PI, high clay fines, Medium Dense	SC				"Decomposed Granite"
	GRANITE - Highly to Moderately Weathered, Dense	ROCK				
6	Lightly Weathered to Intact, Very Dense					ROCK REFUSAL
	Auger Refusal on Intact Rock at 5.75 feet depth.					
8						
10						
12						
14						

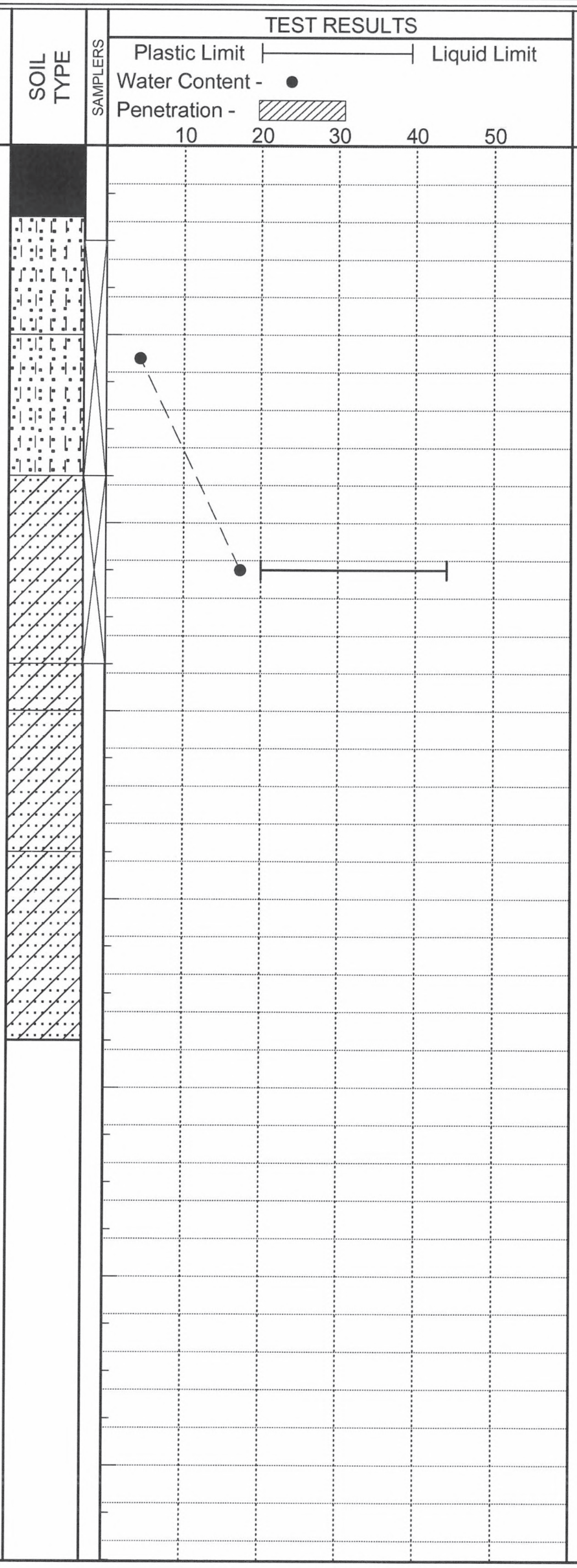
This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-3

ETC
ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-28-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	Remarks
	3.5" ASPHALTIC CONCRETE (incl. chip seal)	AC	
	2.5" ASPHALTIC CONCRETE - Older/weaker	SP-SM	Any AB Layer indistinct
2	3" ASPHALTIC CONCRETE - Very weak		
	SAND WITH SILT AND GRAVEL, damp, Medium Dense		
	With Gravel & Some Rock Pieces		
4	CLAYEY SAND, very moist, High PI & Clay Fines, Loose to Medium Dense	SC	Likely native
	Gravel/Cobble rock pieces		
6	CLAYEY SAND, brown, moist, high PI & clay fines, Medium Dense	SC	"Decomposed Granite"
8	Reddish-orange		
10	Boring terminated at 9.5 feet depth.		
12			
14			



This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-6

PAGE 1 of 1

LOG OF BORING NO. B-4

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	6" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	SAND WITH SILT & GRAVEL, damp, Medium Dense	SP-SM		☒	●	Any AB Layer indistinct
2	Very low silty fines					
	GRANITE - Highly Weathered & Fractured, Medium Dense to Dense	ROCK				Possibly layers and/or weathered rock pieces
4						
	Moderate to Lighly Weathered, Very Dense					Thin water/moisture on rock stratum
6	Auger refusal in Weathered Granite at 6 feet depth.					ROCK REFUSAL
8						
10						
12						
14						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-7

PAGE 1 of 1

LOG OF BORING NO. B-5

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	3.5" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.5" ASPHALTIC CONCRETE - Older/weaker	SP-SM				Any AB Layer indistinct
2	SAND WITH SILT, damp, some gravel & granite pieces, Medium Dense					
	Layer with increased Gravel					
	GRAVEL WITH SAND, Dark brown,	GP-GM				Bituminous odor - Possible millings or pulverized road base
4	SAND WITH GRAVEL, some Cobble, Medium Dense	SP				
6	GRANITE - Moderate to Lighly Weathered, Very Dense	ROCK				Thin water/moisture on rock stratum
	Auger refusal on Intact Rock at 7 feet depth.					ROCK REFUSAL
8						
10						
12						
14						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-6

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	7" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.5" ASPHALTIC CONCRETE - Older/weaker	SP-SM				Any AB Layer indistinct
	SAND WITH SILT, damp, some gravel & granite pieces, Medium Dense					
2	Layer with increased Gravel					
4						
	GRANITE - Decomposed to Highly Weathered, moist, Dense	ROCK				Thin water/moisture on rock stratum
6						
	Moderately Weathered, Dense to Very Dense					
8						
	Boring terminated at 9.5 feet depth.					
10						
12						
14						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-7

ETC
ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-28-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS
Plastic Limit ├──┤ Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	2.75" ASPHALTIC CONCRETE (incl. chip seal)	AC	■			
	4" ASPHALTIC CONCRETE - Older/ weaker	SP-SM	▒			Any AB Layer indistinct
2	SAND WITH SILT, damp, some gravel, Medium Dense		▒			
	GRANITE - Highly Weathered, Medium Dense to Dense	ROCK	▨			
4	Lightly Weathered, Very Dense		▨			
	Auger Refusal in very dense Weathered Granite at 4. 5 feet depth					ROCK REFUSAL
6						
8						
10						
12						
14						

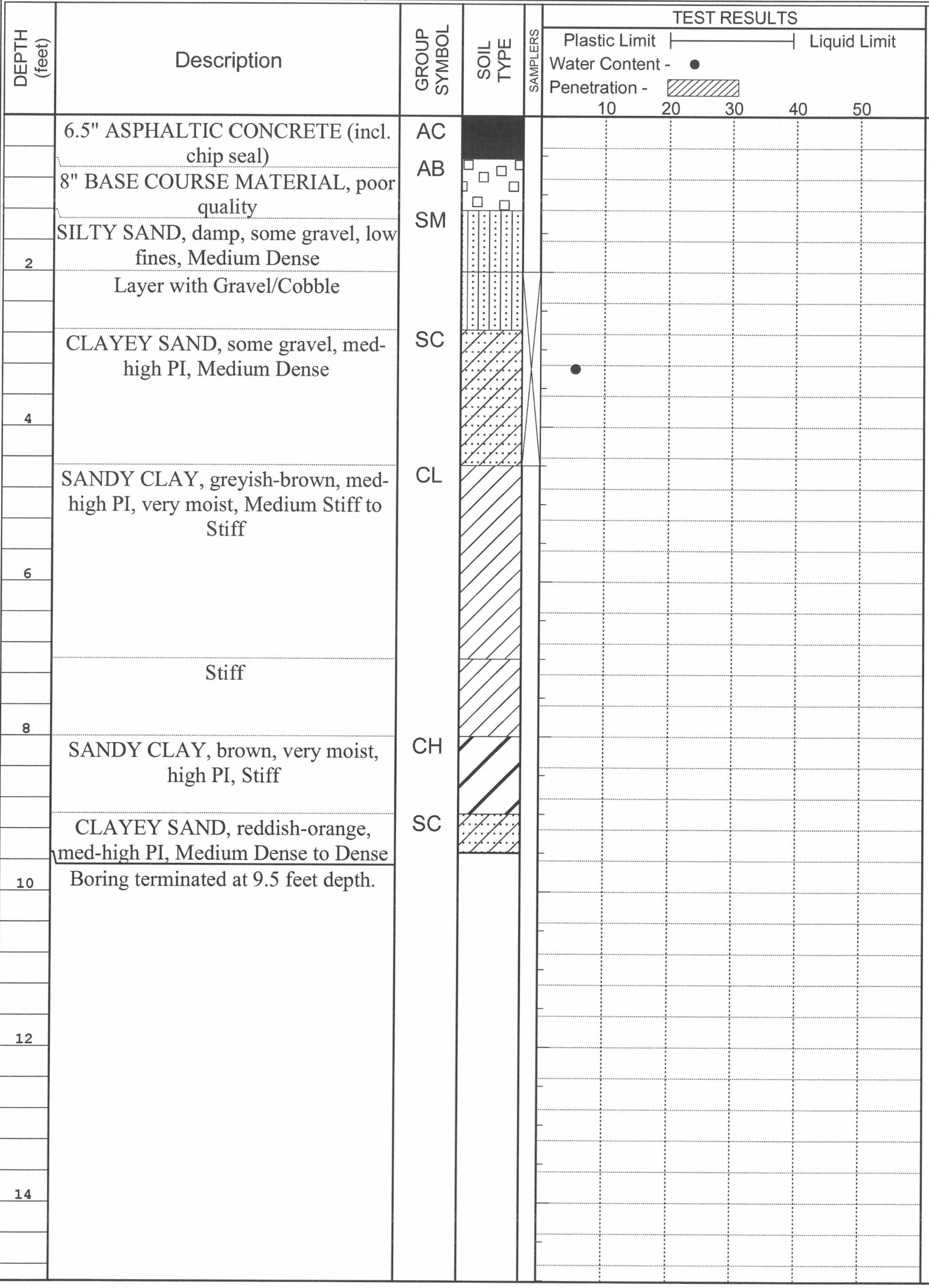
This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-8

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

Description	GROUP SYMBOL	Remarks
6.5" ASPHALTIC CONCRETE (incl. chip seal)	AC	
8" BASE COURSE MATERIAL, poor quality	AB	
SILTY SAND, damp, some gravel, low fines, Medium Dense	SM	
Layer with Gravel/Cobble		
CLAYEY SAND, some gravel, med-high PI, Medium Dense	SC	
SANDY CLAY, greyish-brown, med-high PI, very moist, Medium Stiff to Stiff	CL	Some mottling
Stiff		
SANDY CLAY, brown, very moist, high PI, Stiff	CH	
CLAYEY SAND, reddish-orange, med-high PI, Medium Dense to Dense	SC	"Decomposed Granite"
Boring terminated at 9.5 feet depth.		



This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-11

PAGE 1 of 1

LOG OF BORING NO. B-9

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	4.75" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	4" ASPHALTIC CONCRETE - Older/ weaker	AB				
	5.75" BASE COURSE MATERIAL	SP-SM				
2	SAND WITH SILT, damp, some gravel, Medium Dense					
	Layer with increased/coarser gravel					
4	CLAYEY SAND, orangish, damp, low fines, Medium Dense	SC				
	Medium to high clay fines & PI					
	CLAYEY SAND WITH GRAVEL, damp-moist, Medium Dense to Dense	SC				"Decomposed Granite"
6	GRANITE - Decomposed to Highly Weathered, Dense	ROCK				
8						
10	Boring terminated at 9.5 feet depth.					
12						
14						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

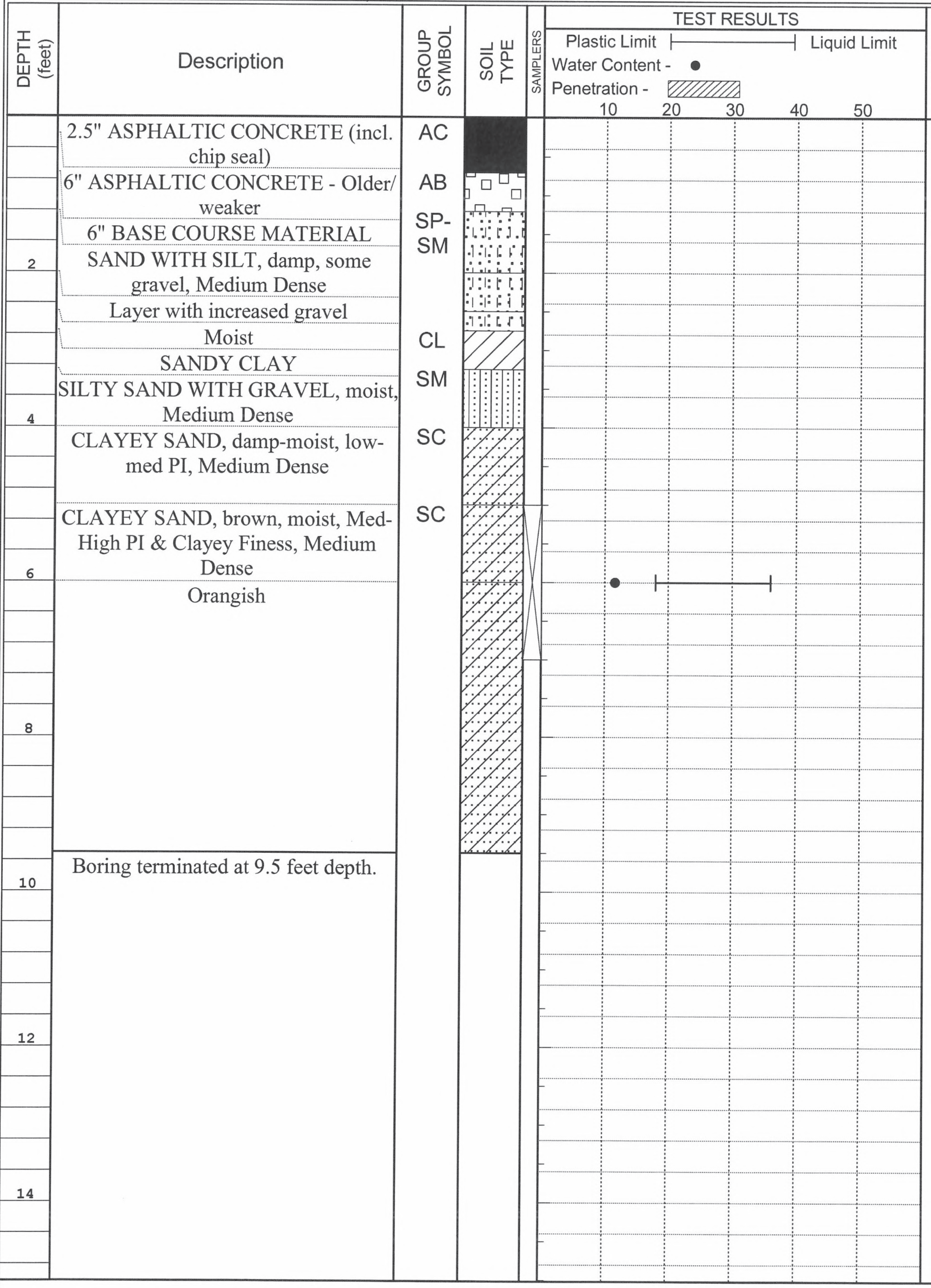
Figure B-12 PAGE 1 of 1

LOG OF BORING NO. B-10

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

Description	Group Symbol	Remarks
2.5" ASPHALTIC CONCRETE (incl. chip seal)	AC	
6" ASPHALTIC CONCRETE - Older/ weaker	AB	
6" BASE COURSE MATERIAL	SP-SM	
SAND WITH SILT, damp, some gravel, Medium Dense		
Layer with increased gravel		
Moist		
SANDY CLAY	CL	
SILTY SAND WITH GRAVEL, moist, Medium Dense	SM	
CLAYEY SAND, damp-moist, low-med PI, Medium Dense	SC	"Decomposed Granite"
CLAYEY SAND, brown, moist, Med-High PI & Clayey Finess, Medium Dense	SC	
Orangish		
Boring terminated at 9.5 feet depth.		



This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-13 PAGE 1 of 1

KEY TO SYMBOLS

Strata symbols

Symbol	Description
■	Asphaltic Concrete
⊡	Aggregate base material
▥	Poorly graded sand with silt
▨	Clayey sand/ Low plasticity clay
▩	Weatherd rock
▦	Poorly graded gravel with silt
⁘	Poorly graded sand
▥	Silty sand
▨	Low plasticity clay
⧄	High plasticity clay

Soil Samplers

Symbol	Description
☒	Bulk sample taken from 4 in. auger

Notes:

1. Exploratory borings were drilled using a 4-inch diameter continuous flight power auger.

2. Some water was encountered on the lower rock strata at the time of drilling.

3. Boring locations were estimated from existing site features.

4. These logs are subject to the limitations, conclusions, and recommendations in this report.

5. Results of tests conducted on samples recovered are reported on the logs.

MEMORANDUM

2475 N Coyote Dr. Tucson, AZ USA | +1.520.670.9774 | www.cnitucson.com

CALL & NICHOLAS

TO: Andrew Baird, PE / Kimely-Horn

FROM: Michael Conley, PE / Call & Nicholas, Inc.
Robert Cummings, PE / Call & Nicholas, Inc.

DATE: June 16, 2025

SUBJECT: DRAFT SR 89 DCR Effluent Main and Sewer Trenching Geotechnical Recommendations

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1. EXECUTIVE SUMMARY

This memorandum presents geotechnical recommendations for the SR89 DCR proposed utility trenching activities, according to field geological and geophysical work done in the corridor by Call & Nicholas, Inc. (CNI) during the last week of January 2025, and the conceptual trench locations provided by Kimley-Horn Associates (KHA), and roadway borings conducted by ETC of Prescott. Because this report is to support the DCR addressing the utility trenching, the field work supporting this report pertains to below grade features, specifically the trenching that has been proposed for a relocated effluent line and the augmentation of the existing effluent line trench. This configuration can be seen in Figure 1.

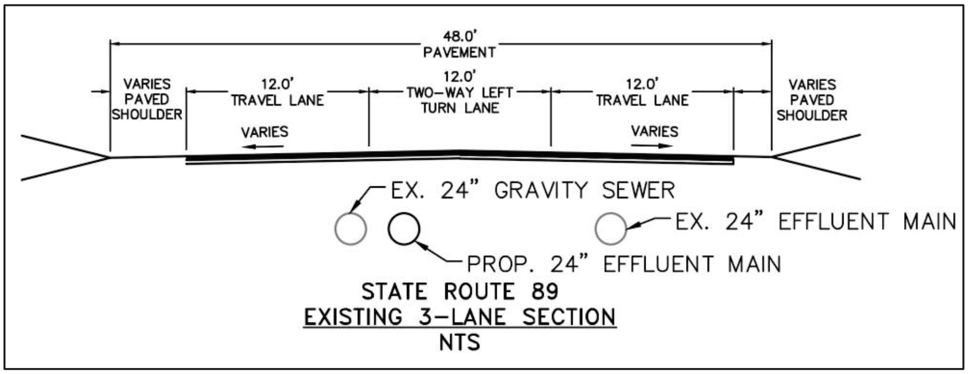


Figure 1. Existing Roadway Configuration and Utility Locations (looking north)

Other geotechnical work was performed to support the design of the rock cut slopes as part of the roadway improvement project. That work is the subject of a separate report.

1.1 Trenching for New Effluent Line

KHA is designing a new 24-inch-diameter effluent line to be installed within the project corridor. This line will require the excavation of a new 4-foot wide trench 6 to 10 feet deep. Variable ground conditions are expected to be encountered during the trenching operations. In the north and south ends of the corridor, trenching is expected to be mainly within compacted embankment and natural alluvial fill. In these locations CNI expects the excavation to be accomplished with a standard excavator.

In the central portion of the corridor, the material to be trenched is comprised of some fill but most of the excavation will be within intact portions of the Dells Granite, and possibly granitic detritus left over from legacy excavations. The granite that crops out and forms the slopes adjacent to the roadway within this portion of the corridor is relatively strong with an estimated unconfined compressive strength of 15,000 to 30,000 psi. In general, blasting would be recommended to excavate this type of material However, the roadway alignment was evidently chosen to exploit a flatter area of weaker, more fractured and weathered rock along a zone of shearing and faulting. Seismic refraction tomography, carried out for this project, bears this out -- the rock below the roadway appears notably lower-velocity than that of the surrounding outcrops. Compression wave velocities of 6,000 fps or less are prevalent within the depths of interest (0-10 feet) for the new effluent line location. This suggests that a rock trencher will be able to remove the material, although with some difficulty. It is highly desirable to avoid blasting for the relocated effluent line trench because the existing HOBAS sewer line is only a short distance away, whose continuous operation is paramount.

1.1.1 Augmenting Existing Effluent Line Trench

KHA and the City of Prescott are also considering rehabilitating the trench presently containing the existing 24-inch effluent line on the east side of the alignment and constructing a new gravity sewer there. This would include re-excavating the trench, pulling the existing effluent line out, and either deepening or backfilling the trench floor to make it suitable for a gravity sewer. KHA requested guidance on the augmentation of this existing effluent line trench. A hydraulic rock drum cutter head on an excavator is suggested as a preferred method of deepening the trench as it is anticipated that only a limited thickness of intact rock will need to be removed.

2. TRENCHING RECOMMENDATIONS

For the new effluent line trench, the method of excavation will vary throughout the corridor. At the northern and southern ends of the corridor, excavation of the trench may be accomplished with a standard bucket excavator like one of the Caterpillar 300 series. There may be limited hard rock exposures within some of the trenching within this area, thus it is also recommended to have a hydraulic rock drum cutter available to mount on the excavator in exchange for the bucket. This combination should be an efficient method of excavation for trenches in these areas. Hoe-ram operation augmented with relief drilling may also be suitable for limited areas of shallow hard rock.

In the central portion of the corridor, where trenching transitions into hard granitic material, a standard excavator is not well suited. Typically blasting would be recommended in these ground conditions, but with the proximity of the new trench to the existing sewer line and residential neighborhoods, an alternative excavation method of using a rock trenching machine was evaluated. The seismic refraction tomography surveys performed for this study indicate that compression wave velocities of 6,000 fps or less are prevalent within the depths of interest (0-10 feet) for the new effluent main location. This suggests that a rock trencher will be able to remove the material, although with some difficulty. It is also important to consider placement and handling of spoils from the rock trenching, because the corridor is relatively narrow in some of these areas and maintenance of traffic and access are considerations.

For comparison, a rock trenching machine was used on another project in Arizona to excavate a 3-ft wide trench 16 ft deep in weathered to somewhat fresh granite. A Vermeer T1155 trencher reportedly progressed between 600 and 800 feet per day on that project. The granite on that project was more fractured and probably less abrasive than the granite in the SR89 corridor. Accordingly, an average rate of about 400 feet per day could be expected. However, this rate could range from 100 feet per day to the quoted 800 feet per day. Some standby time should also be considered for machine maintenance – tooth consumption is unknown but could be significant because the granite contains appreciable silicate minerals.

For the augmentation and re-grading of the existing effluent main trench, a hydraulic rock drum cutter on a standard excavator is recommended. It is considered that the deepening of the existing trench would not need to be more than a foot or two. Because that excavation may not need to be continuous, unlike the case of the new effluent main excavation, a drum cutter is a solution that allows for increased mobility and flexibility.

3. GEOLOGIC SETTING

The Mesoproterozoic Dells Granite pluton, located approximately 5 miles northeast of Prescott, crops out unconformably from surrounding Tertiary sedimentary rocks. Texturally, the rock is massive and medium- to coarse-grained and locally porphyritic with larger feldspar phenocrysts. Feldspar, quartz, and biotite make up the bulk of the rock while tourmaline, fluorite, magnetite, specular hematite, and apatite occur as accessory minerals. Fresh rock is generally white to light gray, while weathered outcrops have been oxidized and range from pink to brown to orange.

The granite has weathered to distinctive spheroidal hills, knobs, and boulders cut by near vertical joint patterns primarily oriented in two directions: north-northeast to south-southwest, and west-northwest to east-northeast. Additional locally variable joint groups cut across these two main joint sets. Persistent planar features are clearly visible in aerial and drone photography. Most of the discontinuities dip more than 70 degrees, but locally, some shallower dips were noted in the field work.

4. FIELD INVESTIGATION SUMMARY

From January 27 through January 31, 2025, geotechnical investigations took place within the corridor consisting of 10 borings, 7 seismic refraction lines, test excavations and potholing, 20 ground penetrating radar (GPR) lines, and rock fabric structure mapping. The borings, test excavations, 5 of the seismic lines, and GPR were all performed for the trenching evaluation. The locations of the GPR surveys, seismic surveys, and borings are presented in Appendix A along with station locations. The findings from these investigations are summarized in the following subsections.

4.1 Borings and Potholing

Ten borings were conducted by ETC along the alignment within the roadway area. All borings were conducted from the roadway surface to an investigation depth or to auger refusal. Because no coring was done, the drilling did not provide data on the intact rock properties but did give insight into the variable depth to intact granite.   The following is a summary; the details of the drilling program, potholing and test excavations are summarized separately by ETC.

Three borings were located between Willow Lake Road (STA. 10+00) and East Calvary Road (~STA. 42+00). Two of these borings (B-1 and B-3) reached the investigation depth of 9.5 feet completely in soil or fill material. One boring (B-2) encountered granite at a depth of 5.5 feet and subsequently terminated due to auger refusal at depth of 5.75 feet. This boring was drilled within a portion of the roadway that has adjacent hard rock slopes. It is expected that trenching will encounter hard rock from station 21+50 to 25+50, approximately a 400 foot length of trench just south of Lillian Lane.

Four borings were located between East Calvary Road (~STA. 42+00) north to the southern intersection of Old Highway 89A (~STA. 79+00). All four encountered granite at depths ranging from 2.5 to 6 feet. Three of the borings (B-4, B-5, and B-7) terminated on auger refusal at depths ranging from 4.5 to 7.0 feet. The other boring (B-6) was completed to the investigation depth of 9.5 feet though the last 4 feet of the boring were through weathered granite. These borings indicate that hard rock is expected to be frequently encountered during trenching between these stations. The ground conditions between these stations are expected to necessitate the use of a rock trenching machine. Some areas may have granite that is highly weathered and weaker, but it will vary, with some portions having hard intact fresh granite nearer to the surface than other portions.

One boring (B-8) was located between the southern intersection of Old Highway 89A (~STA. 79+00) and the end of the proposed trenching activity at Horsemanship facility on the east side of the alignment (~STA. 99+50). This boring was approximately located at Station 86+80 and completed entirely in soil to the investigation depth of 9.5 feet. Immediately south of this boring, granite is expected to be encountered in the trenching activity. At the boring location and to the north of this boring, the trenching may be mostly in alluvial/ compacted fill with the possibility of encountering small sections of granite.

The remaining two borings (B-9 and B-10) were conducted within the alignment beyond the trenching limits.

4.2 Seismic Surveys

Lines SLRW-01 through SLRW-05 were performed along the proposed new effluent main location within the southbound travel lane (Table 1). All lines were conducted at roadway locations that had adjacent rock slopes. The following is a summary; the seismic tomography profiles are found in Appendix C.

TABLE 1 – SEISMIC REFRACTION LINE LOCATIONS

Line Designation	Approx. Station Interval	Length (feet)	Left/Right of Existing Centerline	Refraction Geophone Spacing, feet	Correlative Boring
SLRW-01	85+50 to 87+50	200	Left	3	B-8
SLRW-02	65+00 to 66+50	150	Left	3	B-6
SLRW-03	56+25 to 57+75	150	Left	3	B-5
SLRW-04	50+00 to 51+50	150	Left	3	B-4
SLRW-05	22+80 to 24+30	150	left	3	B-2

For the roadway geophysics, the seismic interpretation in the depth interval 0-10 feet is of most interest in new effluent line trenching. This interval was found in general to correspond to compression wave velocities of 3,200 to 5,500 fps with some zones reaching as much as 6,800 fps. One notable exception is at the south limit of SLRW-02, where a narrow zone of material having a velocity of over 8,000 fps is shown at a depth as shallow as 6 feet, and 6,000 fps material exists close to pavement subgrade depth. SLRW-03 showed zones of 6,500 fps interspersed with zones of much lower velocity (in the range of 3,000 fps). Other profiles show variability as well, appearing to correspond to buried knobs and hard spots possibly bounded by shear or weathered zones, although fewer than SLRW-03. SLRW-04 shows a bedrock knob of higher velocity (6,225 fps at a depth of 8 feet) bounded on its north flank 22 feet away by a zone of much lower velocity (6,225 fps at a depth of 19 feet) indicating a zone of deeper weathering or dense fracturing.

The roadway compression wave velocities overall are lower at comparable depths than the road cut compression wave velocities. This is consistent with the notion that SR 89 through Granite Dells follows a pre-existing topographic low representing a zone of geologic discontinuities and weaker, more weathered rock. This is illustrated by SLRW-05, where rock of 9,500-10,000 fps is not indicated shallower than 25-30 feet whereas the cut slope tomographic profiles (SLCS-01 and SLCS-02) generally show such velocities at depths shallower than 15 feet and commonly as shallow as 6-7 feet.

Roadway shear zone profiles were mostly affected by data anomalies and do not always display subsurface distributions of higher and lower velocities indicated by the refraction tomographic profiles. They should be regarded with caution. SLRW-01 appears to show vertical lenses of higher and lower velocity material but the contrast in velocities is quite low. SLRW-02 shows gradual increases in shear wave velocity to about 4,000 fps at depths and locations where the tomographic profiles indicate 14,000 fps. However, SLRW-02 also indicates a sub-horizontal velocity inversion (from about 3,150 to 2,900 fps) at a depth of 13-22 feet. A similar, but more defined and continuous velocity inversion between 16 and 22 feet in depth is depicted on the MASW profile for SLRW-03. These velocity inversions are unexpected in a rock mass such as this and would need confirmation by drilling. The compression wave velocity contrast evident in the tomographic profile for SLRW-04 is not indicated at all in the SLRW-04 shear wave velocity profile.

4.3 Ground Penetrating Radar

The existing buried utilities were potholed by ETC at various locations. However, additional information was needed to characterize the existing HOBAS sewer trench excavation to assure that new excavation will not disturb the sewer, which must remain in continuous service during relocation of the effluent line.

To identify the likely sewer trench wall locations for the existing HOBAS line, CNI arranged for Ground Penetrating Radar (GPR) surveys to be performed by Collier Geophysics of Colorado. During January 2025, 20 GPR transects were performed approximately perpendicular to centerline at locations spaced throughout the expected areas of rock cut. The survey locations are identified on Appendix A.

Lyon Engineering provided survey markers at the endpoints of each GPR transect so that the results could be located relative to centerline and the proposed new construction.

In general, the GPR results successfully displayed both the HOBAS sewer excavation and the existing effluent line. The backfilled trenches appear as diffuse, commonly prismatic zones below the pavement layer that contrast with the layered appearance of the pavement, subgrade, and rock between the two utilities (Figure 2). The GPR profiles are presented in Appendix D.

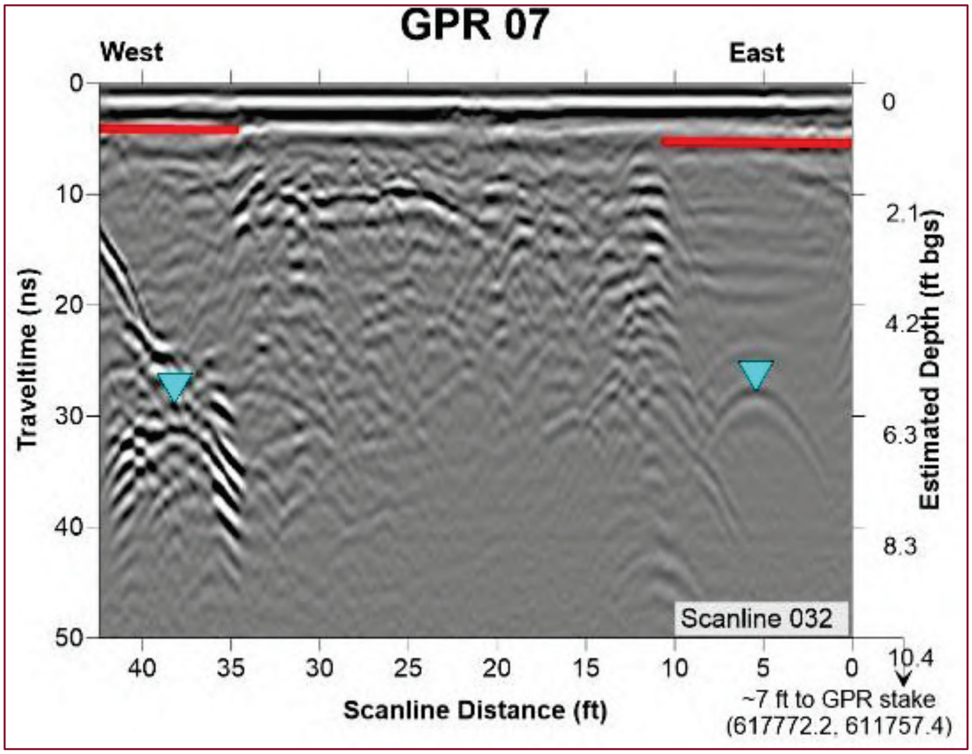


Figure 2 – Example GPR results showing the HOBAS sewer trench (left/west) and existing effluent line trench (right/east). The blue triangles represent radar reflectors that may correspond to the pipes themselves. Depth estimates should be considered approximate.

To identify the trench signatures, the GPR profiles were examined collectively, recognizing that the sewer trench would not change greatly in horizontal position from location to location. The reflections from the pavement layers and underlying undisturbed rocky subgrade were generally clear, as indicated in Figure 2.

The original sewer installation was likely in a blasted trench that would have had irregular, generally sloping sides. After sewer line placement and backfilling, unexcavated blast-damaged rock likely remained at the trench margins and below. Much later, the present sewer was constructed by re-excavating along the old sewer alignment with a trenching machine. This would have produced much more regular sides, but some blast damaged rock may remain outside the trencher limits. The GPR profiles show some diffuse areas with vertical sides, like what is depicted in Figure 2, and at other locations the sides are less distinct and/or sloping, suggesting broader areas of rock damage or a weaker, decomposed rock condition; the GPR signatures thus indicate varying widths of excavation-related disturbance. The GPR signature of the reconstructed trench backfill appears mostly to represent more homogeneous, granulated material probably produced by the trenching machine, although there are some reflectors at places that could signify buried rock within the backfill. The sewer pipe itself, being nonmetallic, would not strongly reflect radar energy so the radar reflections identified may in some cases be responding to the sewer contents or the presence of intact rock below the pipeline itself.

The existing effluent line trench has less regular sides and its backfill was found to be rocky at the locations of effluent line repairs. These conditions were generally indicated in the GPR transects. Figure 2 suggests more homogeneous backfill than other profiles show. Because the effluent pipeline is metallic, the reflector indicated in Figure 2 and similar interpreted reflectors in the other profiles likely represent the actual pipe.

Summary

The GPR profiles suggest that trenching conditions in the area proposed for the relocated effluent pipe will vary and, in some cases, present mixed-face conditions (weathered rock/old backfill and fresher, undisturbed rock).

Most, but not all, of the rock fracturing exhibited in the rock outcrops is parallel or nearly so to the roadway alignment and thus the trench sides. In those locations the tendency will be for the new rock released by the trencher to fall away along near-vertical discontinuities that roughly parallel the trench sidewalls. However at some places the fracturing is at angles to the roadway centerline. Where that occurs, there is an increased possibility that the trencher may detach rock blocks beyond the new excavation limits in the direction toward the existing HOBAS sewer pipe. There is also the possibility that old fil will contain rock that may be dislodged by the trencher. A safe amount of separation between the effluent line relocation trench, and the existing sewer, is therefore desirable.

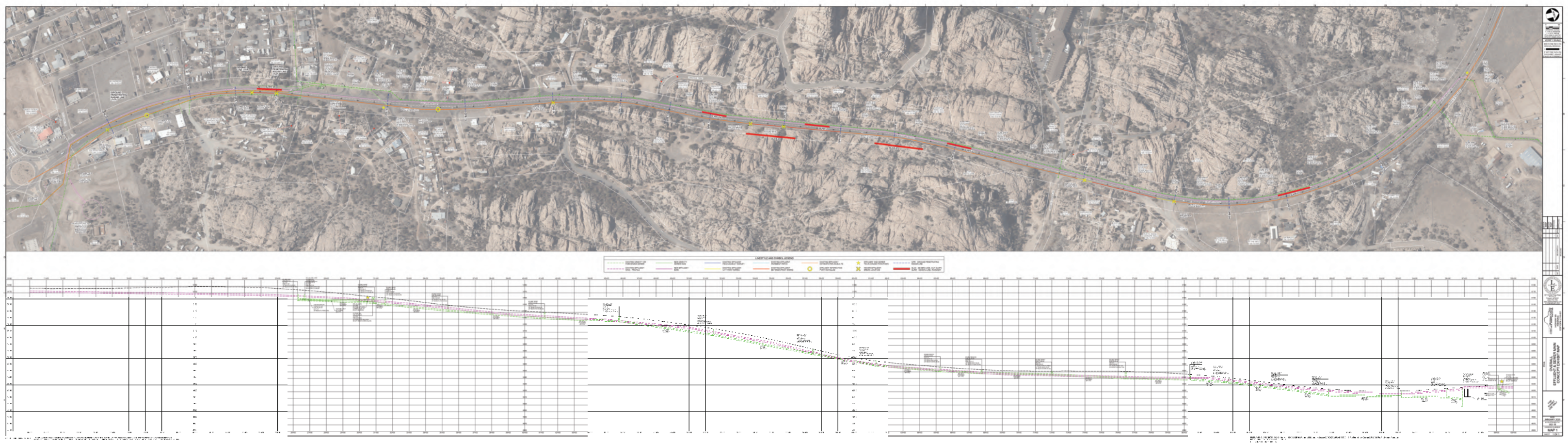
From the GPR profiles and observations of the rock condition, it is recommended that *at least 3 feet* of trench *wall* separation be maintained between the trenches for the existing sewer and the relocated effluent line. This will reduce the chance that the existing HOBAS sewer pipe could be adversely impacted during effluent line trenching by rock blocks dislocated by the trencher, loss of granular trench wall material by caving, or problems with trencher alignment.

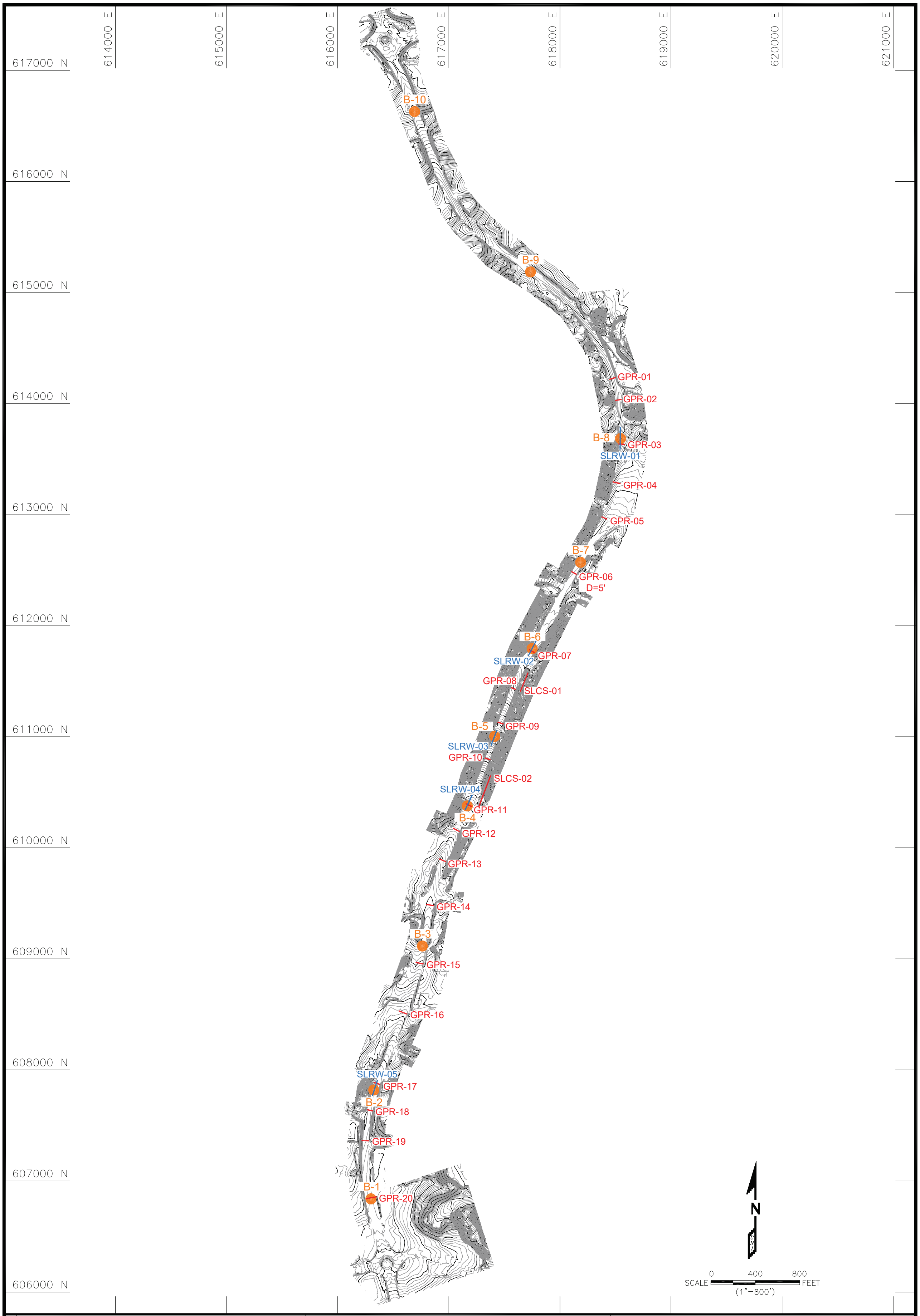
Presuming that the 24-inch-diameter sewer pipe installation has roughly 1 foot of pipe bedding all around, and the 24-inch effluent pipe will be similarly bedded, that would make *the minimum centerline separation 7 feet* for design purposes. Additional separation distance will provide further protection of the HOBAS pipe but possibly at the expense of tighter working space within which to manage material handling and traffic passage.

APPENDIX A

Investigation Locations

And Stationing Maps


LINESTYLE AND SYMBOL LEGEND
EXISTING GRAVITY OR FORCE MAIN SEWER
EXISTING EFFLUENT MAIN - PROFILE
NEW GRAVITY SEWER MAIN
NEW EFFLUENT MAIN
EXISTING EFFLUENT FIELD AS-BUILT SURVEY
EXISTING EFFLUENT CITY PAINT MARKS
EXISTING EFFLUENT PAVEMENT PATCH
EXISTING EFFLUENT BETWEEN PAINT MARKS
EXISTING EFFLUENT ESTIMATE PER AS-BUILTS
EFFLUENT INSPECTION PORT INSTALLED
EFFLUENT AND SEWER TIE-IN CONNECT POSITIONS
KNOWN EFFLUENT BREAK LOCATION
GPR - GROUND PENETRATING RADAR LINE
VERIFY SCALE
CITY of PRESCOTT
OVERALL EFFLUENT & SEWER MAIN CONCEPT EXHIBIT MAP
JANUARY 2025
MAP 1
1 OF 1



LEGEND

SLCS-01	SEISMIC LINE CUT SLOPE
SLRW-05	SEISMIC LINE ROADWAY
GPR-17	GROUND PENETRATING RADAR LINE
B-# ●	ETC BORE HOLE LOCATION

CALL & NICHOLAS, INC.
TUCSON, ARIZONA USA

DRAWN LMC
DATE 02/25
REVISED 6/10/2025 10:38 AM

\PROJECTS\CNI_CIVIL\24346 SR 89 DCR GRANITE DELLS\REPORTING\GEOTECH DCR\FIGURES\FIGXX_2025-02-07 GEOTECH EXP LOCATIONS.DWG

2025 GEOTECHNICAL EXPLORATION LOCATION MAP

SR89 ROADWAY IMPROVEMENTS

SCALE 1"=800'
MAP 2

APPENDIX B

ETC Bore Hole Logs

KEY TO SYMBOLS

Strata symbols

Symbol	Description
■	Asphaltic Concrete
⁙	Poorly graded sand with silt
▨	High plasticity clay
▨	Low plasticity clay
▫	Aggregate base material
▨	Clayey sand
▩	Weatherd rock
●	Poorly graded gravel with silt
⁙	Poorly graded sand
▥	Silty sand

Notes:

1. Exploratory borings were drilled using a 4-inch diameter continuous flight power auger.

2. Some water was encountered on the lower rock strata at the time of drilling.

3. Boring locations were estimated from existing site features.

4. These logs are subject to the limitations, conclusions, and recommendations in this report.

5. Results of tests conducted on samples recovered are reported on the logs.

LOG OF BORING NO. B-1

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──────┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	5.5" ASPHALTIC CONCRETE (incl. chip seal)	AC	■			
	2.75" ASPHALTIC CONCRET - Older/Weaker		■			
1	6" BASE COURSE MATERIAL, some granite pieces		■			
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM	⁙			
	Layers of Gravel/Cobble with Loose Pockets		⁙			
2			⁙			
3			⁙			
	SANDY CLAY, reddish-brown, very moist, Medium Stiff to Stiff	CH	▨			Mottled
4			▨			
	SANDY CLAY, dark brown, high PI, very moist to wet, Soft	CL	▨			
5			▨			
6			▨			
7			▨			

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-1

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

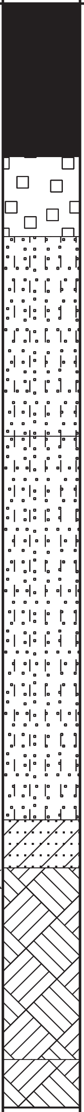
DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
			▨			
8			▨			
9	Moist, Stiff		▨			
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-2

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	6.75" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.75" ASPHALTIC CONCRETE - Older/weaker					
1	5" BASE COURSE MATERIAL	AB				
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM				
2						
	Some larger rock pieces & Loose to Medium Dense pockets					
3						
4						
	CLAYEY SAND, moist, med-high PI, high clay fines, Medium Dense	SC				"Decomposed Granite"
	GRANITE - Highly to Moderately Weathered, Dense	ROCK				
5						
	Lightly Weathered to Intact, Very Dense					ROCK REFUSAL
6	Auger Refusal on Intact Rock at 5.75 feet depth.					
7						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-5

LOG OF BORING NO. B-3

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements **PROJECT NO.:** 12825
CLIENT: Kimley-Horn & Assoc. **DATE:** 1-28-2025
LOCATION: See Boring Location Map **ELEVATION:** ---
DRILLER: ETC **LOGGED BY:** M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	3.5" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.5" ASPHALTIC CONCRETE - Older/weaker					
	3" ASPHALTIC CONCRETE - Very weak	SP-SM				Any AB Layer indistinct
1	SAND WITH SILT, damp, some gravel, Medium Dense					
2	With Gravel & Some Rock Pieces					
3						
	SANDY CLAY, very moist, Medium Stiff to Stiff	CH				Likely native
4						
5						
	Gravel/Cobble rock pieces					
6	CLAYEY SAND, brown, moist, high PI & clay fines, Medium Dense	SC				"Decomposed Granite"
7						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-3

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-28-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	Reddish-orange		▨			
8			▨			
9			▨			
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-4

ETC
ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS
Plastic Limit ├──┤ Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	6" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	SAND WITH SILT & GRAVEL, damp, Medium Dense	SP-SM				Any AB Layer indistinct
1						
2	Very low silty fines					
	GRANITE - Highly Weathered & Fractured, Medium Dense to Dense	ROCK				Possibly layers and/or weathered rock pieces
3						
4						
5	Moderate to Lighly Weathered, Very Dense					Thin water/moisture on rock stratum
6	Auger refusal in Weathered Granite at 6 feet depth.					ROCK REFUSAL
7						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-5

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS
Plastic Limit ├──┤ Liquid Limit
Water Content - ●
Penetration - ▨
10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	3.5" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.5" ASPHALTIC CONCRETE - Older/weaker					
	SAND WITH SILT, damp, some gravel & granite pieces, Medium Dense	SP-SM				Any AB Layer indistinct
2	Lyaer with increased Gravel					
3	GRAVEL WITH SAND, Dark brown,	GP-GM				Bituminous odor - Possible millings or pulverized road base
	SAND WITH GRAVEL, some Cobble, Medium Dense	SP				
6	GRANITE - Moderate to Lighly Weathered, Very Dense	ROCK				Thin water/moisture on rock stratum
7	Auger refusal on Intact Rock at 7 feet depth.					ROCK REFUSAL

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-6

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	7" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	2.5" ASPHALTIC CONCRETE - Older/weaker					
1	SAND WITH SILT, damp, some gravel & granite pieces, Medium Dense	SP-SM				Any AB Layer indistinct
2	Lyaer with increased Gravel					
3						
4						
5						
	GRANITE - Decomposed to Highly Weathered, moist, Dense	ROCK				Thin water/moisture on rock stratum
6						
7	Moderately Weathered, Dense to Very Dense					

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-6

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-27-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
8			▨			
9			▨			
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-7

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-28-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├───┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
0	2.75" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	4" ASPHALTIC CONCRETE - Older/ weaker					
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM				Any AB Layer indistinct
2.5	GRANITE - Highly Weathered, Medium Dense to Dense	ROCK				
3	Lightly Weathered, Very Dense					
4.5	Auger Refusal in very dense Weathered Granite at 4. 5 feet depth					ROCK REFUSAL

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Figure B-10 PAGE 1 of 1

LOG OF BORING NO. B-8

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	6.5" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	8" BASE COURSE MATERIAL, poor quality					
1						
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM				
2	Layer with Gravel/Cobble					
3	CLAYEY SAND, some gravel, med-high PI, Medium Dense	SC				
4						
	SANDY CLAY, greyish-brown, med-high PI, very moist, Medium Stiff to Stiff	CL				Some mottling
5						
6						
7	Stiff					

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-8

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-30-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
8	SANDY CLAY, brown, very moist, high PI, Stiff	CH	▨			
9	CLAYEY SAND, reddish-orange, med-high PI, Medium Dense to Dense	SC	▨			"Decomposed Granite"
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-9

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
	4.75" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	4" ASPHALTIC CONCRETE - Older/weaker					
	5.75" BASE COURSE MATERIAL	AB				
1						
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM				
2						
	Layer with increased/coarser gravel					
3						
	CLAYEY SAND, orangish, damp, low fines, Medium Dense	SC				
4	Medium to high clay fines & PI					
5	CLAYEY SAND WITH GRAVEL, damp-moist, Medium Dense to Dense	SC				"Decomposed Granite"
6	GRANITE - Decomposed to Highly Weathered, Dense	ROCK				
7						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-9

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
8			▨			
9			▨			
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-10

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

TEST RESULTS: Plastic Limit ├──┤ Liquid Limit; Water Content - ●; Penetration - ▨; 10 20 30 40 50

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS	Remarks
	2.5" ASPHALTIC CONCRETE (incl. chip seal)	AC				
	6" ASPHALTIC CONCRETE - Older/ weaker					
1	6" BASE COURSE MATERIAL	AB				
	SAND WITH SILT, damp, some gravel, Medium Dense	SP-SM				
2	Layer with increased gravel					
	Moist					
3	SANDY CLAY	CL				
	SILTY SAND WITH GRAVEL, moist, Medium Dense	SM				
4	CLAYEY SAND, damp-moist, low-med PI, Medium Dense	SC				"Decomposed Granite"
5	CLAYEY SAND, brown, moist, high PI, high clayey fines, Medium Dense	SC				
6	Orangish					
7						

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

LOG OF BORING NO. B-10

ENGINEERING & TESTING CONSULTANTS, INC.

PROJECT: SR89 Pipeline Improvements
PROJECT NO.: 12825
CLIENT: Kimley-Horn & Assoc.
DATE: 1-29-2025
LOCATION: See Boring Location Map
ELEVATION: ---
DRILLER: ETC
LOGGED BY: M. Wilson
DRILLING METHOD: Continuous flight auger

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

DEPTH (feet)	Description	GROUP SYMBOL	SOIL TYPE	SAMPLERS	TEST RESULTS Plastic Limit ├──┤ Liquid Limit Water Content - ● Penetration - ▨ 10 20 30 40 50	Remarks
8			▨			
9			▨			
	Boring terminated at 9.5 feet depth.					
10						
11						
12						
13						
14						
15						

APPENDIX C

Seismic Survey Report

From Hasbrouck Geophysics, Inc.

TABLE OF CONTENTS

FIGURES

DATA USED TO CONSTRUCT CROSS-SECTIONS

INTRODUCTION

Two-dimensional (2D) surface refraction seismic tomography and surface-wave seismic surveys were conducted on seven lines along portions of State Route 89 (SR89) within and near the Dells in Prescott, Arizona. The surveys are part of a pipeline improvements project.

METHODOLOGY

Surface refraction seismic tomography surveys essentially consist of recording seismic waves that have been generated by artificial sources, observing the arrival times of these waves, and producing cross-sections of variations in subsurface seismic wave velocities that can then be related to geology. For surface-wave seismic surveys the fundamental property utilized is dispersion or the change in seismic phase velocity (defined as the seismic velocity of any given phase, such as a trough or peak) with frequency. Shear-wave seismic velocities are calculated by mathematical inversion of the dispersive phase velocity of surface-waves. The source of seismic energy for relatively shallow surface surveys is generally either a sledgehammer or weight-drop system, primarily dependent upon target depths and logistics.

In surface surveys the seismic waves are detected by geophones that consist of a coil suspended by a spring with magnets build into the case. A seismic wave moves the case and the magnets while the coil remains relatively stationary because of its inertia. The relative movement of the magnetic field with respect to the coil generates a voltage across the coil with the voltage proportional to the relative velocity of the coil to the magnets. The electrical voltages produced by the geophones are transmitted back to a seismograph via cables.

DATA ACQUISITION

Surface seismic data were acquired in a manner suitable for 2D tomographic and surface-wave analyses by Bird Seismic Services, Inc., Globe, Arizona. The data were acquired with a *Seistronix EX-6* signal-enhancement seismograph in 32-bit floating-point format with 1,600 samples per channel, 0.25 millisecond (ms) sample interval, and 200 milliseconds record length. The refraction seismic tomographic data were acquired with 10-Hz geophones, while the surface-wave data were acquired with 4.5-Hz geophones (the lower frequency geophones are necessary for broadband surface-wave data, while the higher frequency geophones generally provide sharper first arrivals of seismic energy). The seismic source was a 200-pound accelerated weight-drop or 10-pound slide hammer depending upon logistics. Geophones were located at intervals of three feet for the tomographic data with source points between geophones every nine feet, while for the surface-wave surveys the geophone interval was initially the same as for the tomographic survey but after in-field analyses of the data it was decided that geophone and source point intervals of 15 feet resulted in essentially the same quality data so the expanded geophone array was used for the remainder of the survey.

The seismic data were stacked nominally three to five times at each source point to increase the signal-to-noise ratio. Stacking, or signal enhancement, involved repeated source impacts at the same point into the same set of geophones. For each source point, the stacked data were recorded into the same seismic data file and theoretically the seismic signals arrived at the same time from each impact and thus were enhanced, while noise was random and tended to be reduced or canceled.

DATA PROCESSING

Seismic tomography is defined as a method for finding the seismic velocity distribution within the subsurface from a multitude of observations using combinations of source and receiver locations. The subsurface is divided into cells and the seismic data are expressed as line integrals along raypaths through the cells. A velocity is assigned to each cell and traveltimes are calculated by tracing rays through the model. The results are compared with observed times, the model is modified, and then the process is repeated iteratively to minimize errors.

The seismic tomography data for this project were processed using the *Rayfract* (version 4.05) computer software program developed by Intelligent Resources Inc. of Vancouver, BC, Canada. The models produced by the *Rayfract* tomography program use multiple signal propagation paths (e.g., refraction, reflection, transmission and diffusion) that comprise a first break. For the seismic tomography processing, the first arrival of seismic energy at each geophone is chosen as the first significant variation from a somewhat straight line. These arrivals or traveltimes are then modeled and iteratively compared with the original times. The modeling for this project consists the WET (wavepath eikonal traveltime) smooth inversion method with an initial gradient velocity input model. The WET method automatically adjusts the subsurface velocity model until the synthetic times optimally match the first arrival times and delivers continuous depth versus velocity profiles for all geophones. The modeled traveltimes are then used in the tomographic calculations to determine the subsurface seismic velocity distribution. Resulting depth cross-sections (seismic velocity versus depth) are initially produced from the *Rayfract* program using Golden Software's *Surfer* (version 28.4.300) computer program and subsequently with the Tecplot Focus (version 2024 R1) computer program for display in two- and three-dimensions.

The multi-channel analysis of surface-waves (MASW) method measures the dispersion or change in phase velocities of surface waves generated by multiple source points along a spread of geophones. Different seismic wavelengths, or frequencies, penetrate to different depths with longer wavelength, or lower frequency, surface-waves penetrating deeper than shorter wavelength, or higher frequency, surface-waves. These different wavelengths, and associated variations in penetration depths, propagate with different velocities. By analyzing the dispersion of surface-waves, a shear-wave (Vs) velocity profile is obtained.

The surface-wave data for this project were processed with the *SeisImager/SW-2D* set of computer programs from Geometrics using multi-channel active source data. The programs consist of *Pickwin* and *WaveEq*. Using *Pickwin* the data are input, the source-geophone geometries are established, and dispersion curves are determined and edited as appropriate. The dispersion curves are then input into *WaveEq* and initial and inverted models are constructed. The resulting inverted model, or back-calculated shear-wave velocities from the dispersion curves, are then converted and output in ASCII format. The resulting depth section is produced using Golden Software's *Surfer* (version 28.4.300) computer program and subsequently with the Tecplot Focus (version 2024 R1) computer program for display in two- and three-dimensions.

RESULTS

With surface seismic tomography a full representation of the subsurface velocities is obtained and first breaks can be from refractions, reflections, transmissions or diffusions and thus, to a certain extent, velocity inversions can be mapped. Surface seismic tomography results are generally considered to present a more geologically representative view of the subsurface than other shallow refraction seismic methods (e.g., delay-time). Changes in topography over short distances (e.g., ravines, hilltops, etc.) can adversely affect the quality of the model through erroneous raypaths. Lines SLRW-01 to SLRW-05 are essentially flat or gently sloping so there are no adverse topographic effects along those line and although there are some topographic changes along lines SLCS-01 and SLCS-02 there did not appear to be any adverse effects. Also, rock faces near the seismic lines can produce interfering sound wave noise (sound waves traveling at approximately 1,100 feet per second) although because of the relatively short lines in the survey and fast P-wave seismic velocities, the effects on the refracted first arrivals of seismic energy are considered essentially non-existent in this survey.

Overall, the surface seismic tomography data and results for this project are considered excellent. P-wave refraction seismic tomography cross-sections are presented in both two- and three-dimensions in this report with similar velocities and depths for each cross-section. Also included are the data used to construct the cross-sections. Note that for some of the lines there are data deeper than the cut-off of 30 feet in the cross-sections, but those deeper results are not considered appropriate for use.

Surface-waves are best generated over flat or gently sloping ground, while variable topography can interfere with surface-wave propagation. Also, rock faces near the seismic lines can produce interfering sound wave noise and, different from the P-wave tomography data, because of the relatively short lines in the survey, slower shear-wave seismic velocities and seismic waves of interest beyond first arrivals, the surface waves can be adversely affected by the sound wave noise. Variably dense and/or thick asphaltic concrete and base course material in addition to little sedimentary material above weathered granite may also adversely affect surface waves. An optional approach to generate shear-waves is by using horizontal geophones and a source struck perpendicular and horizontal to the axis of a seismic line. However, because of the slower shear-wave velocities, possibly more sound wave noise because the source is struck perpendicular to the nearby presence of rock faces, variably dense and/or thick asphaltic concrete and base course material, and logistics particularly on the cut-slope lines, the optional approach is not considered more feasible than the surface-wave approach used in the survey.

Because of the adverse effects described above, the MASW shear-wave data are considered poor and the results should be used with caution. MASW shear-wave cross-sections are presented in both two- and three-dimensions in this report with similar depths but different velocities because of variable seismic velocities. Note that MASW shear-wave results for lines SLRW-03, SLRW-04, SLRW-05 and SLCS-01 are shorter than acquired in the field because of anomalously low seismic velocities, like those seen for line SLRW-01 where there are question marks, and thus portions of those lines are deleted. Also included are the data used to construct the cross-sections. Note that for some of the lines there are data deeper than the cut-off of 30 feet in the cross-sections, but those deeper results are not considered appropriate for use.

LIMITATIONS OF INVESTIGATION

This survey was conducted with state-of-the-art instrumentation by experienced field personnel and the data were processed by an experienced and licensed geophysicist using commercial software packages utilized on projects with similar objectives. However, no warranty, expressed or implied, is made as to the results and professional advice included within this report.

The findings of this report are valid as of the present date. However, changes in the conditions of a property can and do occur with the passage of time, whether they be due to natural processes or the work of people on this or adjacent properties. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside of our control. Therefore, this report is subject to review and revision as changed conditions are identified.

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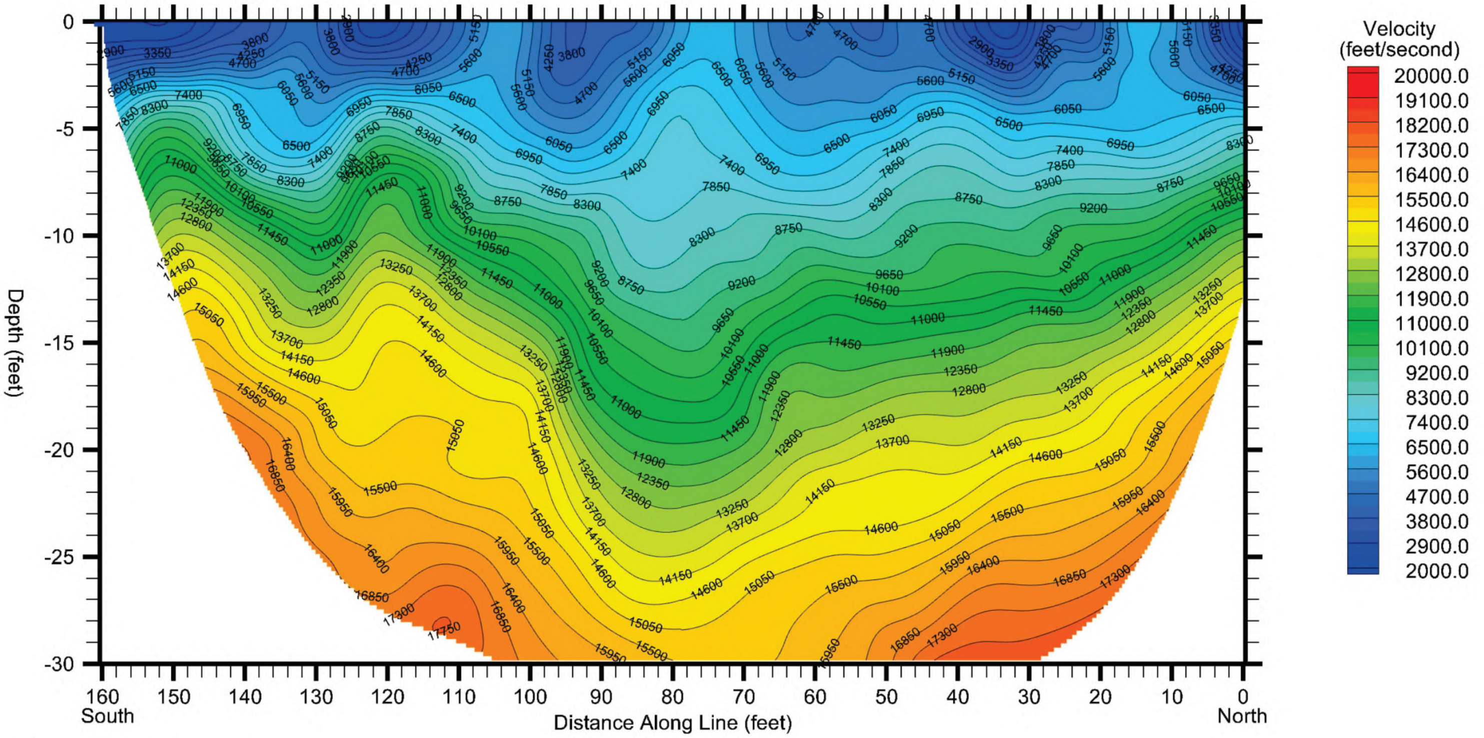
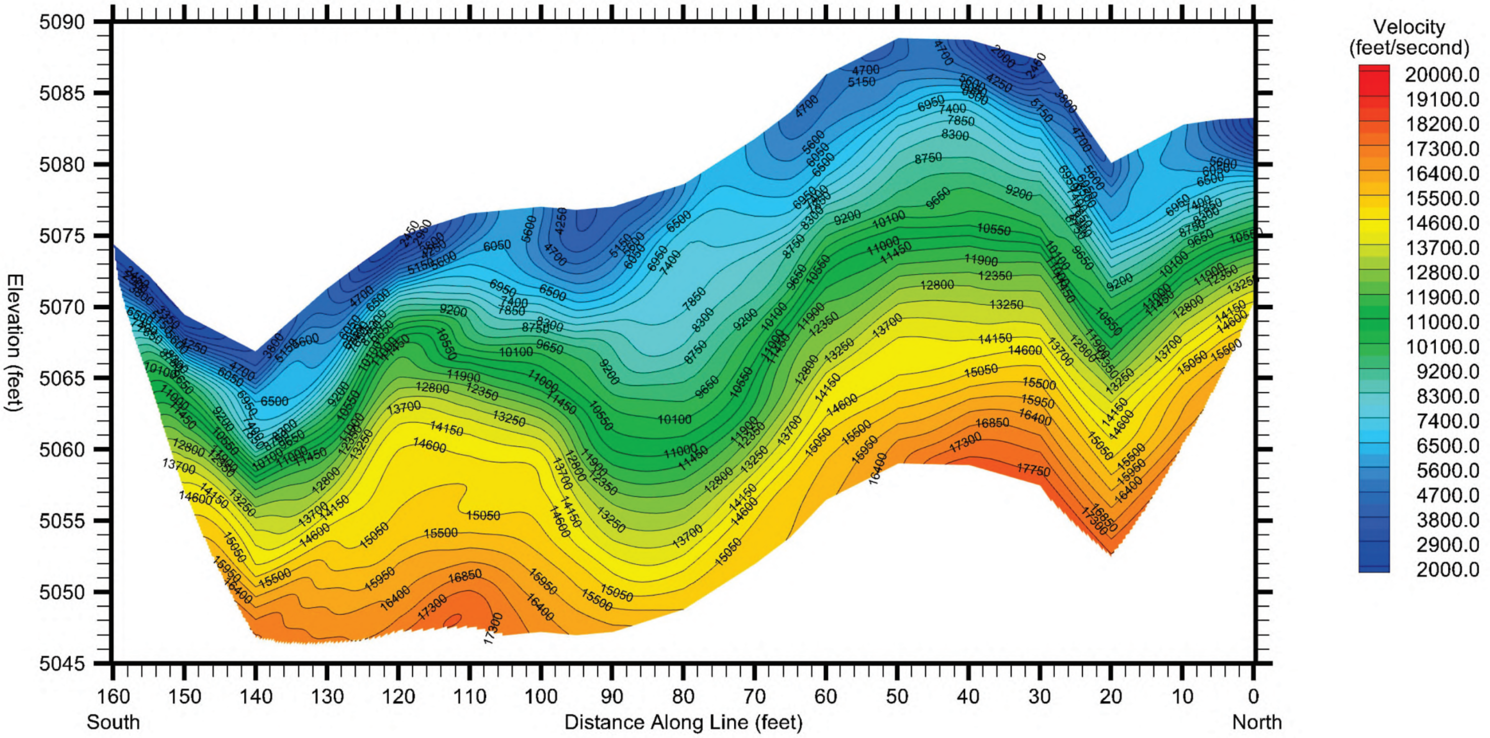
P-Wave Refraction Seismic Tomography Survey
Line SLCS-01 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

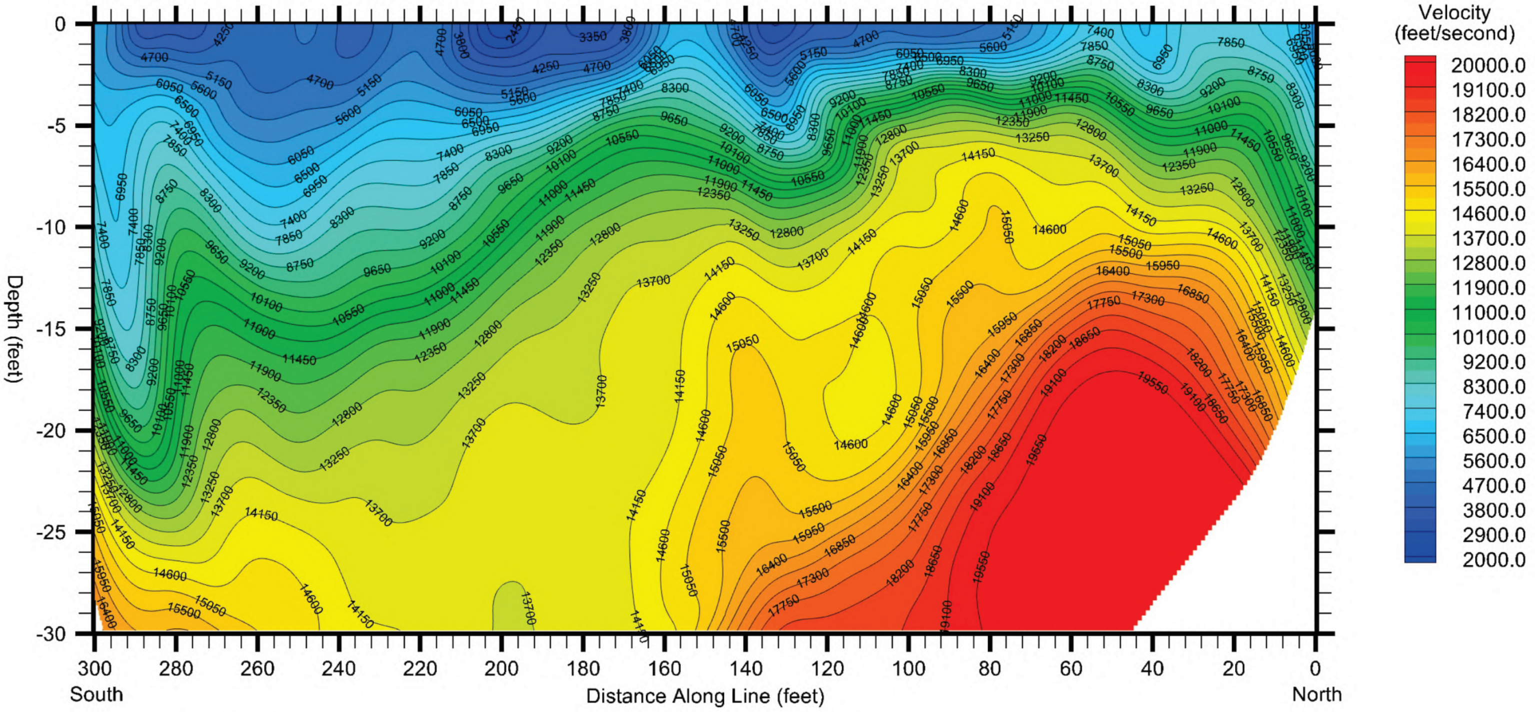
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-01 2D Elevation Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2

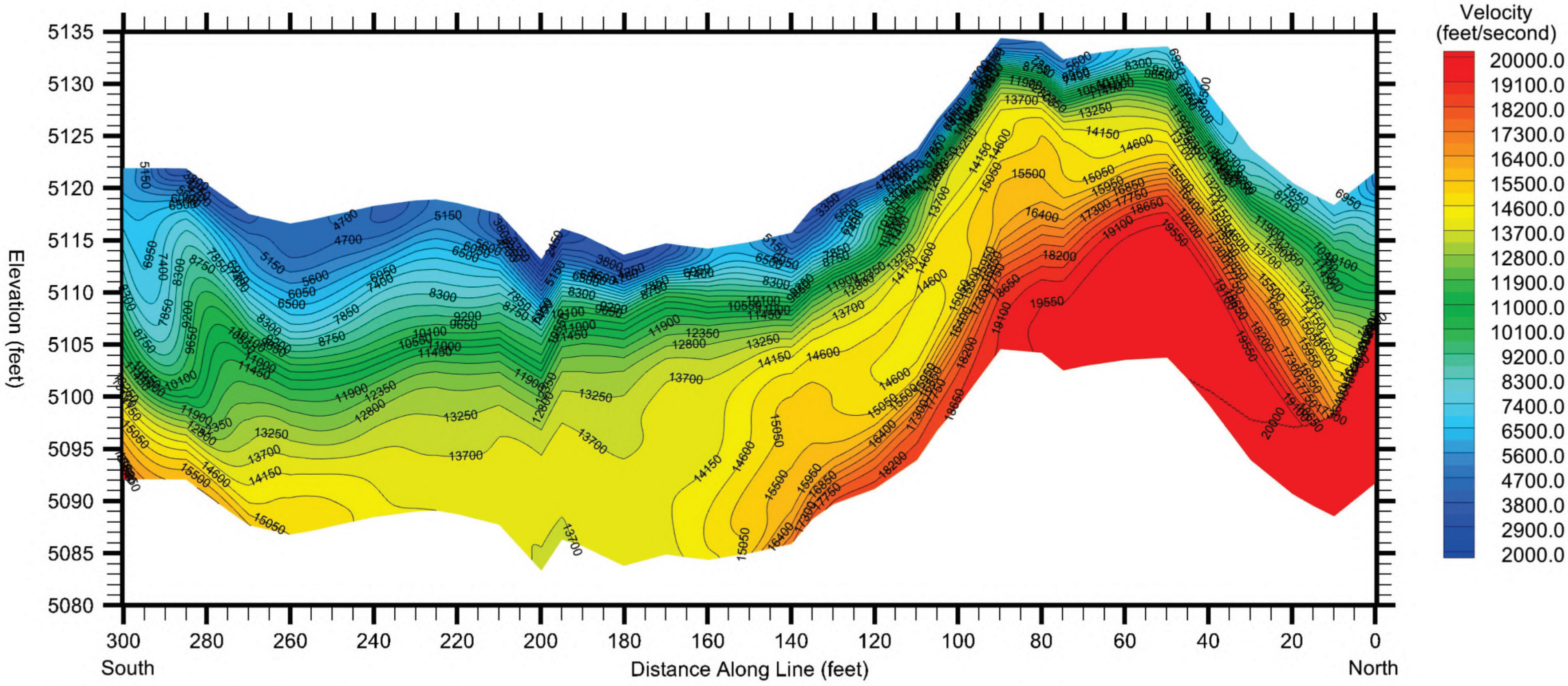
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-02 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 5

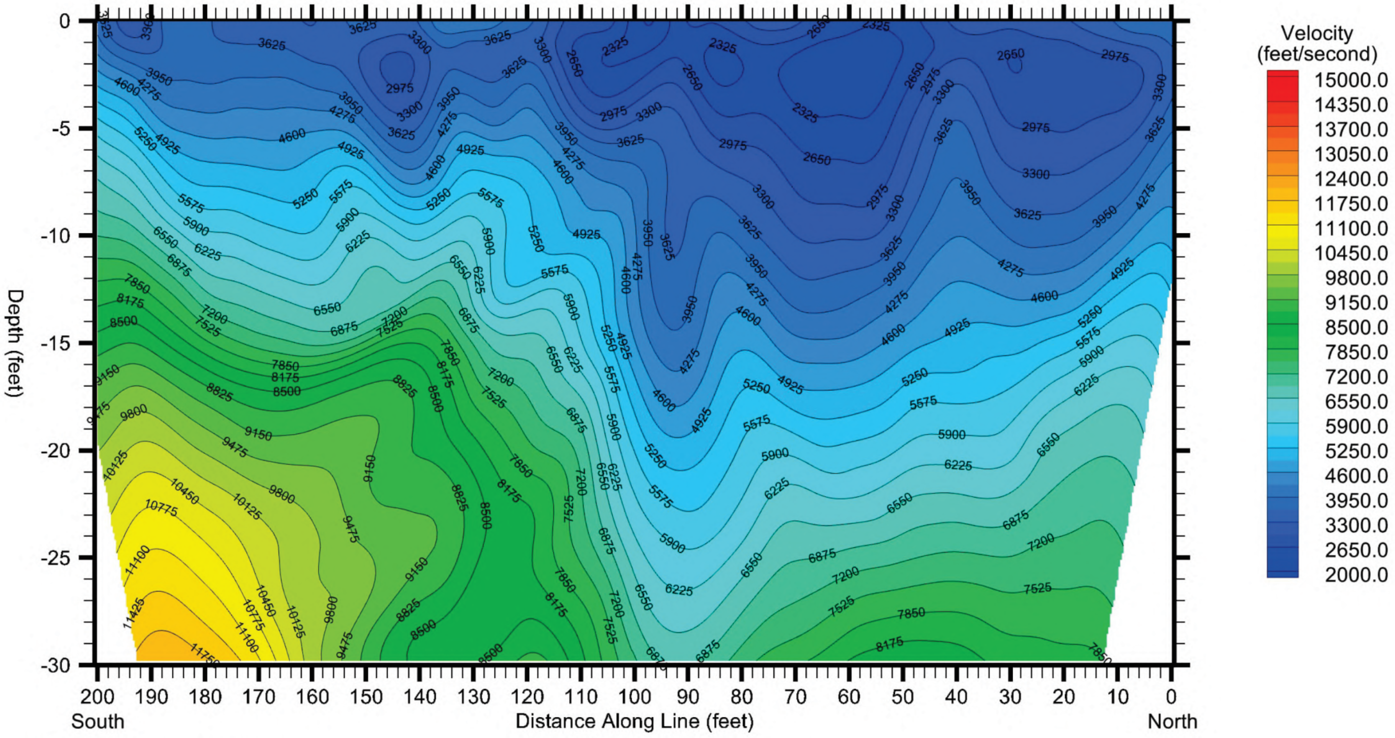
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-02 2D Elevation Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2.5

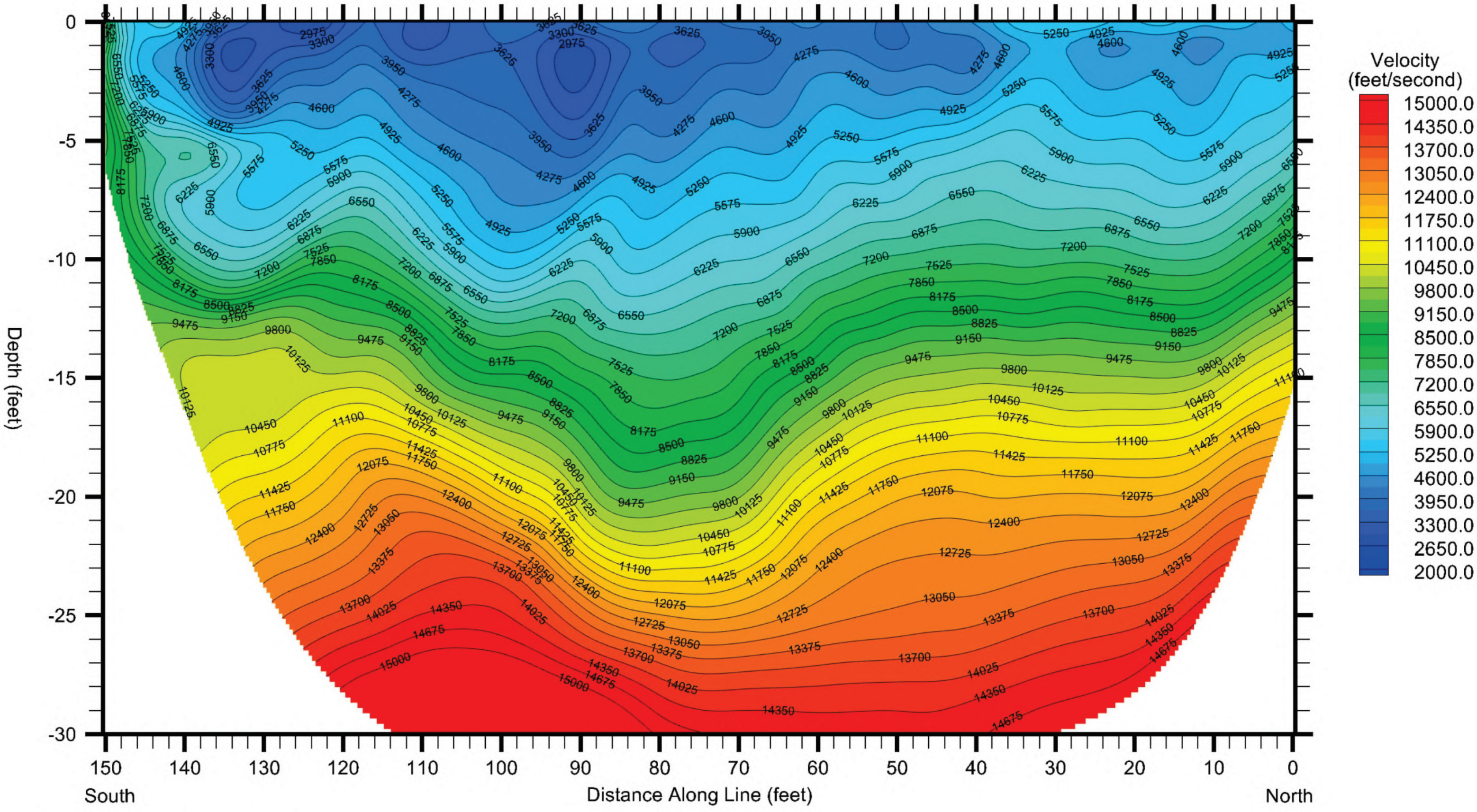
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-01 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 4

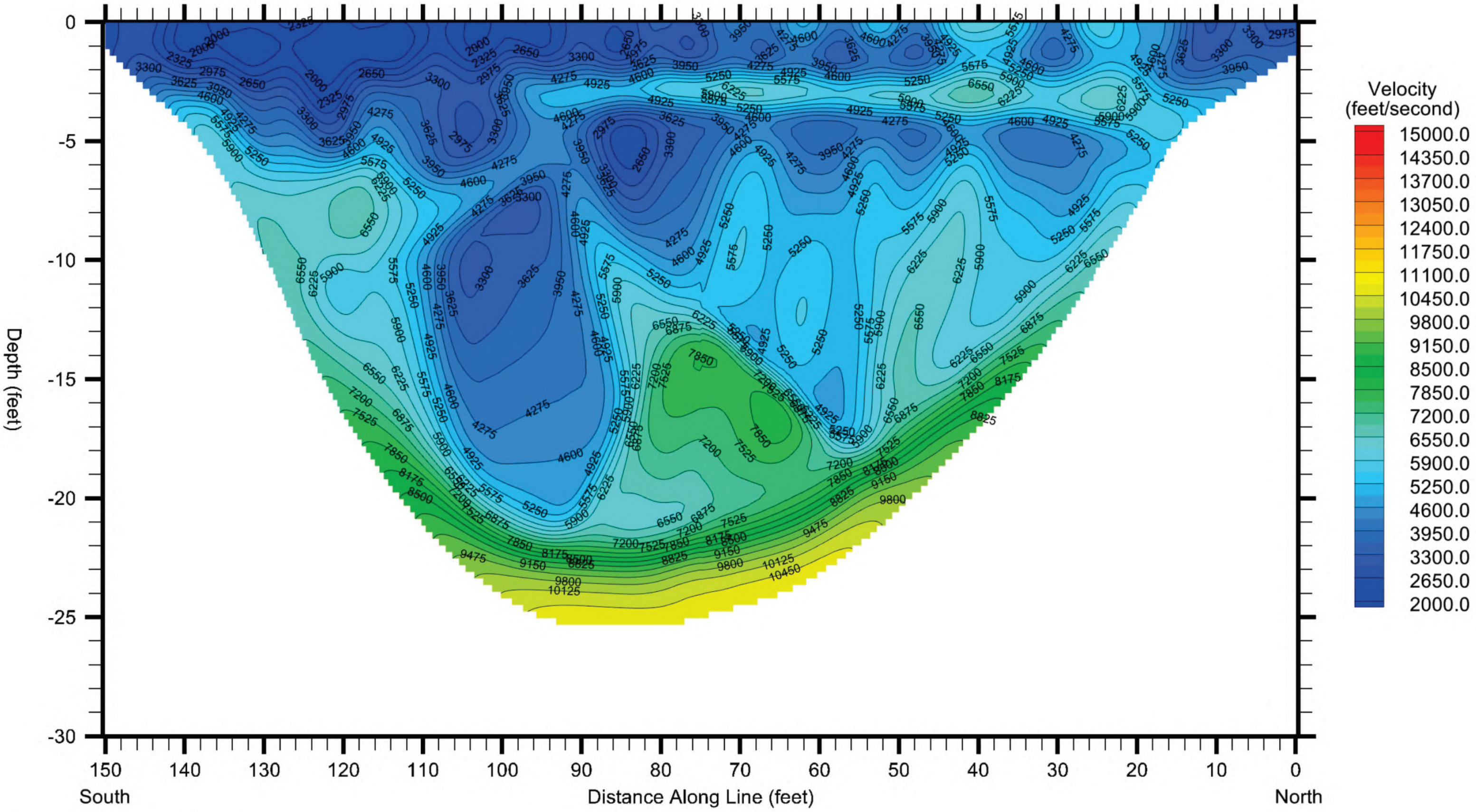
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-02 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

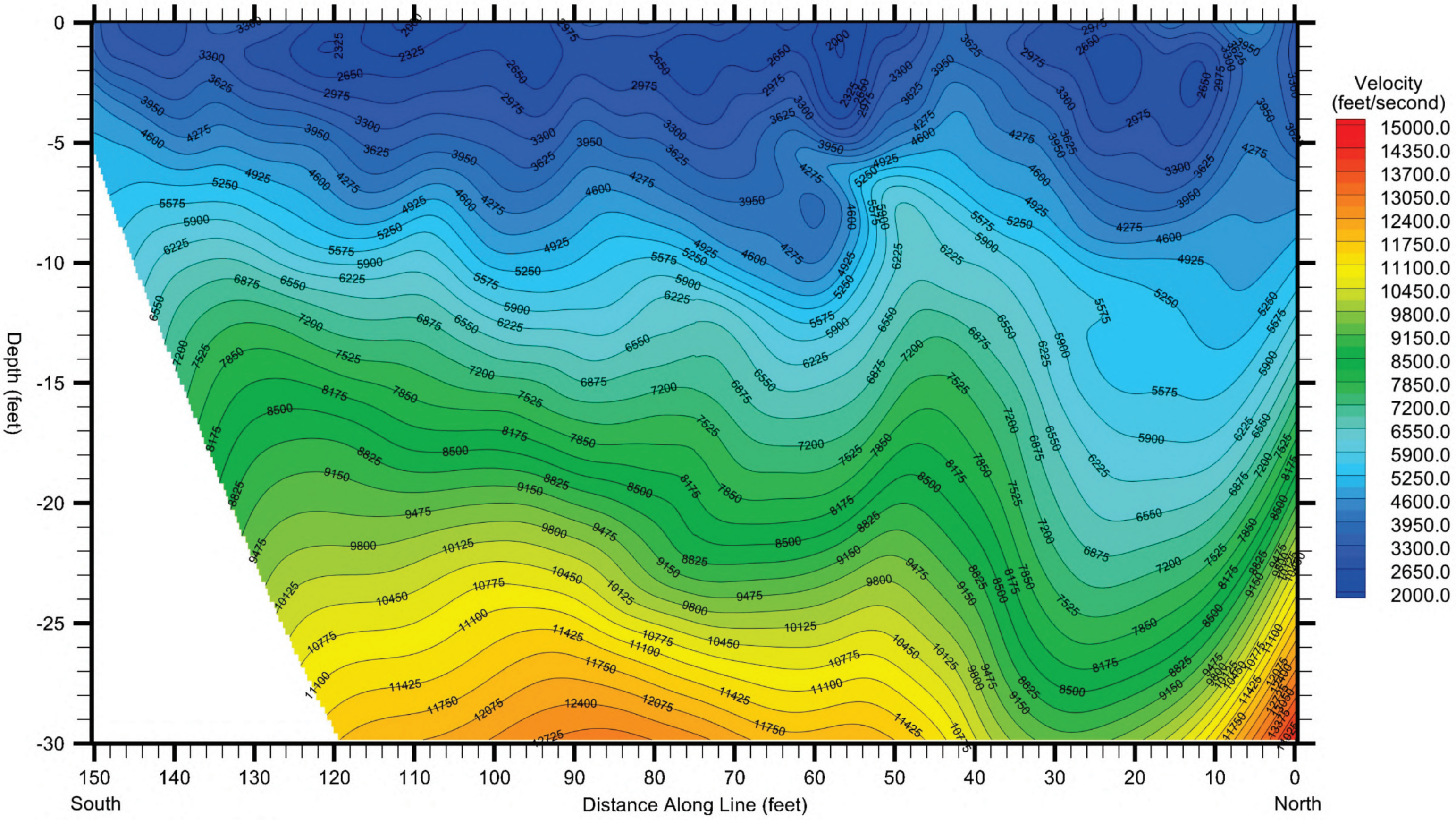
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-03 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

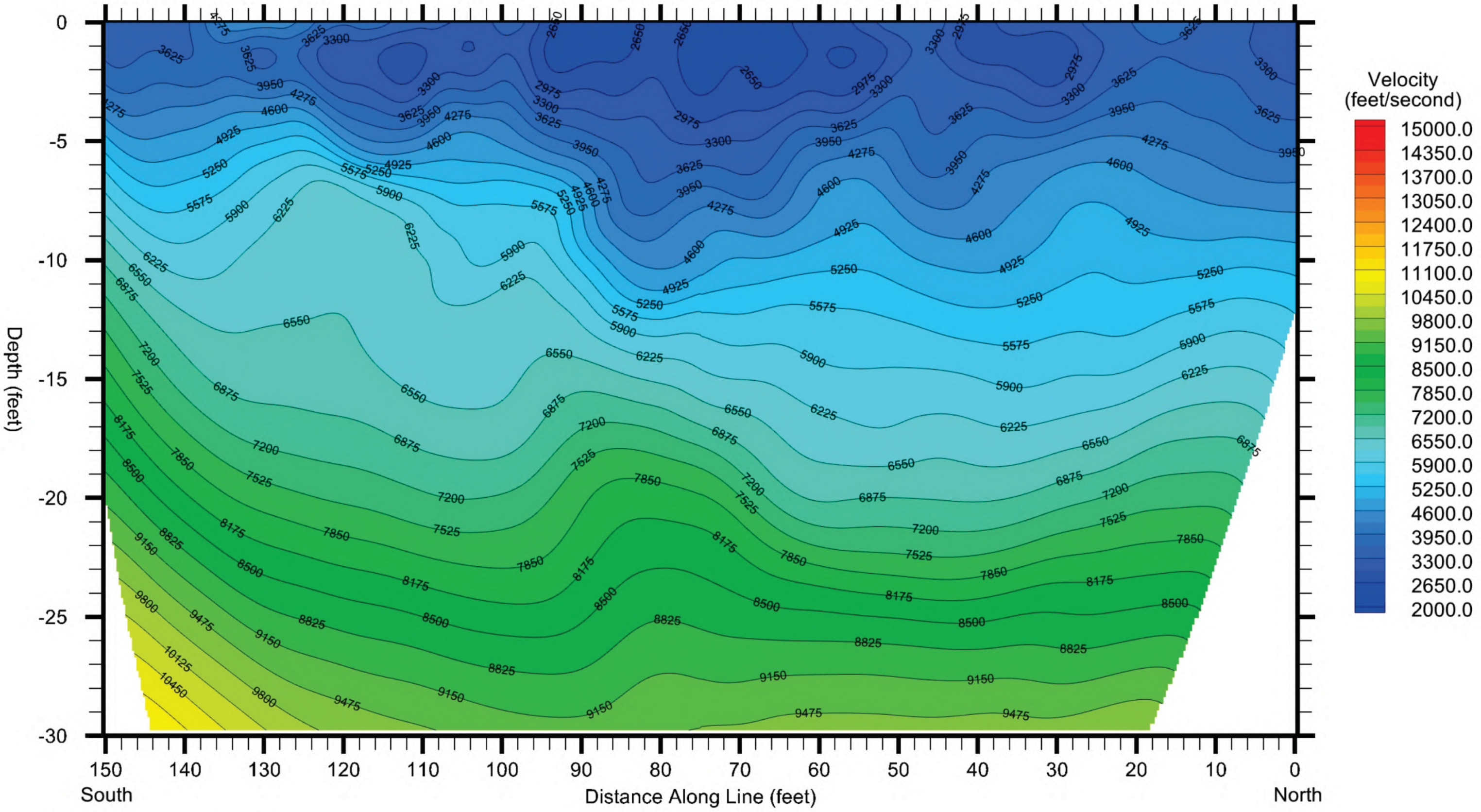
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-04 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

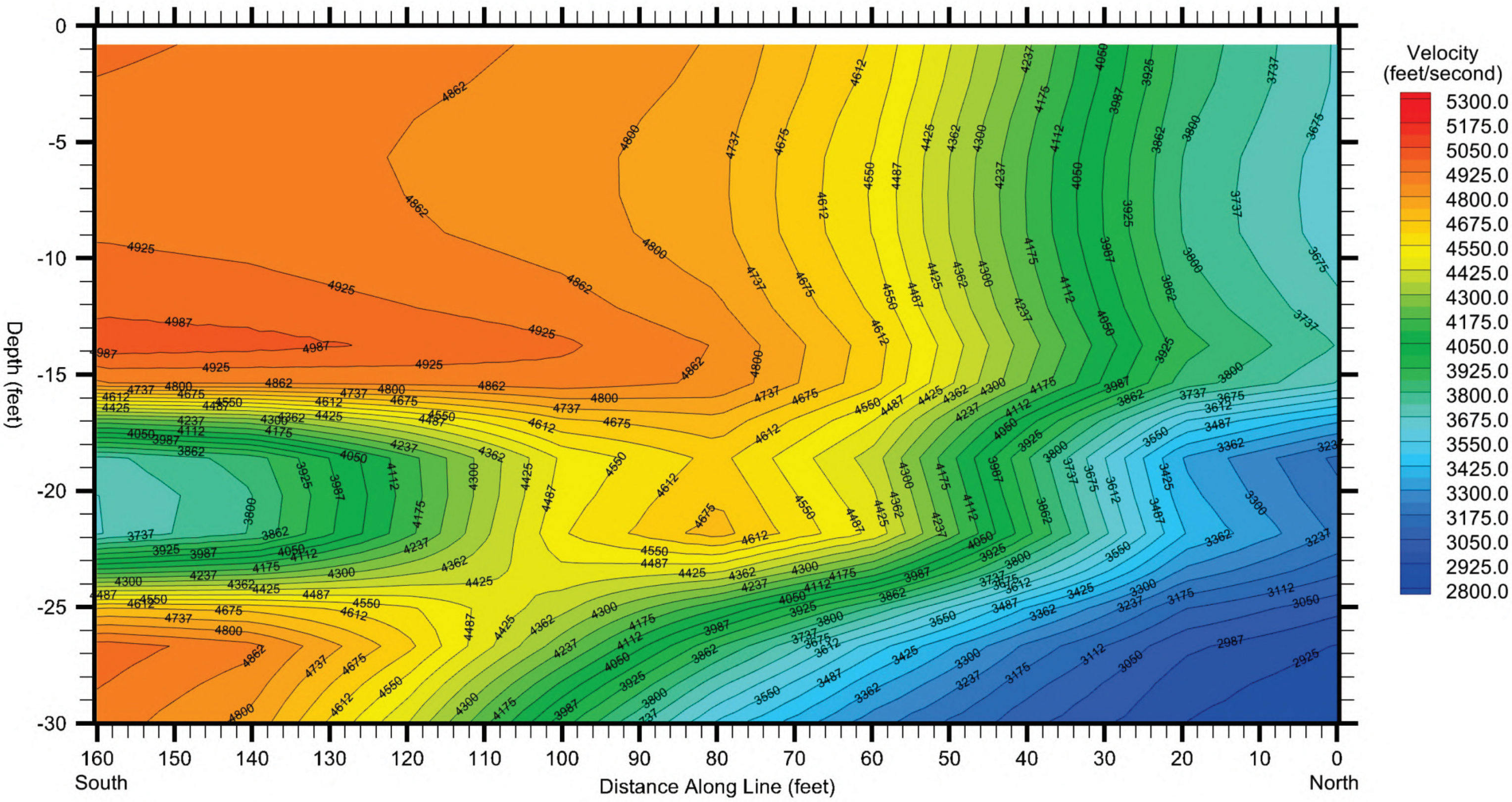
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-05 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-01 2D Cross-Section

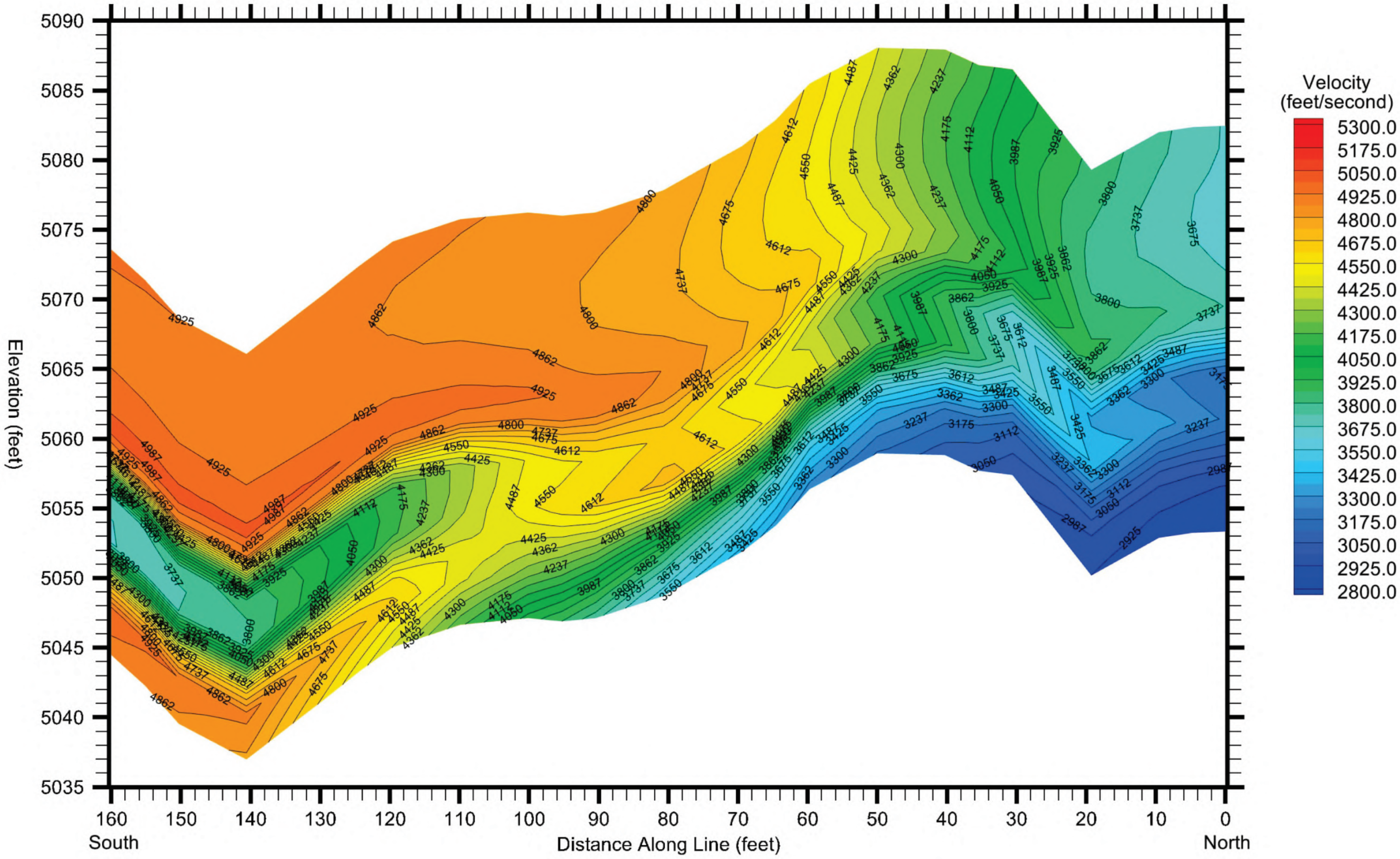


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

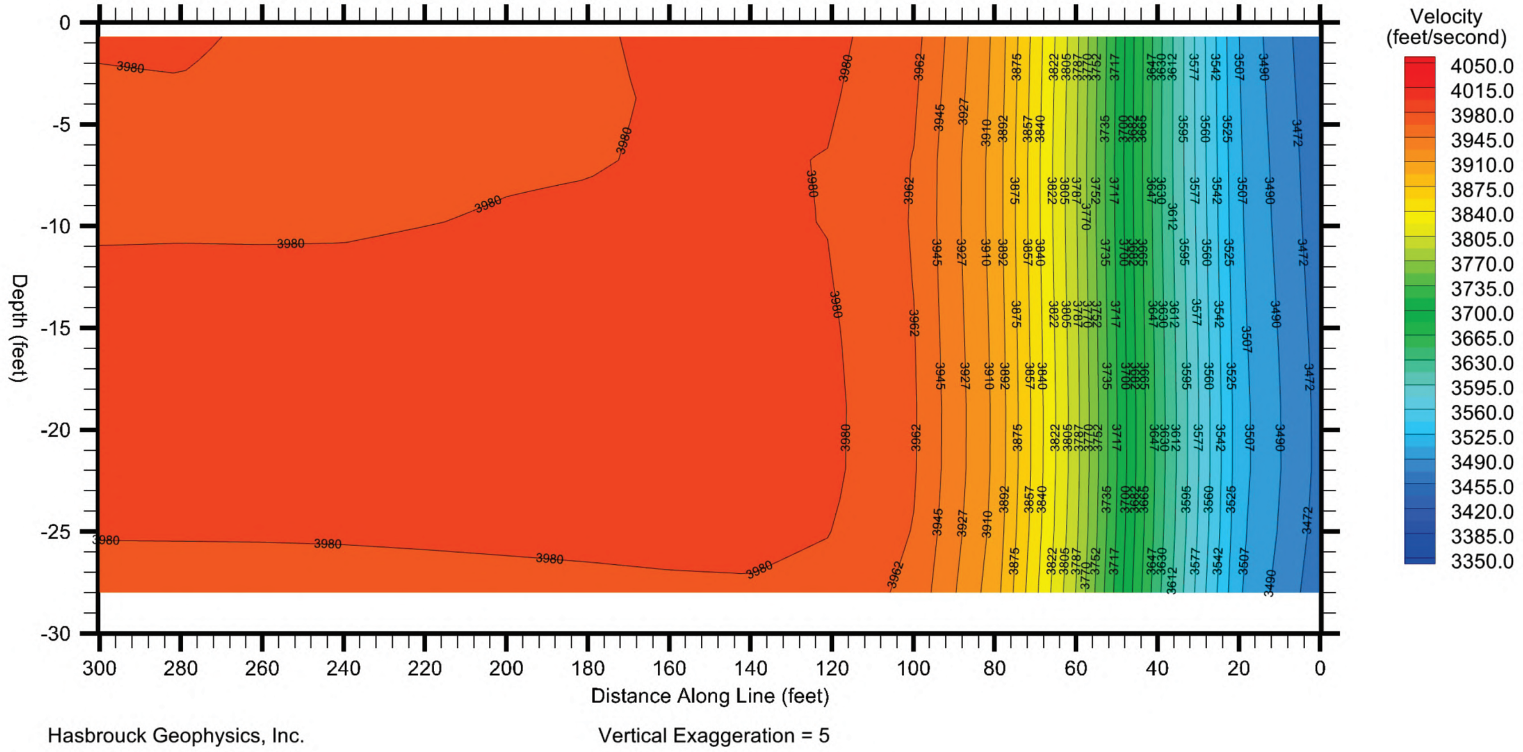
SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-01 2D Elevation Cross-Section



Vertical Exaggeration = 2

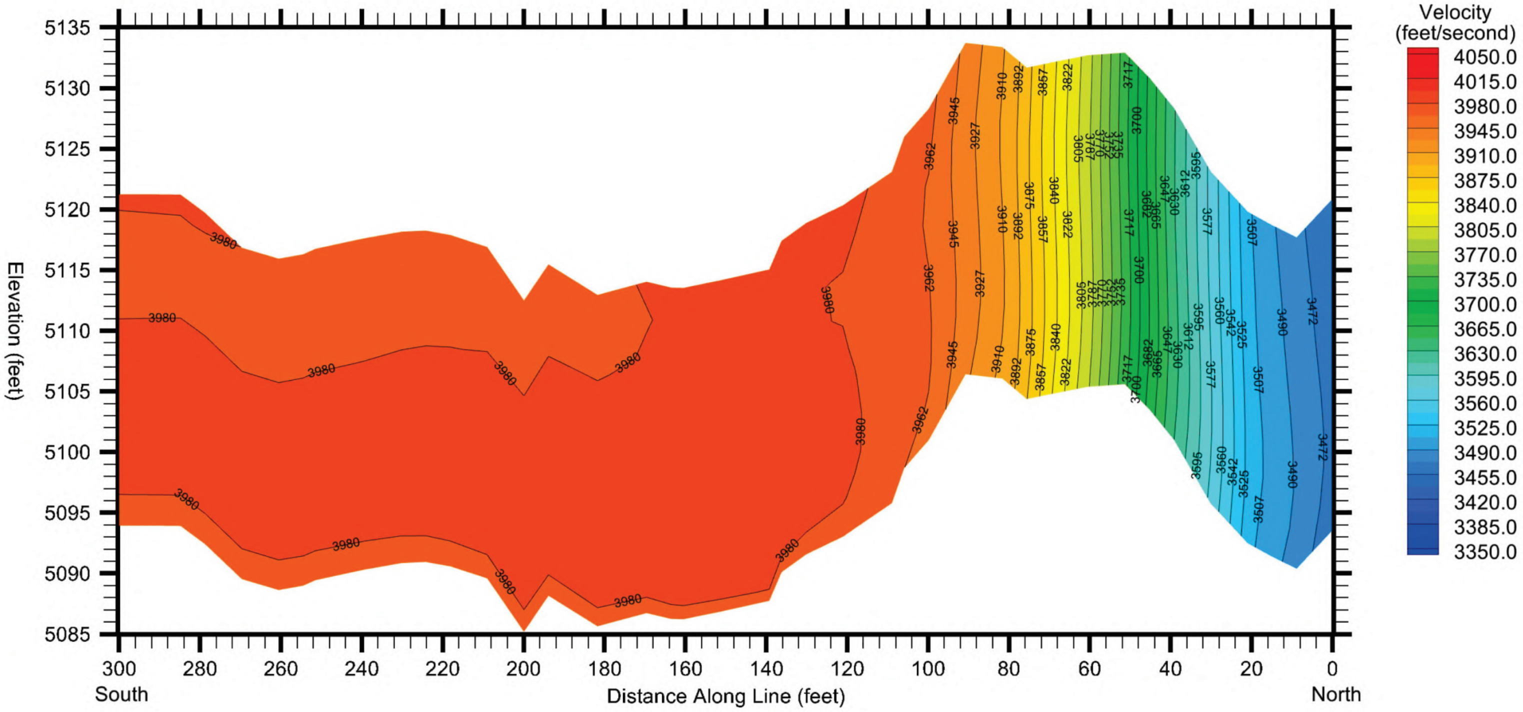
Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-02 2D Cross-Section



Use results with extreme caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-02 2D Elevation Cross-Section

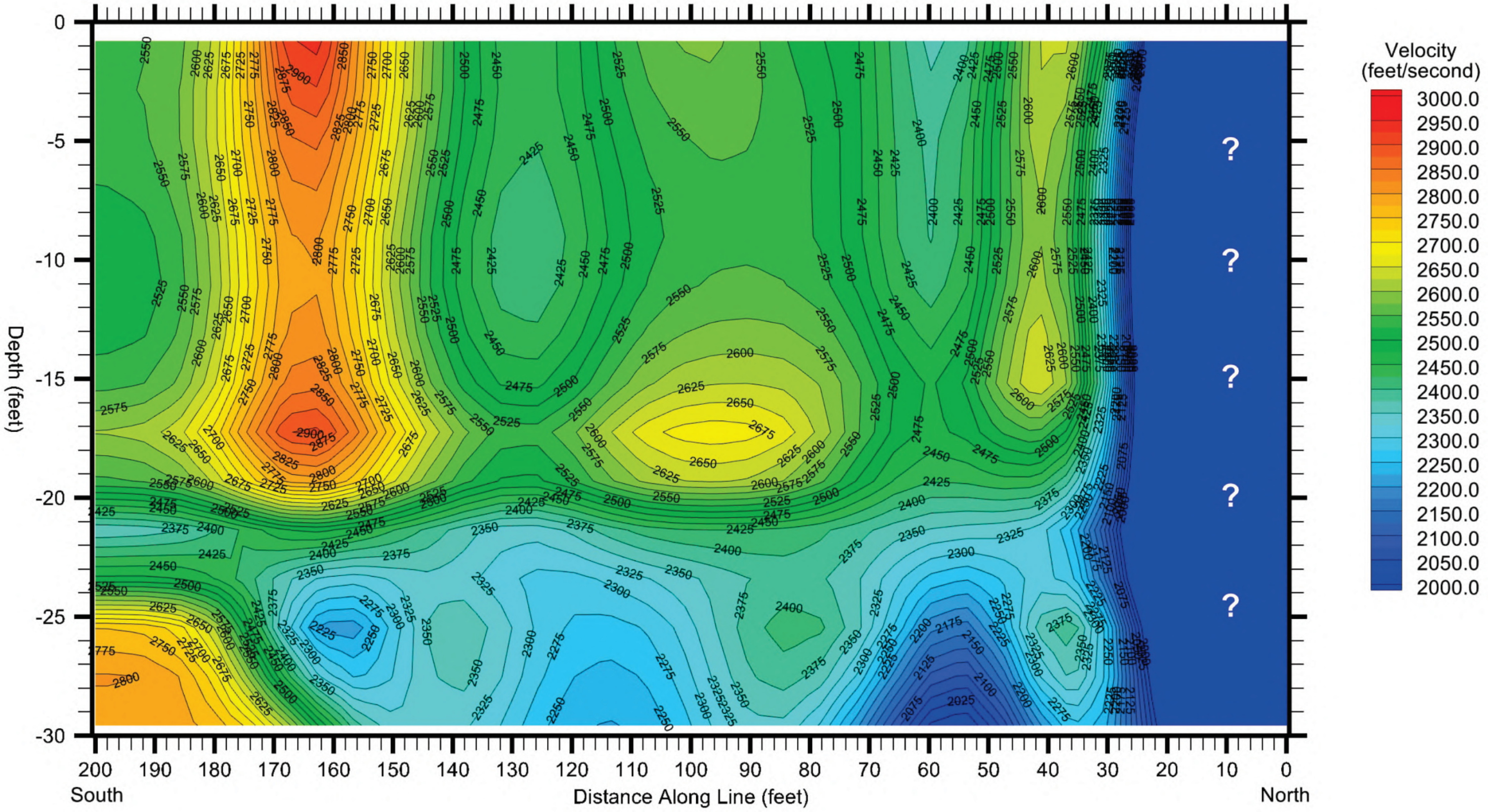


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with extreme caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-01 2D Cross-Section

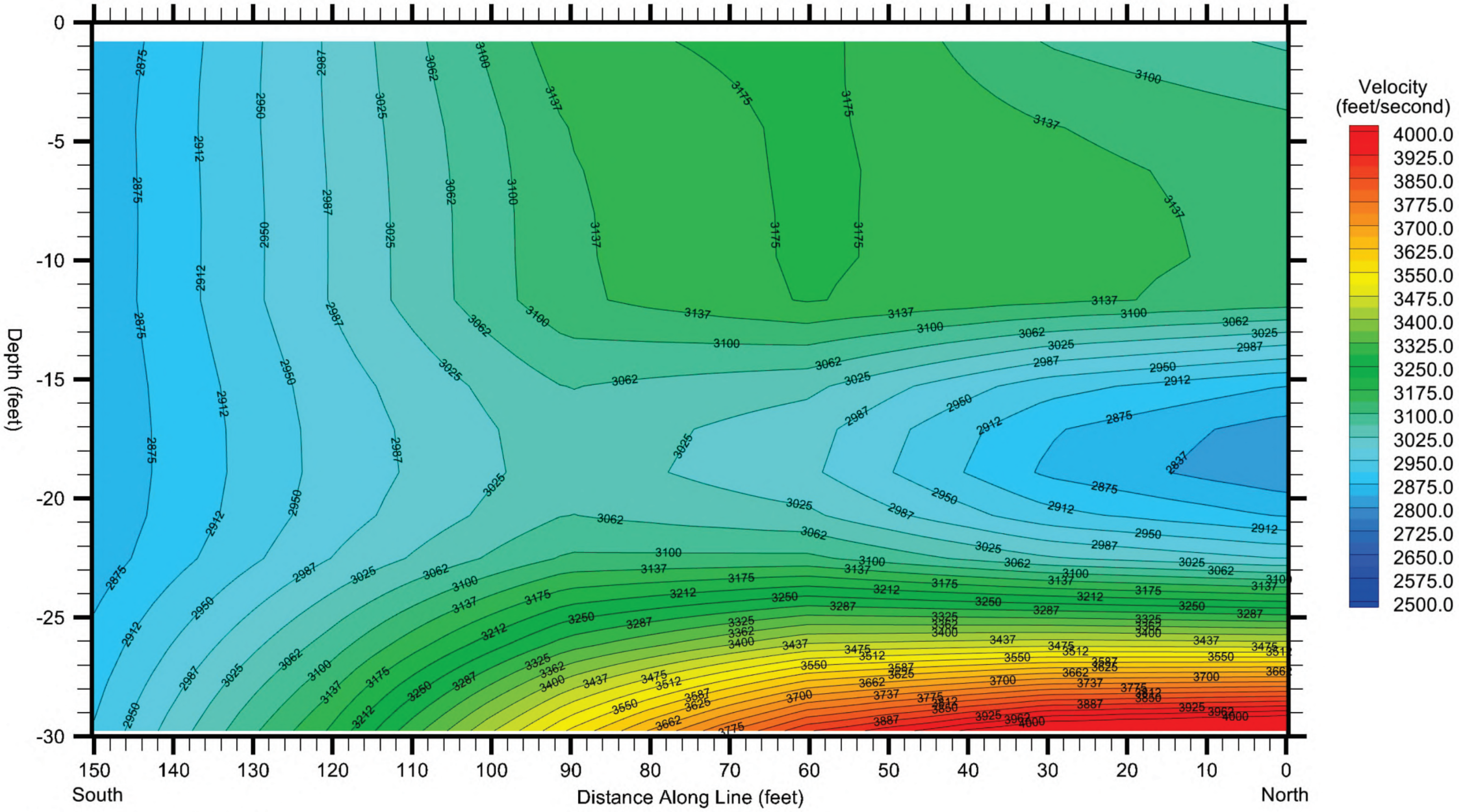


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 4

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-02 2D Cross-Section

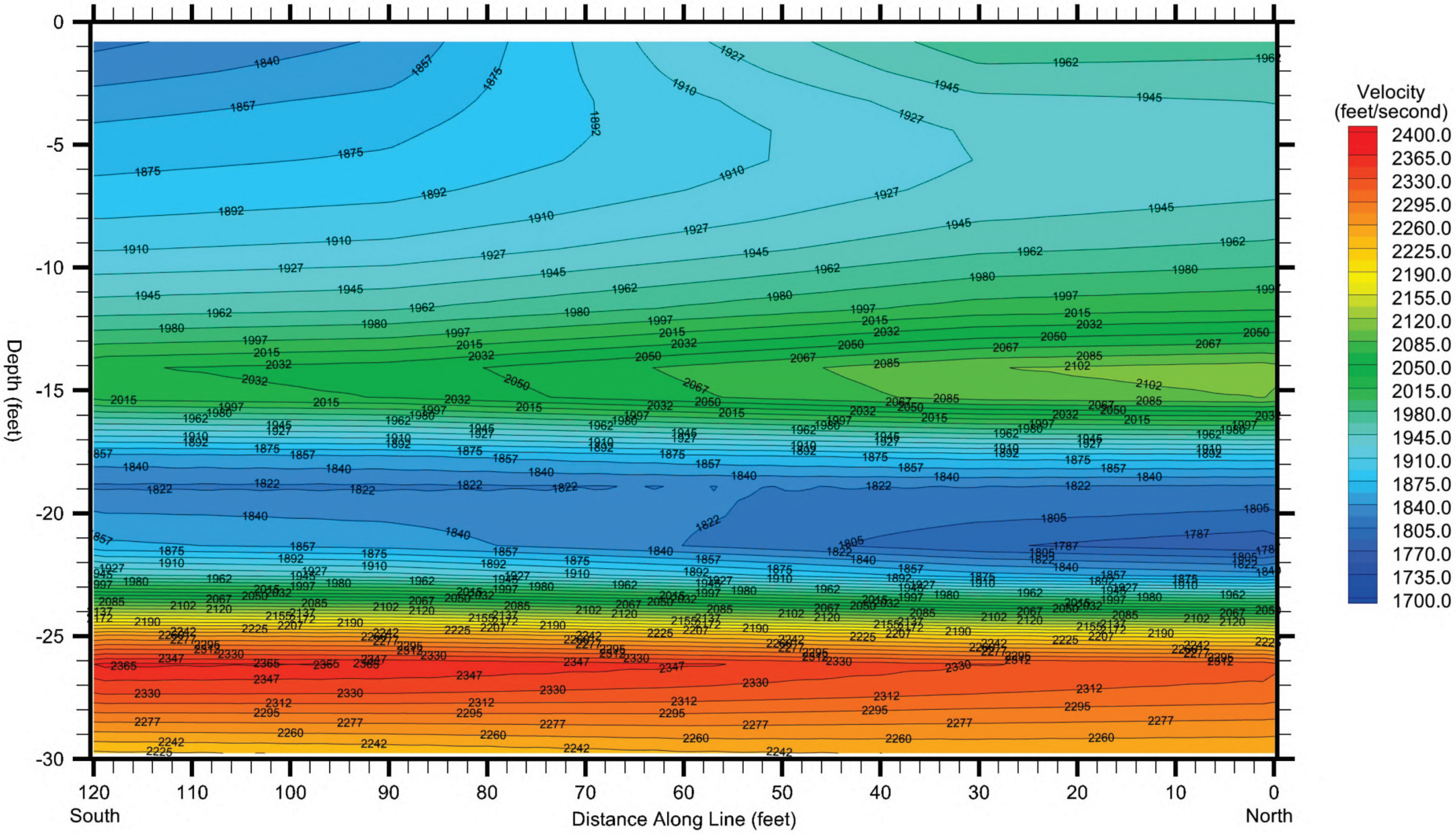


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-03 2D Cross-Section

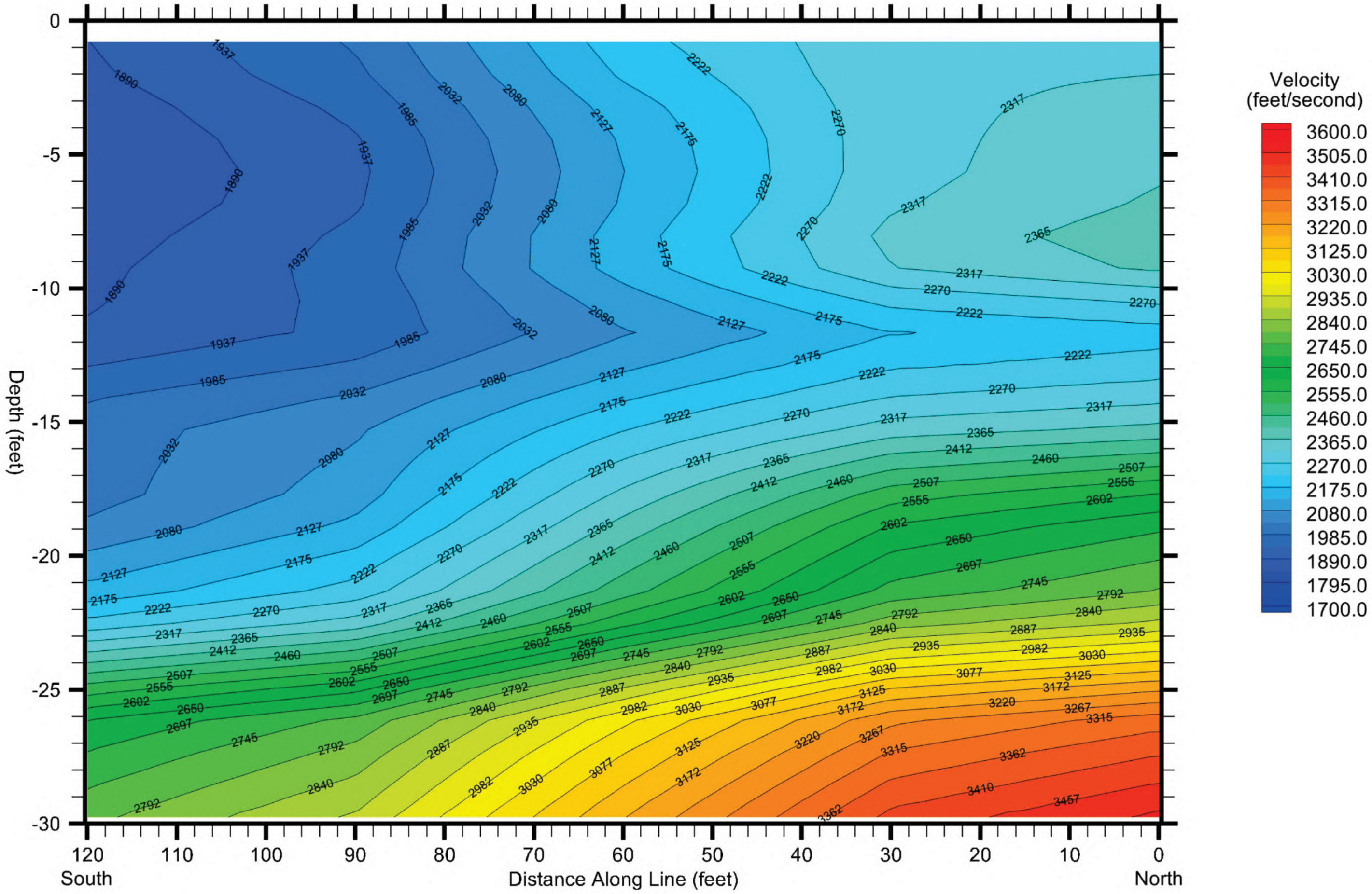


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2.5

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-04 2D Cross-Section

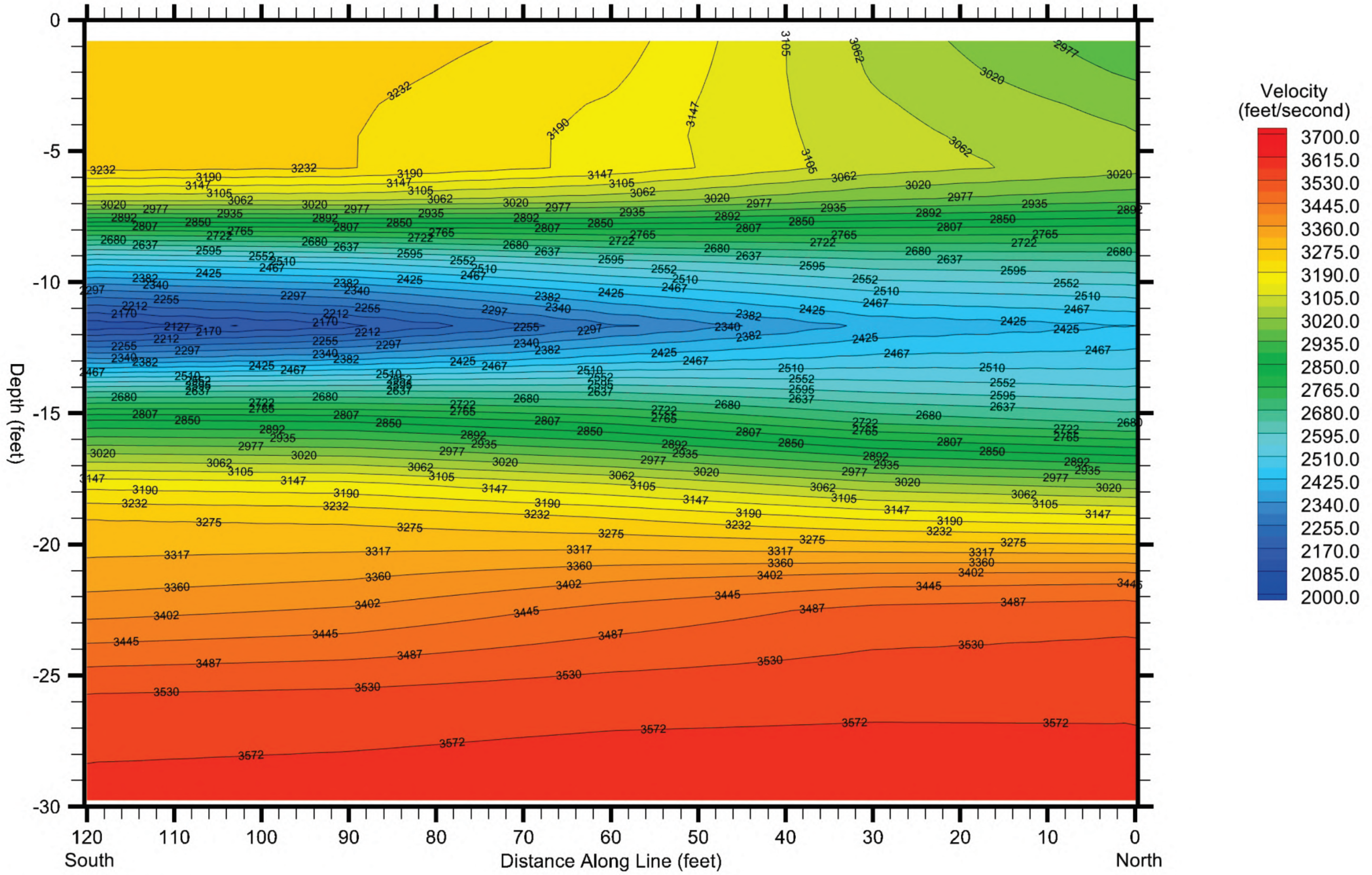


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-05 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

APPENDIX D

Ground Penetrating Radar Survey Report

From Collier Geophysics

COLLIER
GEOPHYSICS
Locate · Delineate · Characterize

February 19, 2025

Attn: Ken Bernstein
ken@birdseismic.com
928-719-1848

Bird Seismic Services
661 S. Broad St.
Globe, AZ. 85501

RE: Prescott Highway 89 GPR Investigation
Prescott, AZ

Collier Geophysics (Collier) is pleased to present this memorandum describing the work and results of geophysical investigations on Highway 89 in Prescott, AZ. At the request of Bird Seismic Services (Client), Collier completed a total of 45 GPR scans along 20 transects on Highway 89 to locate: 1) 24" steel effluent pipeline on the east side of the section, 2) 24" HOBAS fiberglass sewer line on the west side of the section, 3) The associated excavation boundaries for the above; and 4) Fill/Bedrock contact if possible. Data collection took place on January 28th. During the investigation, the on-site Collier Geophysicist marked locations on the road where utilities were identifiable in the field. The ground-penetrating radar (GPR) system used for this project was the Impulse Radar Crossover CO1760, equipped with dual-frequency 170 MHz and 600 MHz antennas.

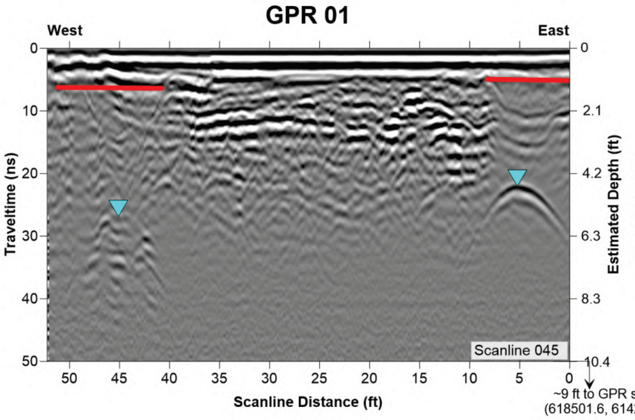
The GPR data analysis was conducted using 600 MHz profiles, providing enhanced near-surface resolution for assessing the extent of the trenches. While GPR successfully detected steel pipes, it was unable to directly identify fiberglass pipe, and there was insufficient evidence from the scanlines to determine bedrock depth. It should be noted that fiberglass is transparent to GPR. The edges of the two trenches occasionally extended beyond the ends of the GPR scanlines. Additionally, scanlines 011, 012, and 015 experienced data recording malfunctions and were excluded from the final analysis. Trench extents were identified by locating a continuous horizontal layer at approximately 2.1 feet below ground surface (bgs) and noting the breaks in or absence of this horizon. Using the boring logs provided by Call & Nicholas Inc., the sand and silt layer located beneath the asphaltic concrete was interpreted as the continuous horizontal layer seen around 2.1ft bgs on the GPR scanlines. Further indicators of prior excavation activity included V-shaped attenuated zones on the east and west sides.

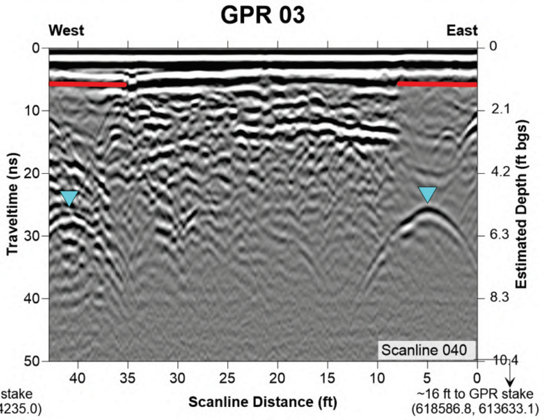
As shown in Figure A-1, potential pipes or utilities were detected on the eastern side of the scanline at an approximate depth of 4.5 feet bgs, associated with a trench extending about 10 feet in width. Another trench was identified on the western side of the scanline, measuring approximately 15 feet in width with a bottom depth of around 8 feet bgs. Due to varying site conditions, some scanlines were unable to capture both trenches simultaneously and detect a bottom reflector within the trenches. All estimated depths are based on a GPR-wave velocity of 0.417 ft/ns (0.127 m/ns), specifically calculated for this site.

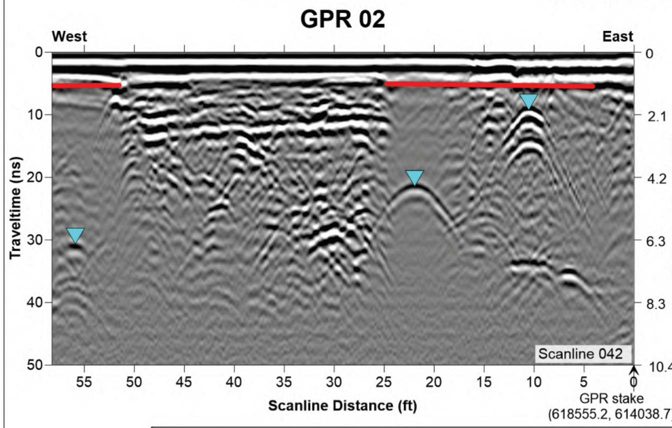
Respectfully Submitted,
Collier Consulting Inc.

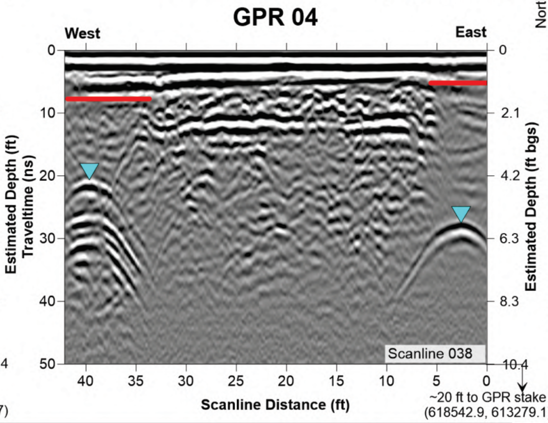
Dawn M. Lipfert
Dawn Lipfert
Geophysicist

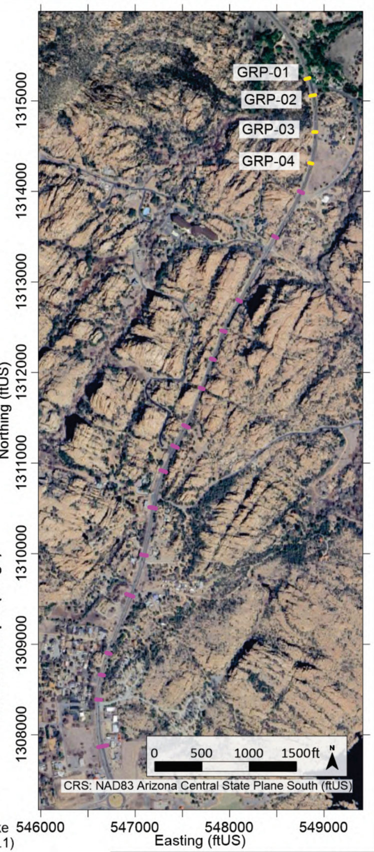
Jim Pfeiffer
Jim Pfeiffer, P.Gp., P.G.
Senior Geophysicist











Scanline Key

- 🟥 Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative 0 Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- 🟪 Collected GPR Scanline
- 🟨 Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

Bird Seismic Services

Project #: 250025

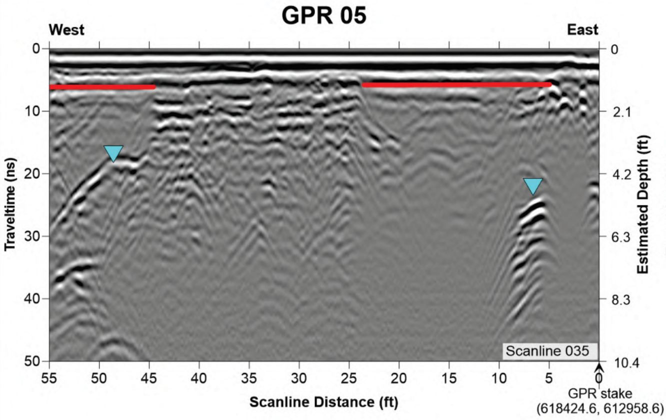
May 2025

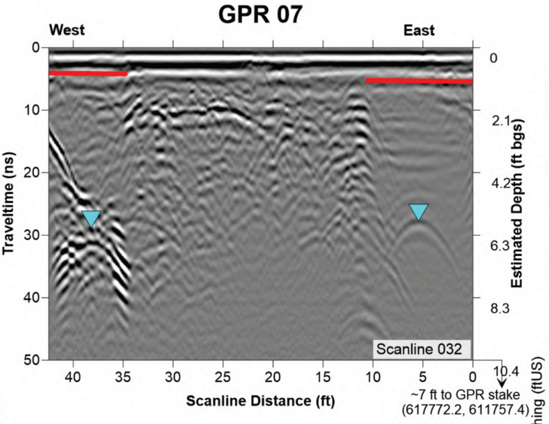
COLLIER GEOPHYSICS

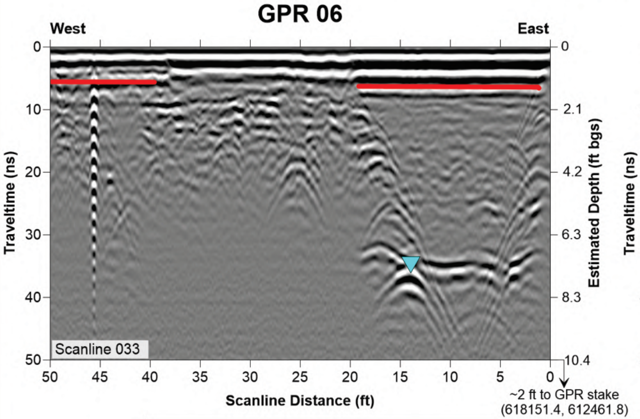
Drafted by: D. Lipfert

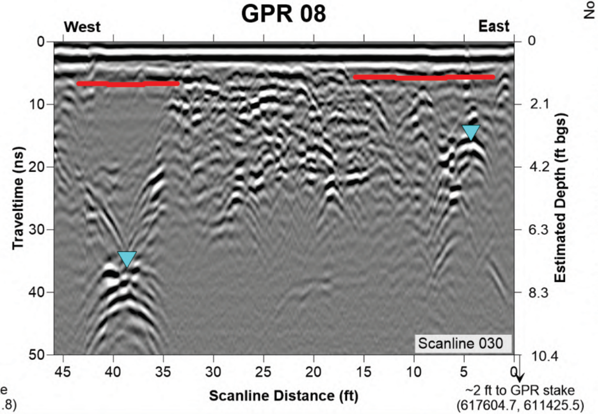
Reviewed by: J. Pfeiffer

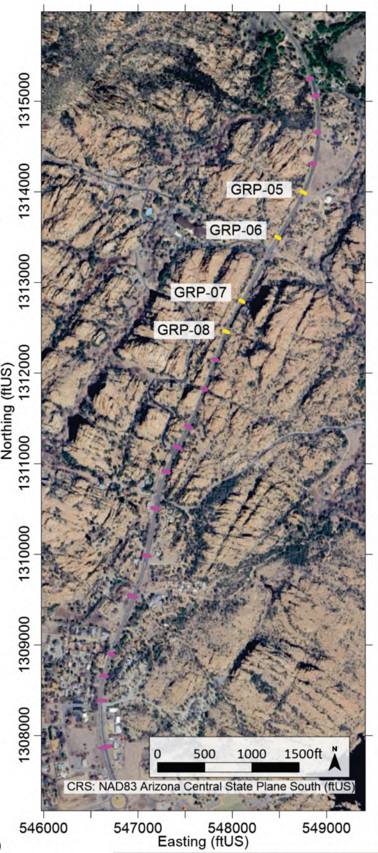
Figure A-2a











Scanline Key

- ∿ Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative 0 Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- ∿ Collected GPR Scanline
- ∿ Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

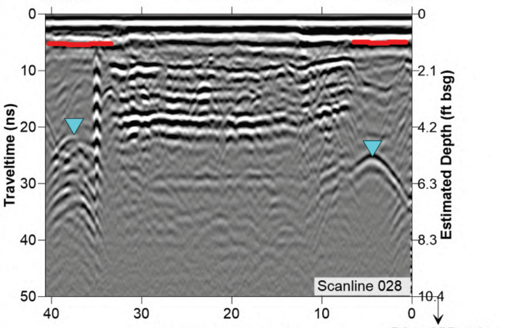
Bird Seismic Services

Project #: 250025	May 2025
Drafted by: D. Lipfert	Reviewed by: J. Pfeiffer

COLLIER GEOPHYSICS

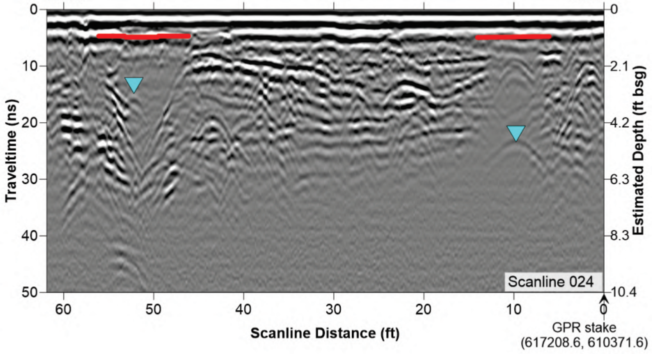
Figure A-2b

GPR 09



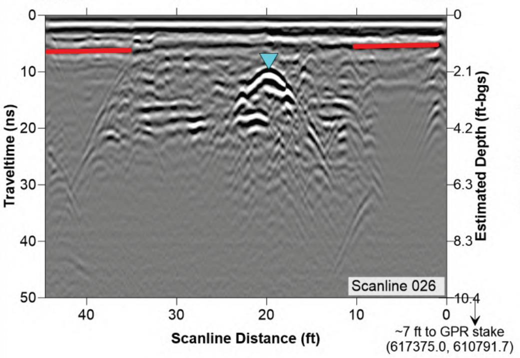
~7 ft to GPR stake
(617492.9, 611113.6)

GPR 11



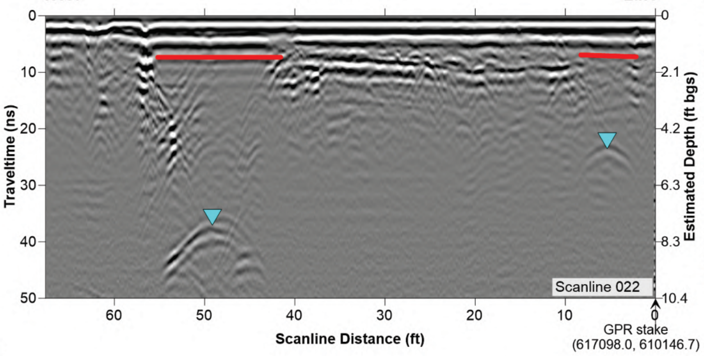
GPR stake
(617208.6, 610371.6)

GPR 10

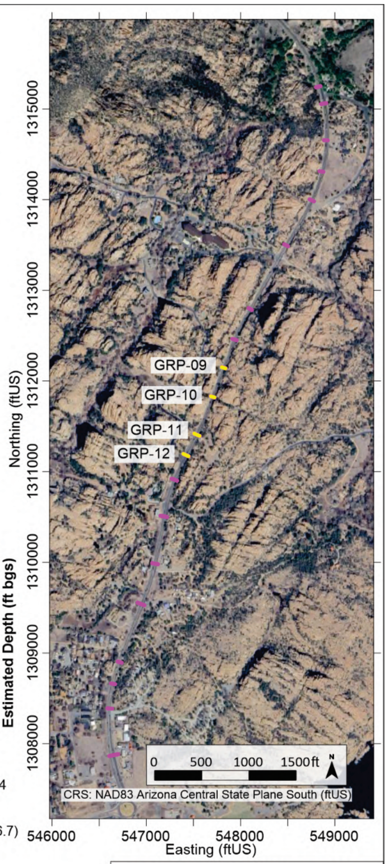


~7 ft to GPR stake
(617375.0, 610791.7)

GPR 12



GPR stake
(617098.0, 610146.7)



CRS: NAD83 Arizona Central State Plane South (ftUS)

Scanline Key

- 〰 Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative — 0 — Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- 〰 Collected GPR Scanline
- 〰 Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

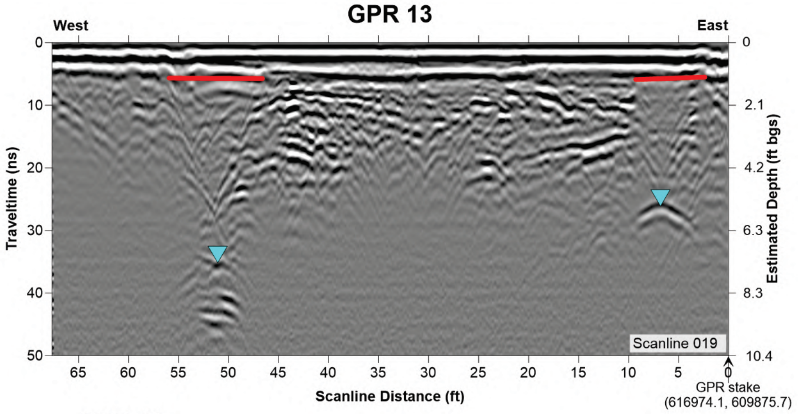
Bird Seismic Services

Project #: 250025
May 2025

COLLIER GEOPHYSICS

Drafted by: D. Lipfert
Reviewed by: J. Pfeiffer
Figure A-2c

GPR 13



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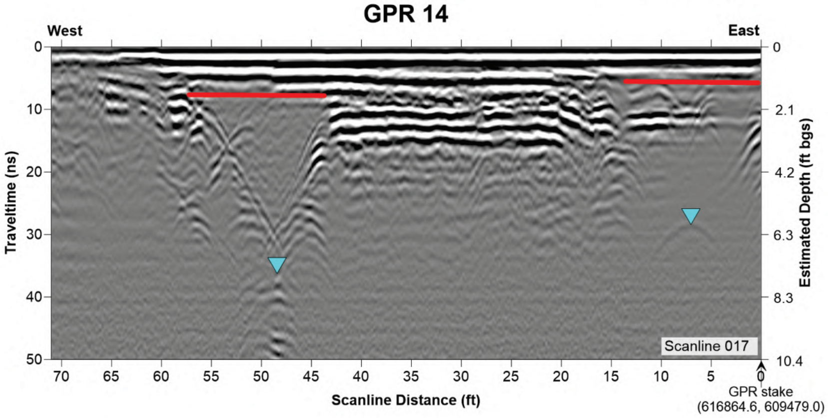
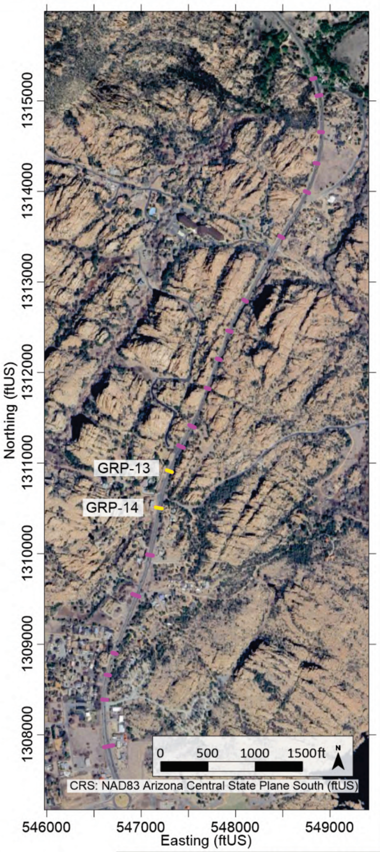




Scanline Key

- 〰 Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative 0 Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- 〰 Collected GPR Scanline
- 〰 Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

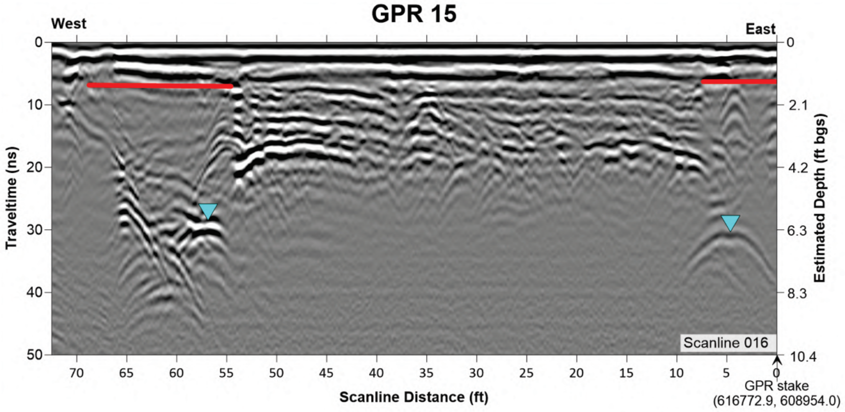
Bird Seismic Services

Project #: 250025	May 2025
Drafted by: D. Lipfert	Reviewed by: J. Pfeiffer

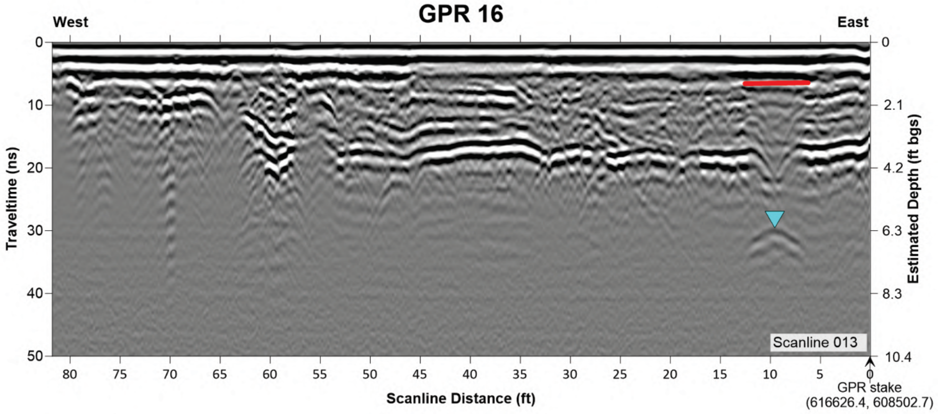
COLLIER GEOPHYSICS

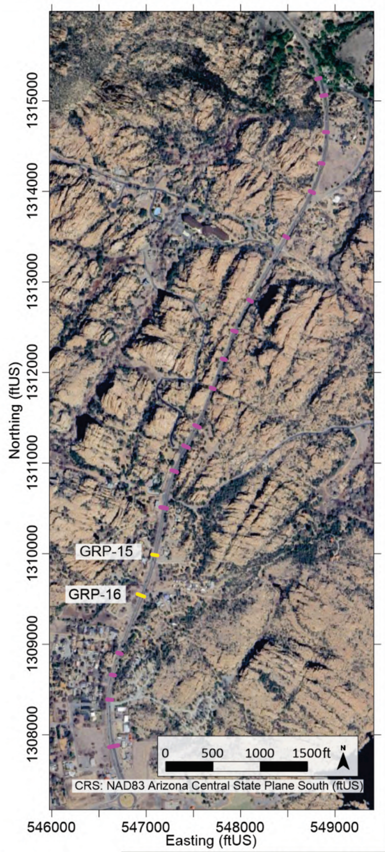
Figure A-2d

GPR 15



GPR 16





Scanline Key

- 〜 Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative 0 Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- 〜 Collected GPR Scanline
- 〜 Example GPR Segment Shown

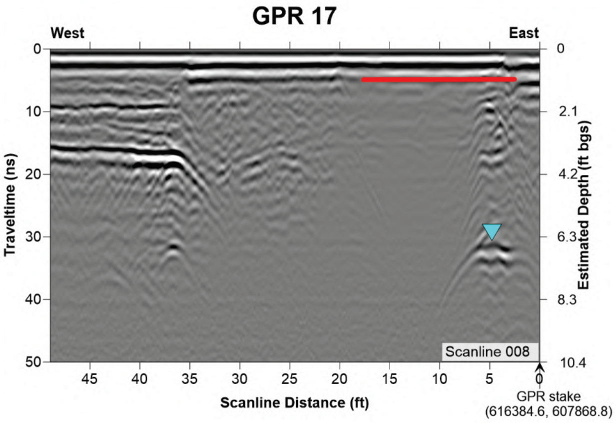
GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

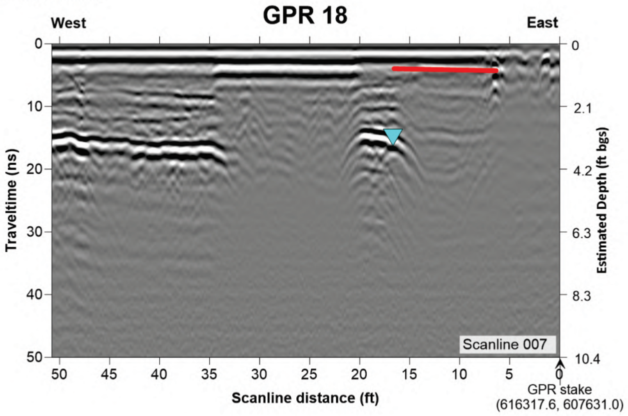
Bird Seismic Services

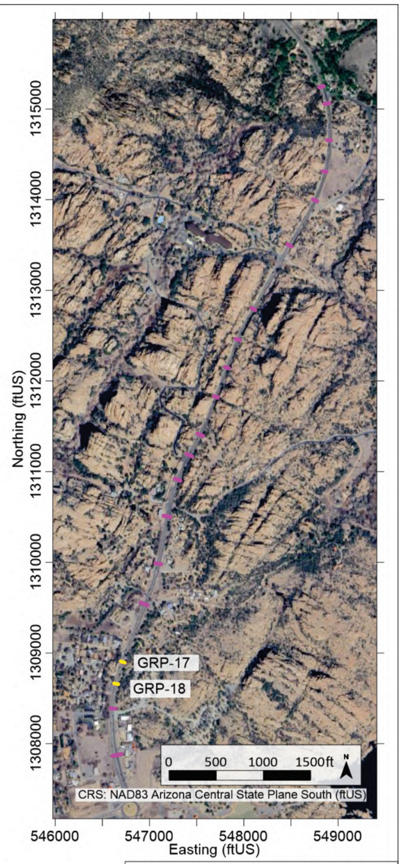
Project #: 250025 | May 2025

COLLIER GEOPHYSICS

Drafted by: D. Lipfert | Reviewed by: J. Pfeiffer | **Figure A-2e**







Scanline Key

〜 Interpreted Trench Extents

▼ Possible Pipe/Utility

GPR Signal

Negative 0 Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

〜 Collected GPR Scanline

〜 Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

Bird Seismic Services

Project #: 250025

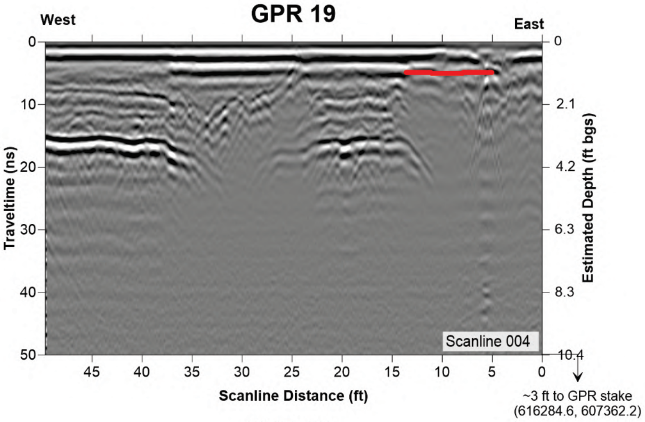
May 2025

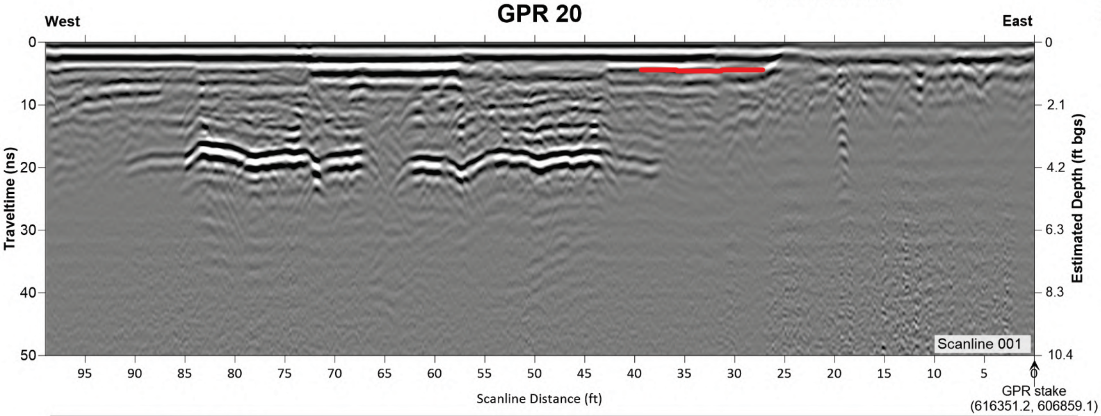
COLLIER GEOPHYSICS

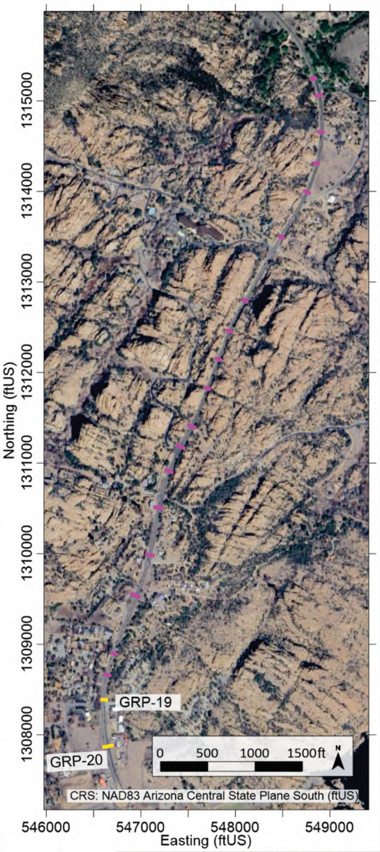
Drafted by: D. Lipfert

Reviewed by: J. Pfeiffer

Figure A-2f







Scanline Key

- 〰 Interpreted Trench Extents
- ▼ Possible Pipe/Utility

GPR Signal

Negative — 0 — Positive

Note: Estimated depths based on a bulk EM wave velocity of 0.417 ft/ns (0.127 m/ns)

Map Key

- 〰 Collected GPR Scanline
- 〰 Example GPR Segment Shown

GPR Results: Prescott Highway 89
GPR Investigation
Prescott, AZ

Bird Seismic Services

Project #: 250025	May 2025	COLLIER GEOPHYSICS
Drafted by: D. Lipfert	Reviewed by: J. Pfeiffer	Figure A-2g

MEMORANDUM

2475 N Coyote Dr. Tucson, AZ USA | +1.520.670.9774 | www.cnitucson.com

CALL & NICHOLAS

TO: Andrew Baird, PE / Kimley-Horn

FROM: Michael Conley, PE / Call & Nicholas, Inc.
Robert Cummings, PE / Call & Nicholas, Inc.

DATE: June 10, 2025

SUBJECT: **DRAFT** SR89 DCR Roadway Cut Slope Geotechnical Recommendations

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1. EXECUTIVE SUMMARY

This memorandum presents geotechnical recommendations for the SR89 DCR according to field geological and geophysical work done in the corridor by Call & Nicholas, Inc. (CNI) during the last week of January 2025, CNI's follow up geotechnical mapping using the point clouds received from Lyon Engineering (Lyon) , and the conceptual realignment alternatives provided by Kimley-Horn Associates (KHA). Because this report is to support the DCR addressing roadway alignment and reconstruction alternatives, the field work supporting this report all pertains to above-grade features, specifically the rock cuts.

Other geotechnical work was performed to support the design of the relocated effluent main that included borings by ETC and geophysics at roadway grade performed by CNI. This work is the subject of a separate report.

Slope angles: Instead of providing generalized, uniform slope angles, the excavation of the slopes will leverage natural geological discontinuities. Because most of these discontinuities are near vertical this would result in the excavation of near-vertical, natural appearing slopes similar to what exists today. Where the discontinuities do not parallel the existing roadway, the slopes will be formed by following intersecting discontinuities giving a somewhat prismatic appearance that adds interest and a more open feel to the driving conditions. The result is a far smaller footprint overall than would be obtained by using a conventional slope design template.

Earthwork Factors: Preliminary estimates of rock cut quantities could be made by assuming that overall the volume will be similar to estimates made assuming uniform 0.25:1 (H:V) slopes, although uniform slopes will not be shown on the plans issued for construction. The bulking factor to loose volume will be close to 1.45, and the swell factor to a compacted rockfill embankment will be close to 1.25.

Rock Excavation: Most if not all the rock cuts on this project will require blasting to facilitate excavation. Mechanical excavation, such as with an impact hammer, may be successful in specific locations of weaker, weathered or more fractured rock. Mechanical excavation in hard rock can be facilitated with relief drilling (pre-drilling on close hole centers). Narrow (less than 6-8 feet) cuts may be peeled back to the desired discontinuity with equipment in specific instances. Controlled top-down blasting (presplitting and trim blasting) techniques should be avoided unless they can exploit specific discontinuities as release surfaces.

Laboratory testing for rock uniaxial compressive strength has not yet been performed on this project, as no core drilling has yet been done. Geophysical profiles indicate that seismic compression wave velocities reach 7,000 feet per second (fps) at depths of 5-10 feet from the surface, except for some scattered deeper occurrences of lower-velocity material following ravines and probable shear zones. Much non-rippable rock occurs at the surface. Most of the rock slopes will be cut in material of more than 11,000 fps. For these reasons blasting should be planned for most if not all the rock cut slopes on this project.

Most of the rock cuts have little to no overburden cover – a condition known as “bald-headed” granite. Some of these bald-headed surfaces slope toward the roadway. Crossing the undulatory, rounded rock surfaces to drill cuts from the top down will be difficult and hazardous without suitable pioneering. To create access roads, rock will need to be removed by blasting, hammering, or heavy ripping with preconditioning by drilling. Drilling blast holes horizontally from the roadway is a preferable approach where feasible because it avoids pioneering the top, avoids drill hole traces marking the cut slope, reduces overbreak, improves final cut aesthetics, and avoids scars behind the catch point from pioneer roads. Most required cuts will be reachable by horizontal drilling (where the blast hole pattern does not need to be more than about 20-25 feet high). Practical considerations for horizontal hole drilling such as controls on hole depth, overhead reach, traffic passage, blast design, and safety, will need to be resolved with the CMAR contractor during design development. Cuts or portions of cuts requiring top-down drilling, if any, will be identified during detailed design, Top-down drilling should be restricted to the tallest cuts where horizontal drilling is not feasible. Sliver cuts (those less than 6-8 feet wide) can likely be peeled away from the backing discontinuities with mechanical equipment and the resulting boulders broken down at roadway grade.

Traffic control and the scheduling of blasting activities (drilling, actual blasting, and scaling) are subjects that will need to be addressed during final design. The horizontal drilling method will require that drills occupy portions of the roadway that may otherwise be used by passing traffic, so lane closures will be required.

The visual aesthetics are important for this project. Feedback from attendees at public meetings stressed the importance of retaining the rock contour and established vegetation wherever feasible. Symmetric widening, affecting both sides of the roadway, is less advantageous than an approach that accomplishes necessary widening to the side opposite the greatest existing values (natural rock cuts bearing mature oak vegetation, for example).

To facilitate stability of slopes formed by natural discontinuities, some of which may be vertical or slightly past vertical, rock reinforcement with suitable payment Items should be provided in the contract documents. Rock reinforcement consisting of post-tensioned bolts may be required but the majority of, if not all, the rock conditions expected to warrant reinforcing should be treatable with un-tensioned, un-plated rock dowels. By omitting bolt header plates and coloring the cementitious grout to match the rock, dowel installation will be practically invisible from the roadway. A minimum thickness of 4 feet of surficial rock bond length is recommended if plates are to be omitted.

2. SLOPE RECOMMENDATIONS

The geology and rock fabric mapping indicate that with a carefully planned alignment and controlled blasting practices, steep slope profiles are feasible, limiting the footprint and rock removal quantity required to gain width for the roadway. This report recommends that rock cuts follow specific, dominantly near-vertical discontinuities to reduce the footprint and overall excavation quantities and produce a natural appearance. Examples of this approach are given (Section 4). The specific slope configurations chosen will be a detailed process best performed after the design alternative is designated. Where the fracturing does not parallel the roadway, the slope design will exploit cross-cutting (conjugate) discontinuities to reduce the shoulder width. The CMAR method of delivery chosen for this project supports the coordination among the geotechnical, geological, and construction teams that is necessary for this approach.

3. GEOLOGIC SETTING

The Mesoproterozoic Dells Granite pluton, located approximately 5 miles northeast of Prescott, crops out unconformably from surrounding Tertiary sedimentary rocks. Texturally, the rock is massive and medium- to coarse-grained and locally porphyritic with larger feldspar phenocrysts. Feldspar, quartz, and biotite make up the bulk of the rock while tourmaline, fluorite, magnetite, specular hematite, and apatite occur as accessory minerals. Fresh rock is generally white to light gray while weathered outcrops have been oxidized and range from pink to brown to orange.

The granite has weathered to distinctive spheroidal hills, knobs, and boulders cut by near vertical joint patterns primarily oriented in two directions: north-northeast to south-southwest and west-northwest to east-northeast. Additional locally variable joint groups cut across these two main joint sets. Persistent planar features are clearly visible in aerial and drone photography. Most of the discontinuities dip more than 70 degrees, but locally some shallower dips were noted in the field work. Where shallowly dipping discontinuities are persistent enough, kinematically unstable wedge, toppling, or plane shear geometries may be formed, so the slopes should be reviewed by an experienced geotechnical engineer as they are excavated. In those instances, special care will be needed to attain the slope configuration intended, along with the provision of rock reinforcement.

4. FIELD INVESTIGATION SUMMARY

From January 27th through January 31st, 2025, geotechnical investigations took place within the corridor consisting of 10 borings, 7 seismic refraction lines, test excavations, 20 ground penetrating radar (GPR) lines, and rock fabric structure mapping. The borings, test excavations, 5 of the seismic lines, and GPR were all performed for the effluent line relocation design and are reported upon separately. A summary of the initial findings from these investigations is presented in the following subsections. Two seismic lines, SLCS-01 and SLCS-02, were performed for the roadway cut slopes.

4.1 Borings

Ten borings were conducted by ETC along the alignment within the roadway area. All borings were conducted from the roadway surface and only to auger refusal, and do not provide data pertinent to the cut slopes. If rock excavation for cut slopes turns out to be required for the chosen alternative, dedicated borings will be performed as appropriate and will involve rock coring techniques.

4.2 Seismic Surveys

Lines SLCS-01 and SLCS-02 were performed on the east side of the roadway between Granite Dells Road and Boulder Creek Lane (Figure 1), next page.

Figure 1 -- Seismic Line Locations for Roadway DCR Investigation

The seismic refraction surveys are reported in Appendix 1 and resulted in high-quality tomographic profiles (Figures 2 and 3) indicating strong rock that mostly will require blasting for roadway cut slopes, especially those taller than about 10 feet. Smaller knobs less than 10 feet tall may be feasibly removed with hammering and heavy ripping. Small areas of material more amenable to mechanical excavation on the larger cuts are of such limited extent that they can be blasted along with the rest of the material.

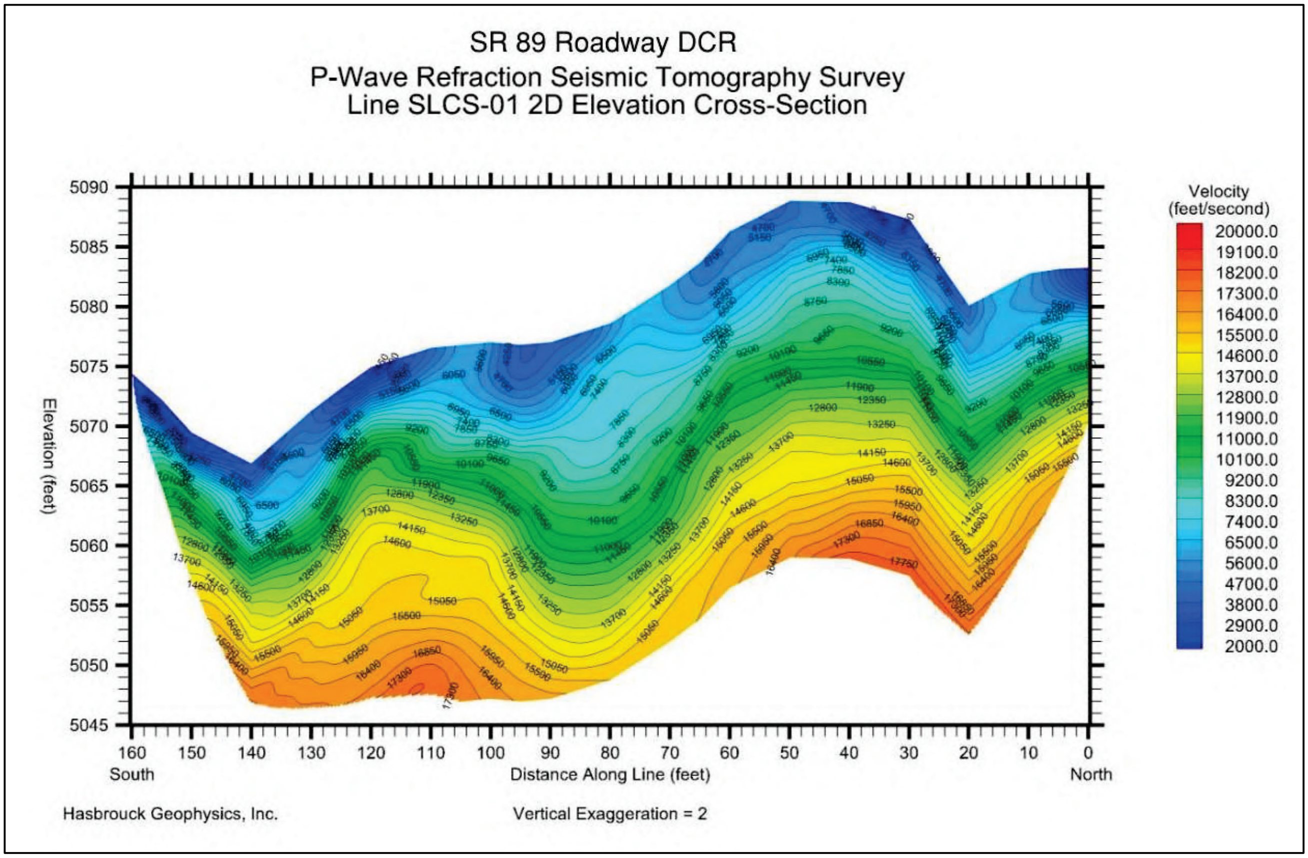

Figure 2 – Seismic tomography profile for SLCS-01

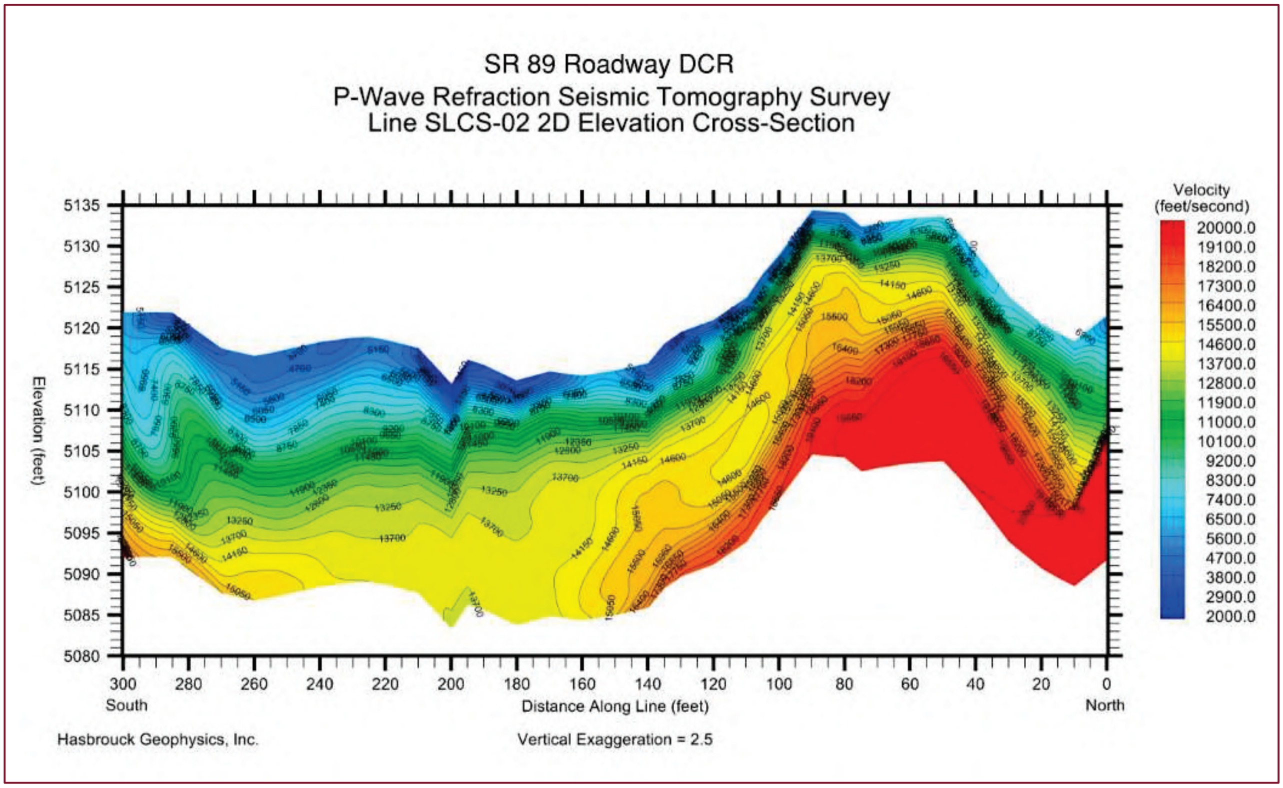

Figure 3 -- Seismic tomography profile for SLCS-02

Shear wave surveys were also performed but were adversely affected by site conditions. As noted in Appendix 1, shear wave profiles should be used with caution. Shear wave profiles do not correlate well with refraction tomography profiles and are largely suspect.

The original roadway alignment was evidently chosen to exploit an area of weaker, more fractured and weathered rock along a zone of shearing and faulting. Seismic refraction tomography bears this out. The subsurface rock material below the roadway appears notably weaker than that of the surrounding outcrops.

4.3 Rock Fabric Mapping

The structural fabric of the granite tends to parallel the centerline so the controls on rock slope stability need to be considered with respect to the discontinuities.

Mapping of structure orientations was conducted during the initial site investigation. Lyon Engineering provided drone surveying which resulted in point clouds of the proposed rock cut areas. Digital imagery was used to support field mapping.

A stereonet of the mapping is presented as Figure 4[1]. The northeast-trending face forming joint sets plotted on the net are long (>30 feet on average) and closely spaced (3 feet on average), dipping steeply. The overall roadway alignment is also oriented approximately southwest to northeast, so the northeast set will control the profile of slopes oriented southwest to northeast.

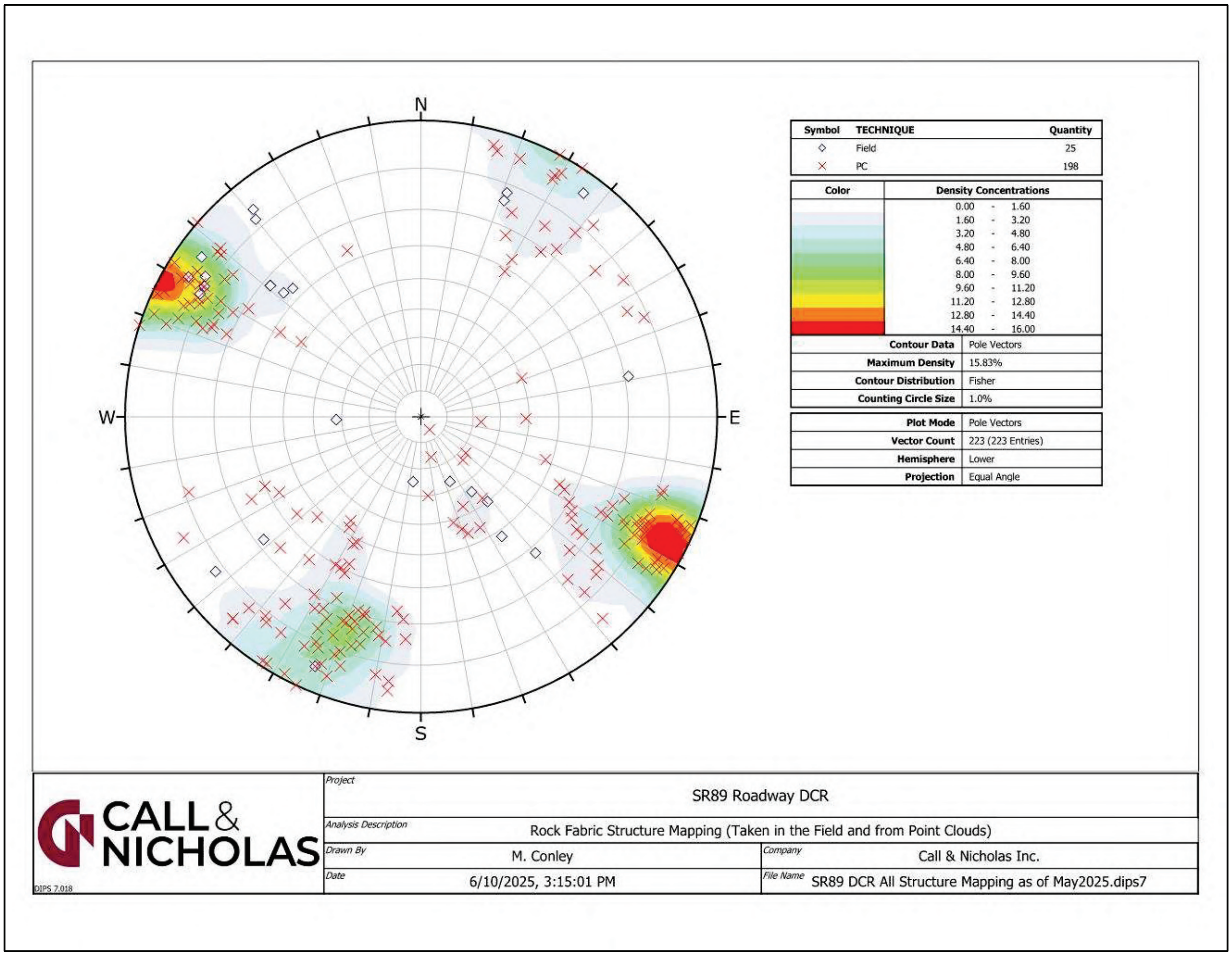

Figure 4 -- Lower-Hemisphere Polar Stereonet of Rock Fabric Mapping

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[1] A stereonet is a means of collecting and depicting fracture orientations. The stereonet represents a half-sphere below a horizontal surface. Planes representing discontinuities can each be described by a line that is exactly perpendicular to the plane. There is only one such line that also passes through the sphere origin – that is termed a "pole" that uniquely describes that particular plane. Groupings of poles represent clusters of similarly oriented planes (in this case, discontinuities) and these clusters can then be examined statistically for variations in strike and dip. On stereonets of poles, the data points plot 90 degrees to the strike orientation and steeper discontinuities plot closer to the perimeter of the stereonet.

The face forming joint set would generally dip steeply into future cut slopes on the east side of the alignment creating a near vertical to slightly overhung slope. Toppling failure mechanisms are a concern when slopes are overhanging and should be evaluated further but can be readily mitigated by installing rock bolts in the upper slope.

The face forming joint set would fall in the plane shear orientation of future cut slopes on the west side of the alignment likely creating a slope with same dip as the face forming joint set at about 83 degrees. There are some structures that dip shallower at about 65 degrees that also fall within the plane shear orientation for a slope on the west side of the alignment. Locally these may also form the face of the slope. The dip of the slopes profiles on the west side of the alignment would range between 65 and 83 degrees with an average of 74 degrees.

Figure 4 also shows a conjugate, persistent northwest-striking family of discontinuities that is not as prevalent as the face-forming set. These discontinuities would be exploited where the main set is not exactly face-parallel.

Figure 4 also shows a few measurements of less-persistent discontinuities having moderate dips, that may locally present plane shear or wedge possibilities in slopes that are formed by the otherwise steeper discontinuities. During construction, the cut slopes should be observed and discontinuities presenting such kinematic instability potential should be mitigated with rock reinforcement.

The program MineSight was used to integrate surface topography, roadway geometry, and the rock discontinuity mapping. Figure 5 (next page) shows an example discontinuity planes relative to the roadway geometry.

Figure 6 (next page) shows how the fractures depicted at the location of Figure 5 would be exploited in forming a natural-appearing cut slope. Note that the cut slope follows different discontinuities along the roadway, using the conjugate set noted above to form the intersections keeping the final toe close to the theoretical toe.

Figure 7 shows a cross section at the same location comparing the theoretical toe (in this case, the alignment option – one of several -- in which the slope theoretical toe is chosen 18 feet outside the existing edge of pavement), but the actual slope is formed by the closest significant discontinuity to the theoretical toe. The result is a slope whose catch point is close to that of a 0.5:1 (H:V) slope. In the cases with taller cuts the equivalent uniform slope would be somewhat steeper, possibly 0.25:1.

Figure 5 – MineSight oblique at Twisted Trail showing mapped discontinuity planes relative to the roadway location

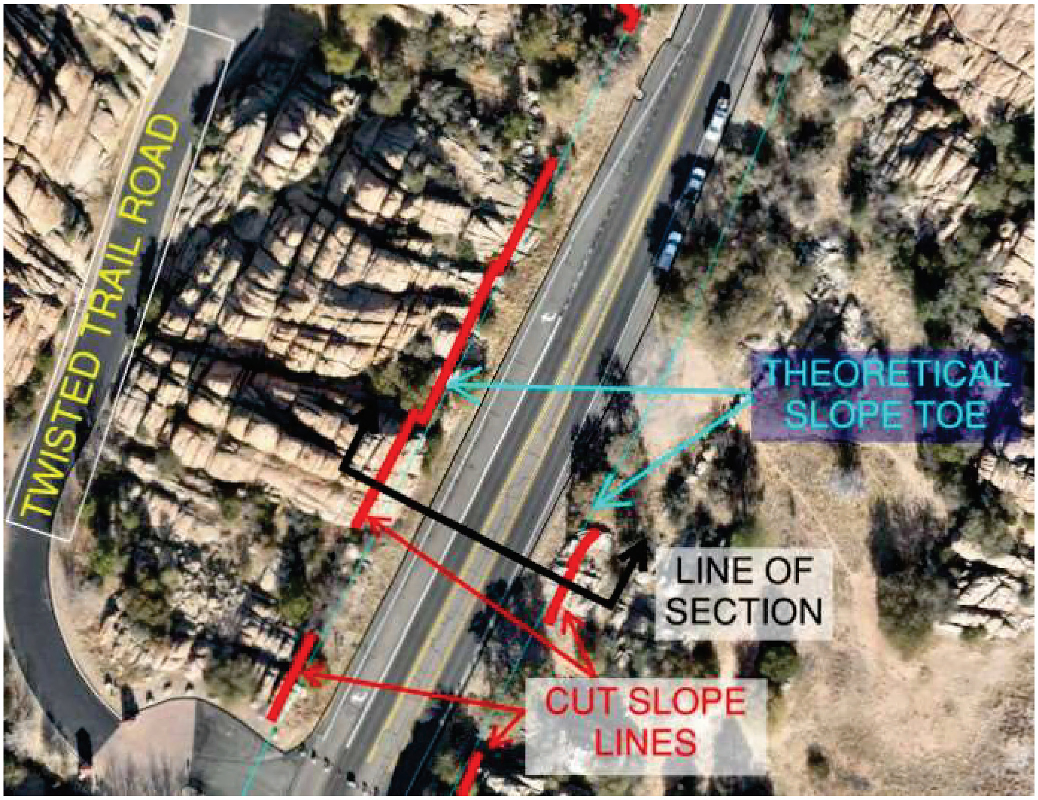

Figure 6 – Slope lines near Twisted Trail (see text)

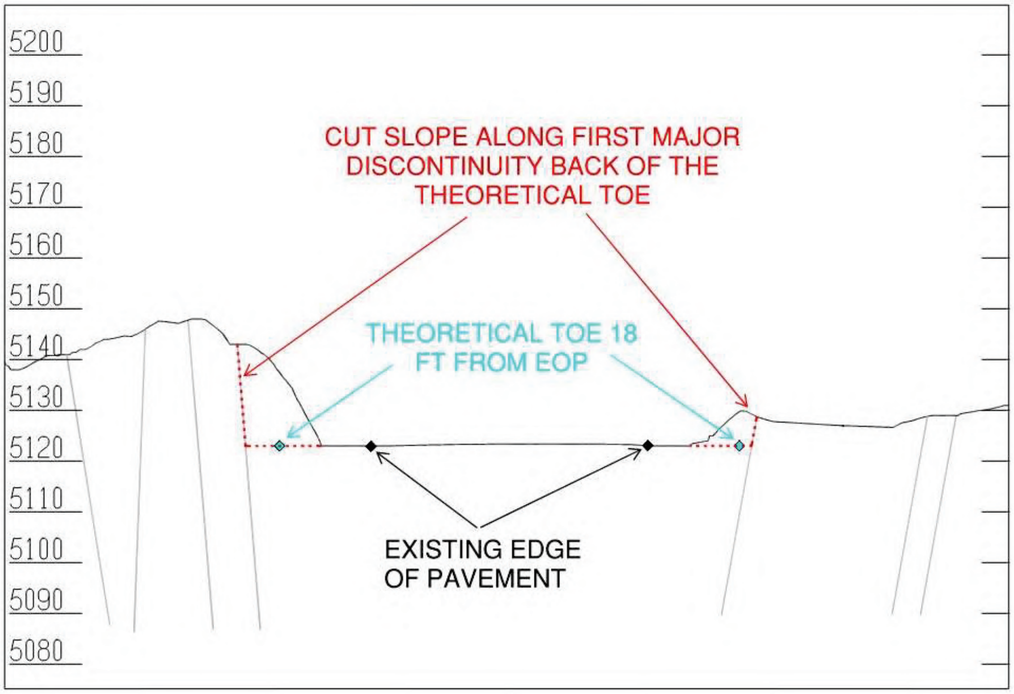

Figure 7 -- Cross section at the location shown in Figure 6

Where the roadway alignment and dominant discontinuity orientations diverge (one such location is north of the location shown in Figures 5 and 6) the slope can follow the dominant sets with intervening portions following either solid rock or the conjugate discontinuity set (Figure 8).

Figure 8 – Using main and conjugate discontinuity sets

It was also observed that vertical structures in the area often had 1/16 to 1/8 inch thick fillings of a smooth mineral (Figure 9) that would aid in the release of slabs to form the steep slopes.

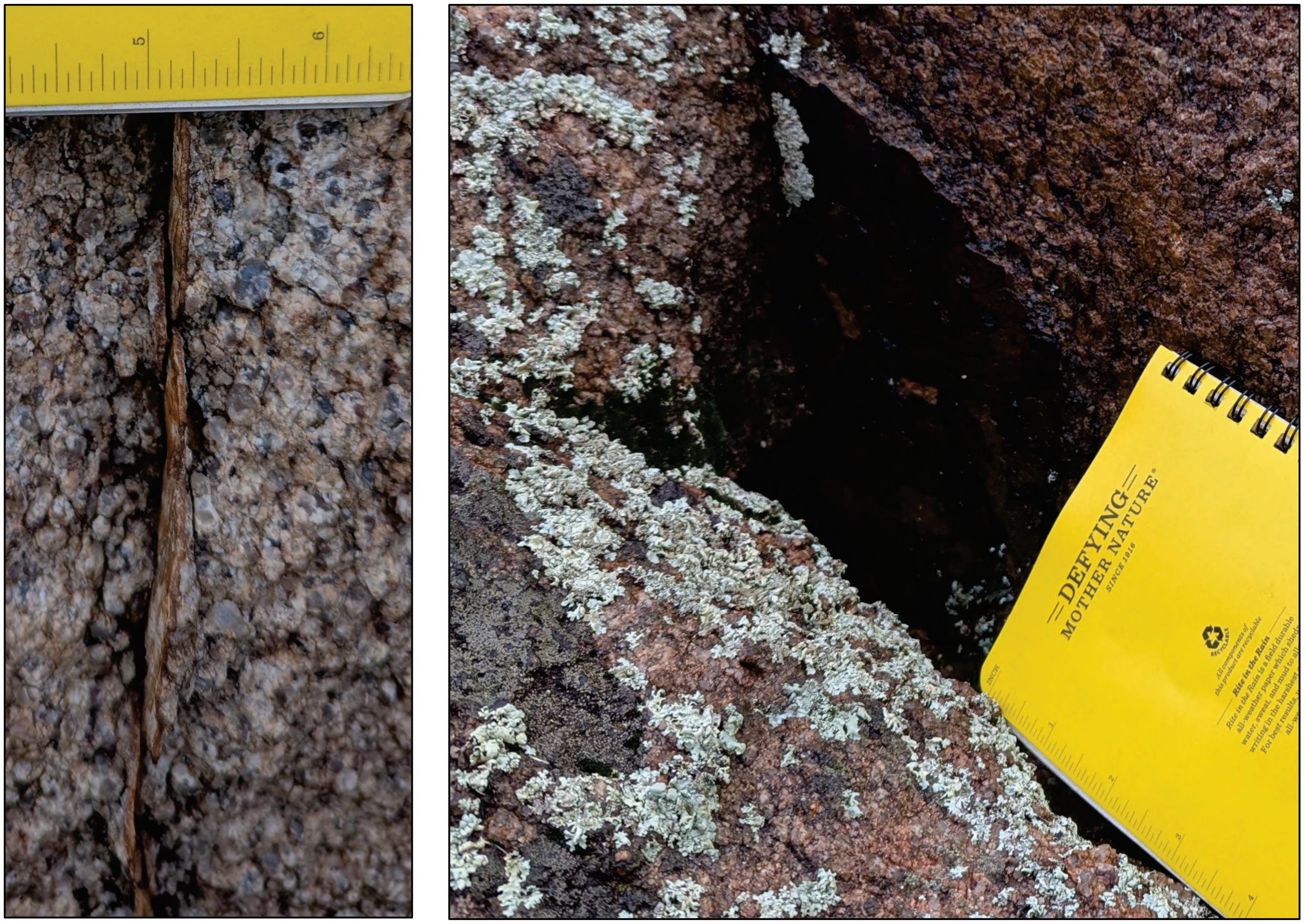

Figure 9. Mineral Filling Along Vertical Joints

5. RECOMMENDATIONS

Slope configurations should be defined chiefly by the native discontinuity system. Slopes resulting from the process recommended will generally be steeper than would result from the more typical design process involving a single slope angle template. The slope toe will be behind (outside of) the theoretical toe to ensure that the profile grade is correct. Between the slope toe and the theoretical toe, the grade will be shallowly (4:1 H:V to 6:1 H:V) toward the theoretical toe, so that the longitudinal drainage will still follow the theoretical toe as it would were the slope constructed at a uniform location and angle.

Bid documents should include allowances for rock reinforcement. Because this is a CMAR project, the quantities of recommended rock reinforcement will need to be estimated fairly closely during design, but the uncertainty during construction will need to be accommodated with an allowance.

The steep dip and the close spacing of the face forming joint set indicate that with a carefully planned alignment and controlled blasting practices, steep slope profiles may be obtained with the location of the slope toe being adjustable in approximately 3 foot increments. For final design, the point cloud data will be used to identify the coordinates of those specific discontinuities that will provide slope surfaces conforming to the chosen alignment. During construction, GPS controls on drilling equipment can be used to identify the orientation and depth of each blast hole so as to terminate close to (within 2 feet of, but not beyond) the desired slope-forming discontinuity. Blast holes drilled too deep would need to be backfilled with mortar colored to match the general tone of the rock, a circumstance best avoided.

The process of choosing slope configurations based on specific, local fracturing, and then attaining those configurations in the field, will require close coordination among the geotechnical engineers, roadway designers, and CMAR contractor, throughout final design development and in the field during construction. It is facilitated with modern computational tools that can digitally represent complex surfaces, and by modern survey and layout tools that can provide the blast hole driller with the proper depths for the blast hole surface coordinates marked out.

Narrow sliver cuts (less than 8 feet thick) may be candidates for removal with mechanical equipment. Such cuts can be blasted with horizontal drrilling but the diameter of the holes and dimensions of the patterns must be kept small.

The public information and scoping meetings disclosed that many are concerned about retaining the existing slope contour and particularly the mature vegetation growing on the existing slopes at many places. Retention of those aesthetic values should be considered when choosing the preferred alternative. From that perspective it would be preferable to confine the disturbance to the side of the roadway with the least impact.

Details associated with cut slope definition, horizontal hole blasting, and with blasting in general, will need to be worked out among the design team, Public Information team, and CMAR contractor during project development. Issues include:

1. Traffic control during drilling, mucking, positioning support equipment
2. Blasting closures – day, night, locations, and blocking stations
3. Pre-blast surveys of potentially impacted structures
4. Blast monitoring
5. Qualifications of the Blaster in Charge and contractor blasting technical team
6. Public Information regarding blasting – Public Meetings may be desirable
7. Complaint response
8. Local access (residents and visitors)
9. Public information connected with the slope design configuration of the selected alternative and the process of considering slope context in alternatives development
10. Method of laying out and staking blast holes
11. Control of fly rock, noise, and dust
12. Breaking down oversize
13. Disposition of excavated rock
14. Provision of suitable stemming materials and stemming plugs
15. Test blasting
16. Ongoing evaluation of results
17. Documentation (Master Blasting Plan, Individual Blasting Plans, Individual Blasting Reports)
18. Earthwork quantities
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20. Access and lift equipment
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23. Estimating quantities of reinforcement

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DATA USED TO CONSTRUCT CROSS-SECTIONS

INTRODUCTION

Two-dimensional (2D) surface refraction seismic tomography and surface-wave seismic surveys were conducted on seven lines along portions of State Route 89 (SR89) within and near the Dells in Prescott, Arizona. The surveys are part of a pipeline improvements project.

METHODOLOGY

Surface refraction seismic tomography surveys essentially consist of recording seismic waves that have been generated by artificial sources, observing the arrival times of these waves, and producing cross-sections of variations in subsurface seismic wave velocities that can then be related to geology. For surface-wave seismic surveys the fundamental property utilized is dispersion or the change in seismic phase velocity (defined as the seismic velocity of any given phase, such as a trough or peak) with frequency. Shear-wave seismic velocities are calculated by mathematical inversion of the dispersive phase velocity of surface-waves. The source of seismic energy for relatively shallow surface surveys is generally either a sledgehammer or weight-drop system, primarily dependent upon target depths and logistics.

In surface surveys the seismic waves are detected by geophones that consist of a coil suspended by a spring with magnets build into the case. A seismic wave moves the case and the magnets while the coil remains relatively stationary because of its inertia. The relative movement of the magnetic field with respect to the coil generates a voltage across the coil with the voltage proportional to the relative velocity of the coil to the magnets. The electrical voltages produced by the geophones are transmitted back to a seismograph via cables.

DATA ACQUISITION

Surface seismic data were acquired in a manner suitable for 2D tomographic and surface-wave analyses by Bird Seismic Services, Inc., Globe, Arizona. The data were acquired with a *Seistronix EX-6* signal-enhancement seismograph in 32-bit floating-point format with 1,600 samples per channel, 0.25 millisecond (ms) sample interval, and 200 milliseconds record length. The refraction seismic tomographic data were acquired with 10-Hz geophones, while the surface-wave data were acquired with 4.5-Hz geophones (the lower frequency geophones are necessary for broadband surface-wave data, while the higher frequency geophones generally provide sharper first arrivals of seismic energy). The seismic source was a 200-pound accelerated weight-drop or 10-pound slide hammer depending upon logistics. Geophones were located at intervals of three feet for the tomographic data with source points between geophones every nine feet, while for the surface-wave surveys the geophone interval was initially the same as for the tomographic survey but after in-field analyses of the data it was decided that geophone and source point intervals of 15 feet resulted in essentially the same quality data so the expanded geophone array was used for the remainder of the survey.

The seismic data were stacked nominally three to five times at each source point to increase the signal-to-noise ratio. Stacking, or signal enhancement, involved repeated source impacts at the same point into the same set of geophones. For each source point, the stacked data were recorded into the same seismic data file and theoretically the seismic signals arrived at the same time from each impact and thus were enhanced, while noise was random and tended to be reduced or canceled.

DATA PROCESSING

Seismic tomography is defined as a method for finding the seismic velocity distribution within the subsurface from a multitude of observations using combinations of source and receiver locations. The subsurface is divided into cells and the seismic data are expressed as line integrals along raypaths through the cells. A velocity is assigned to each cell and traveltimes are calculated by tracing rays through the model. The results are compared with observed times, the model is modified, and then the process is repeated iteratively to minimize errors.

The seismic tomography data for this project were processed using the *Rayfract* (version 4.05) computer software program developed by Intelligent Resources Inc. of Vancouver, BC, Canada. The models produced by the *Rayfract* tomography program use multiple signal propagation paths (e.g., refraction, reflection, transmission and diffusion) that comprise a first break. For the seismic tomography processing, the first arrival of seismic energy at each geophone is chosen as the first significant variation from a somewhat straight line. These arrivals or traveltimes are then modeled and iteratively compared with the original times. The modeling for this project consists the WET (wavepath eikonal traveltime) smooth inversion method with an initial gradient velocity input model. The WET method automatically adjusts the subsurface velocity model until the synthetic times optimally match the first arrival times and delivers continuous depth versus velocity profiles for all geophones. The modeled traveltimes are then used in the tomographic calculations to determine the subsurface seismic velocity distribution. Resulting depth cross-sections (seismic velocity versus depth) are initially produced from the *Rayfract* program using Golden Software's *Surfer* (version 28.4.300) computer program and subsequently with the Tecplot Focus (version 2024 R1) computer program for display in two- and three-dimensions.

The multi-channel analysis of surface-waves (MASW) method measures the dispersion or change in phase velocities of surface waves generated by multiple source points along a spread of geophones. Different seismic wavelengths, or frequencies, penetrate to different depths with longer wavelength, or lower frequency, surface-waves penetrating deeper than shorter wavelength, or higher frequency, surface-waves. These different wavelengths, and associated variations in penetration depths, propagate with different velocities. By analyzing the dispersion of surface-waves, a shear-wave (Vs) velocity profile is obtained.

The surface-wave data for this project were processed with the *SeisImager/SW-2D* set of computer programs from Geometrics using multi-channel active source data. The programs consist of *Pickwin* and *WaveEq*. Using *Pickwin* the data are input, the source-geophone geometries are established, and dispersion curves are determined and edited as appropriate. The dispersion curves are then input into *WaveEq* and initial and inverted models are constructed. The resulting inverted model, or back-calculated shear-wave velocities from the dispersion curves, are then converted and output in ASCII format. The resulting depth section is produced using Golden Software's *Surfer* (version 28.4.300) computer program and subsequently with the Tecplot Focus (version 2024 R1) computer program for display in two- and three-dimensions.

RESULTS

With surface seismic tomography a full representation of the subsurface velocities is obtained and first breaks can be from refractions, reflections, transmissions or diffusions and thus, to a certain extent, velocity inversions can be mapped. Surface seismic tomography results are generally considered to present a more geologically representative view of the subsurface than other shallow refraction seismic methods (e.g., delay-time). Changes in topography over short distances (e.g., ravines, hilltops, etc.) can adversely affect the quality of the model through erroneous raypaths. Lines SLRW-01 to SLRW-05 are essentially flat or gently sloping so there are no adverse topographic effects along those line and although there are some topographic changes along lines SLCS-01 and SLCS-02 there did not appear to be any adverse effects. Also, rock faces near the seismic lines can produce interfering sound wave noise (sound waves traveling at approximately 1,100 feet per second) although because of the relatively short lines in the survey and fast P-wave seismic velocities, the effects on the refracted first arrivals of seismic energy are considered essentially non-existent in this survey.

Overall, the surface seismic tomography data and results for this project are considered excellent. P-wave refraction seismic tomography cross-sections are presented in both two- and three-dimensions in this report with similar velocities and depths for each cross-section. Also included are the data used to construct the cross-sections. Note that for some of the lines there are data deeper than the cut-off of 30 feet in the cross-sections, but those deeper results are not considered appropriate for use.

Surface-waves are best generated over flat or gently sloping ground, while variable topography can interfere with surface-wave propagation. Also, rock faces near the seismic lines can produce interfering sound wave noise and, different from the P-wave tomography data, because of the relatively short lines in the survey, slower shear-wave seismic velocities and seismic waves of interest beyond first arrivals, the surface waves can be adversely affected by the sound wave noise. Variably dense and/or thick asphaltic concrete and base course material in addition to little sedimentary material above weathered granite may also adversely affect surface waves. An optional approach to generate shear-waves is by using horizontal geophones and a source struck perpendicular and horizontal to the axis of a seismic line. However, because of the slower shear-wave velocities, possibly more sound wave noise because the source is struck perpendicular to the nearby presence of rock faces, variably dense and/or thick asphaltic concrete and base course material, and logistics particularly on the cut-slope lines, the optional approach is not considered more feasible than the surface-wave approach used in the survey.

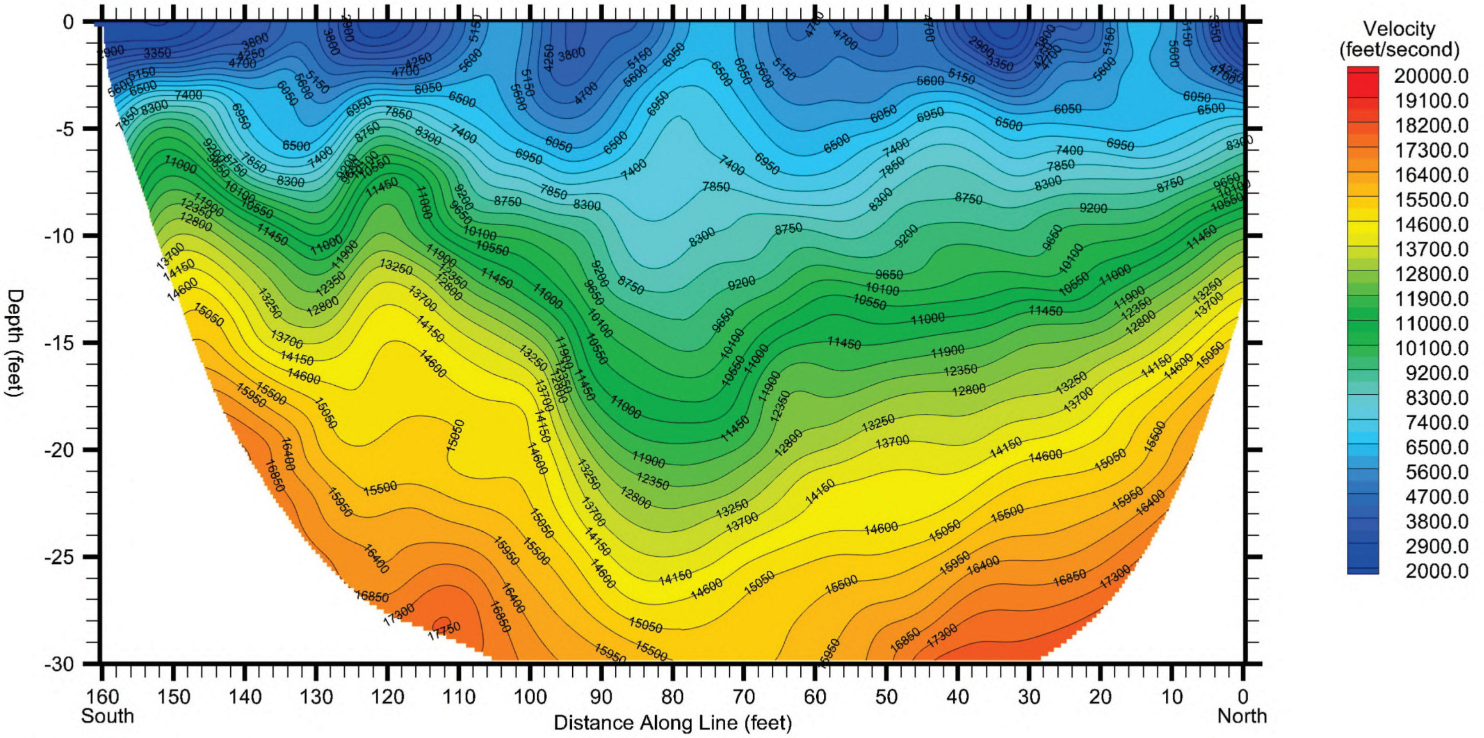
Because of the adverse effects described above, the MASW shear-wave data are considered poor and the results should be used with caution. MASW shear-wave cross-sections are presented in both two- and three-dimensions in this report with similar depths but different velocities because of variable seismic velocities. Note that MASW shear-wave results for lines SLRW-03, SLRW-04, SLRW-05 and SLCS-01 are shorter than acquired in the field because of anomalously low seismic velocities, like those seen for line SLRW-01 where there are question marks, and thus portions of those lines are deleted. Also included are the data used to construct the cross-sections. Note that for some of the lines there are data deeper than the cut-off of 30 feet in the cross-sections, but those deeper results are not considered appropriate for use.

LIMITATIONS OF INVESTIGATION

This survey was conducted with state-of-the-art instrumentation by experienced field personnel and the data were processed by an experienced and licensed geophysicist using commercial software packages utilized on projects with similar objectives. However, no warranty, expressed or implied, is made as to the results and professional advice included within this report.

The findings of this report are valid as of the present date. However, changes in the conditions of a property can and do occur with the passage of time, whether they be due to natural processes or the work of people on this or adjacent properties. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside of our control. Therefore, this report is subject to review and revision as changed conditions are identified.

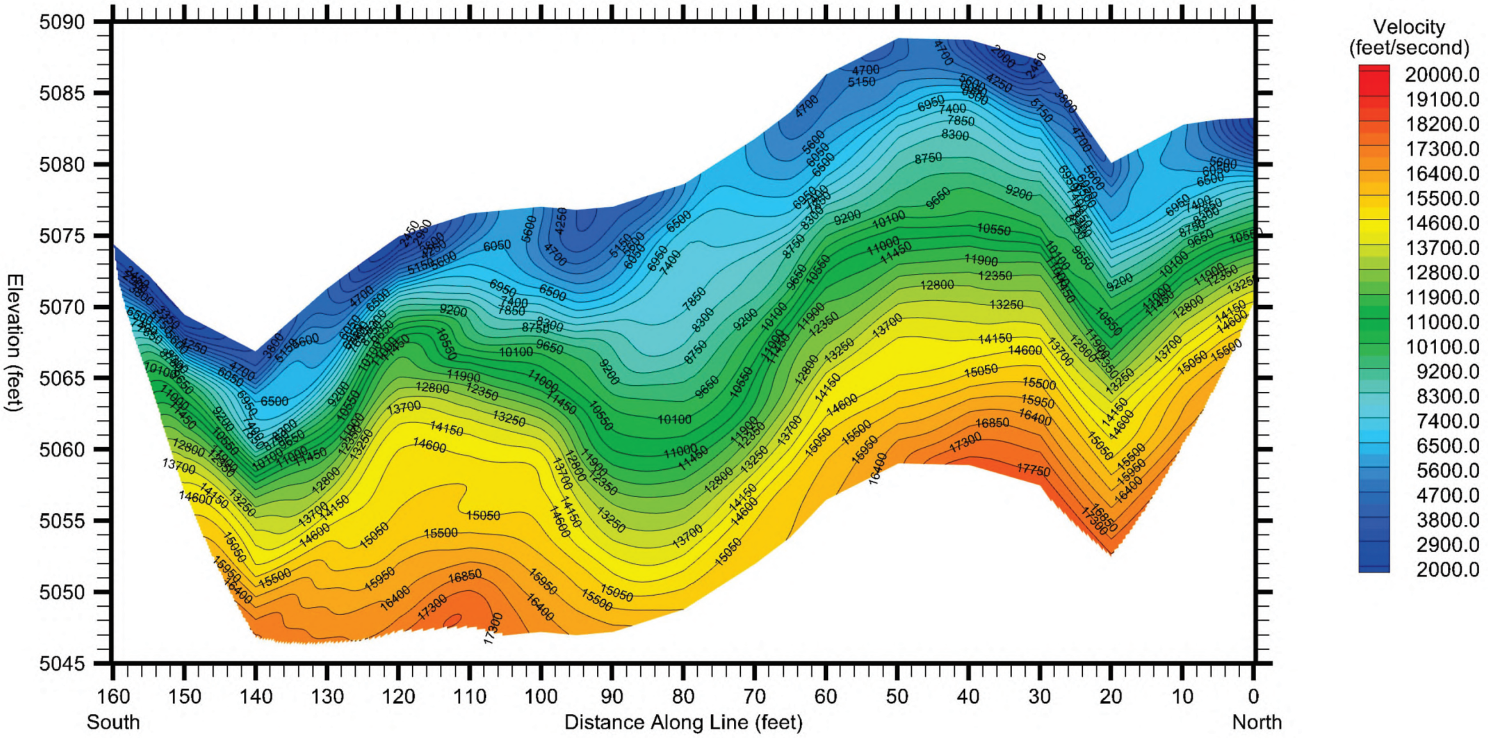
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-01 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

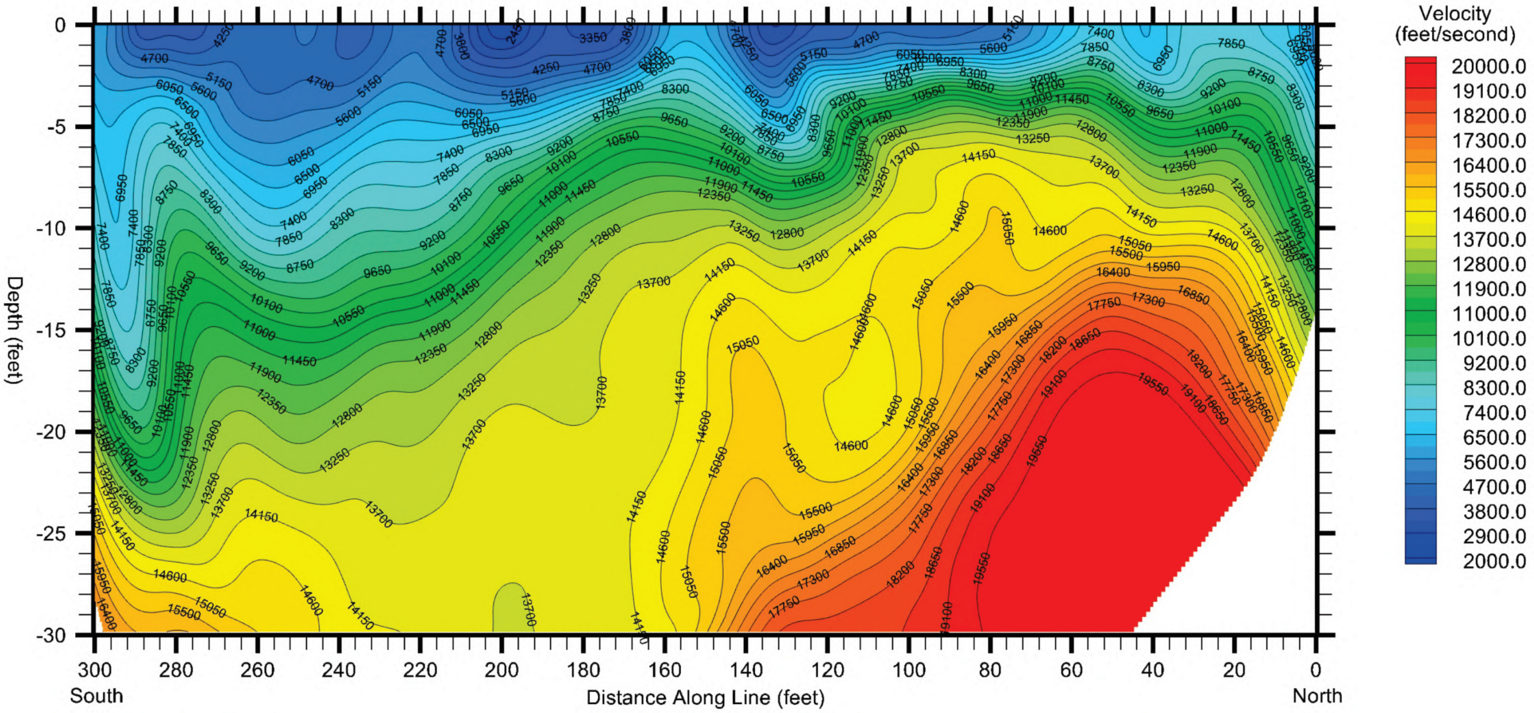
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-01 2D Elevation Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2

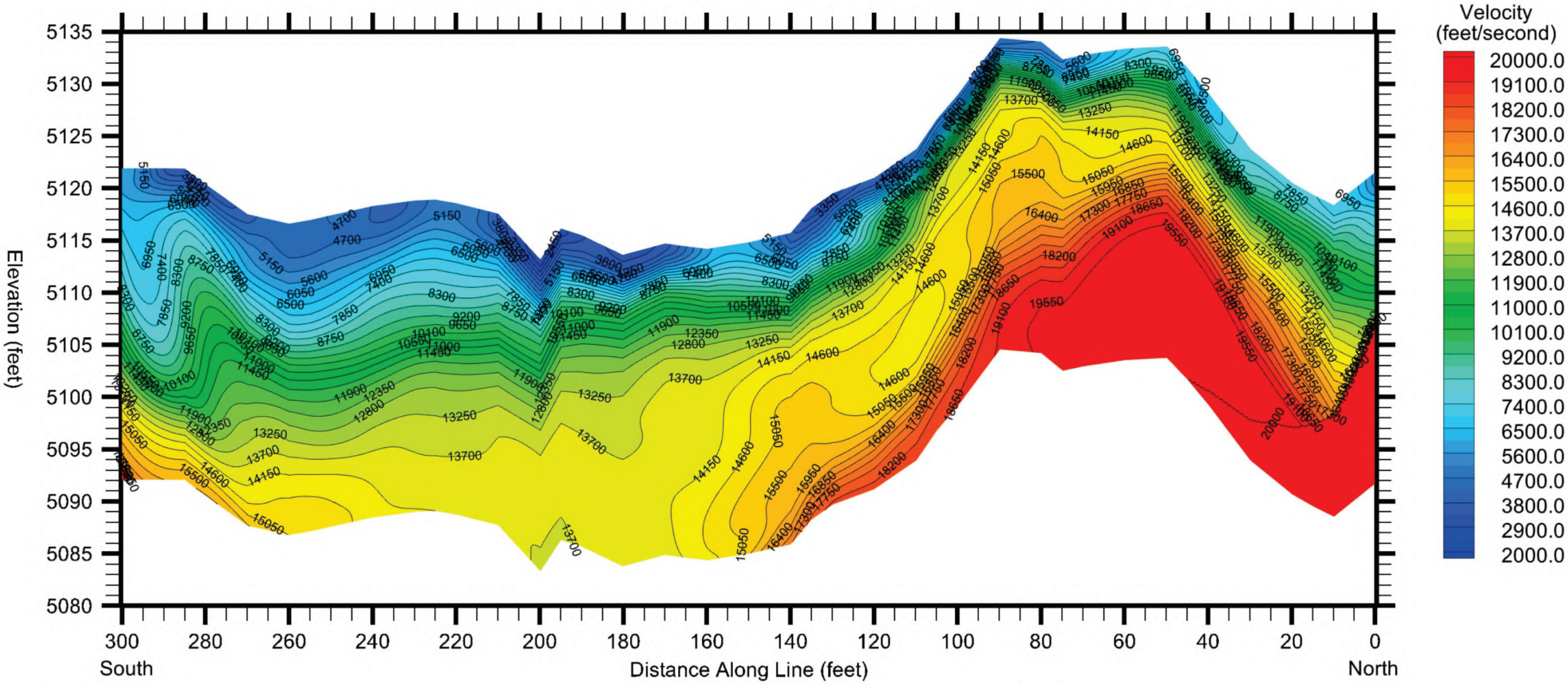
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-02 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 5

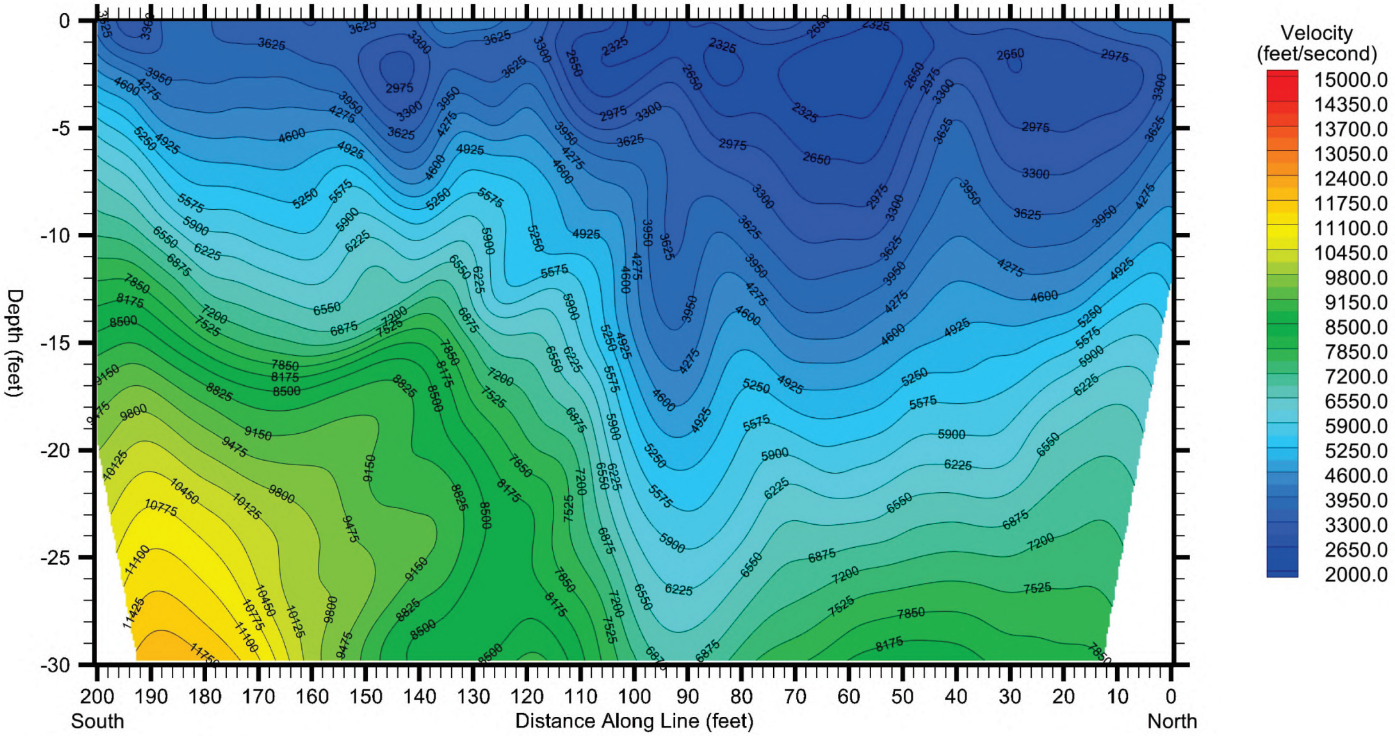
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLCS-02 2D Elevation Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2.5

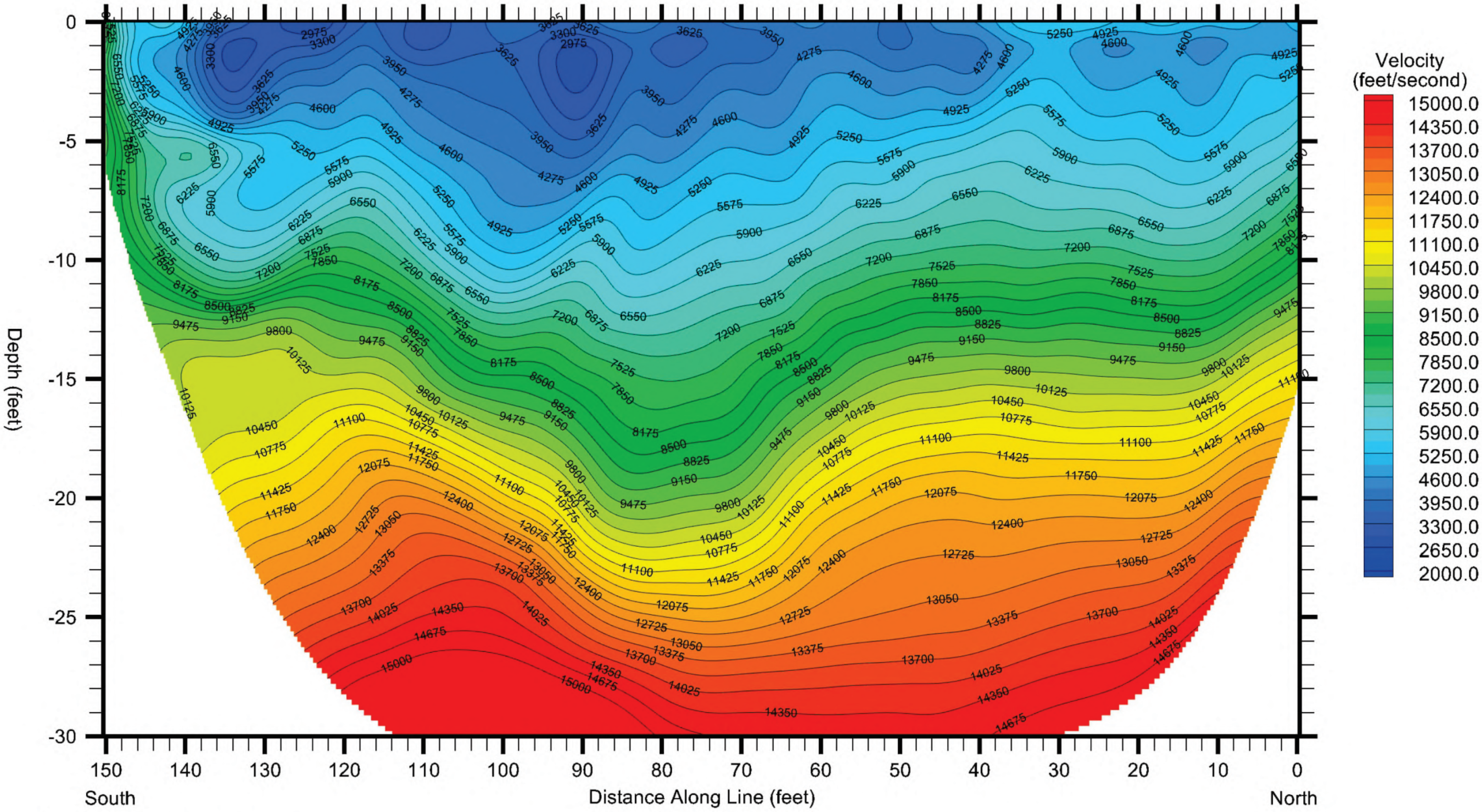
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-01 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 4

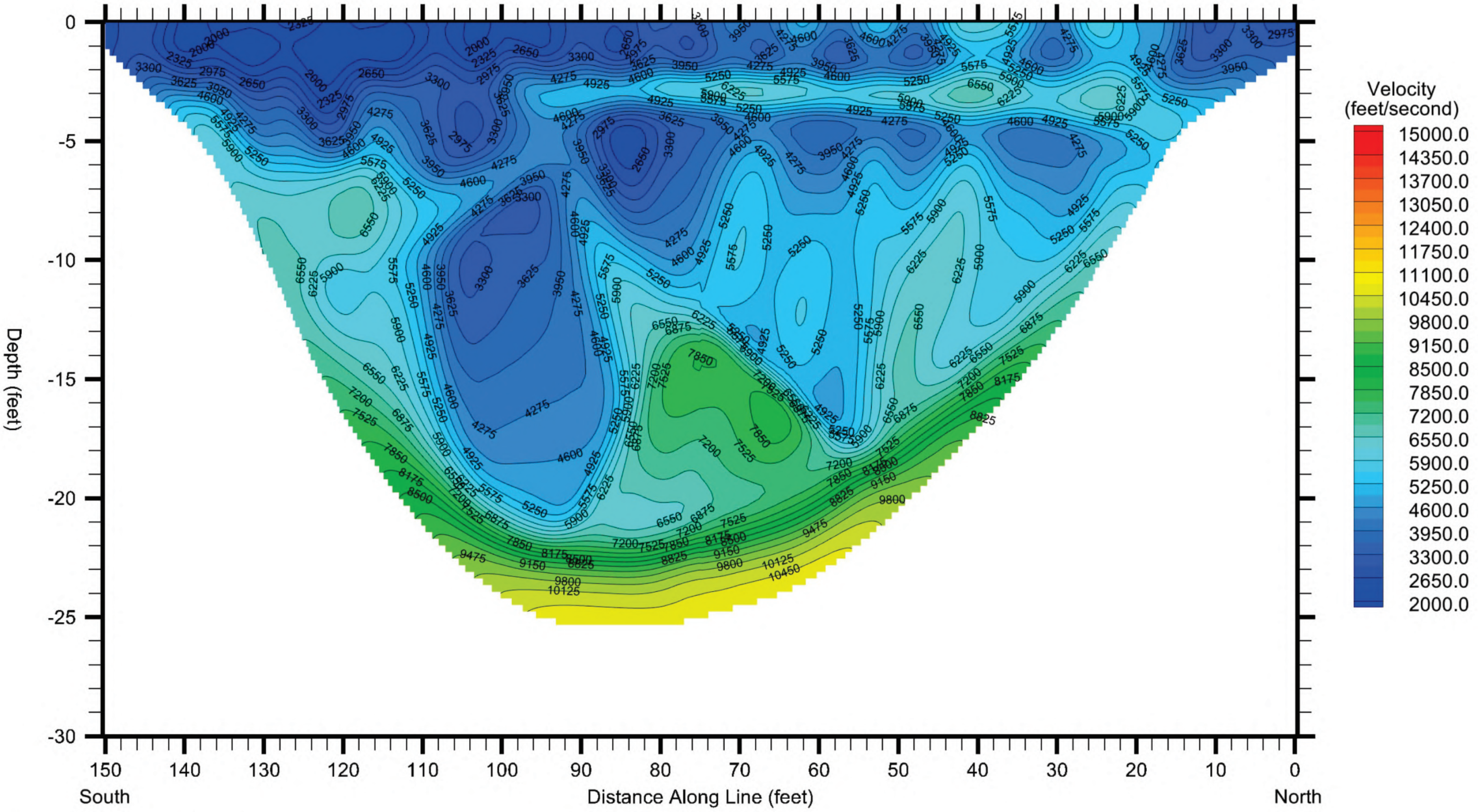
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-02 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

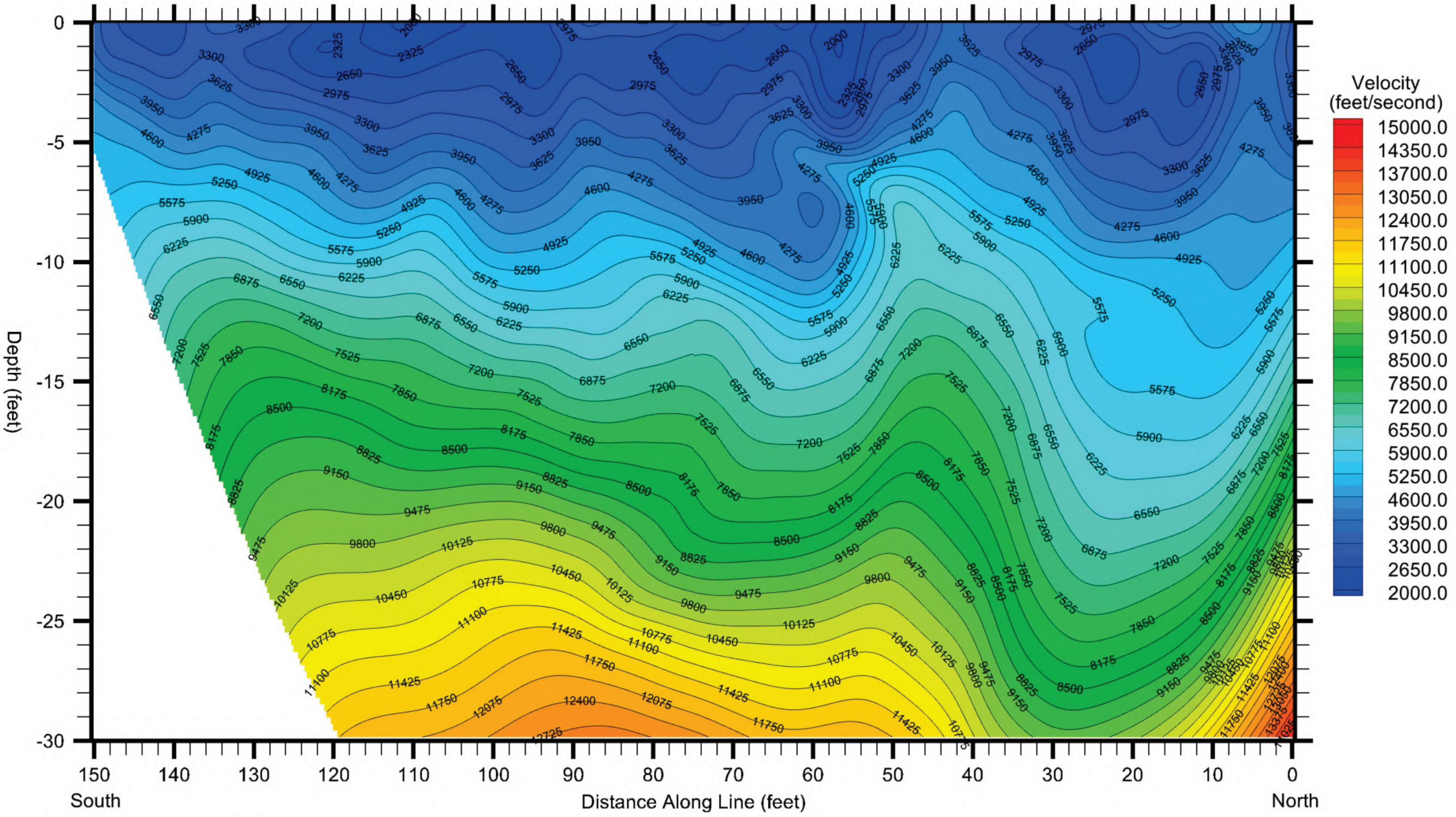
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-03 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

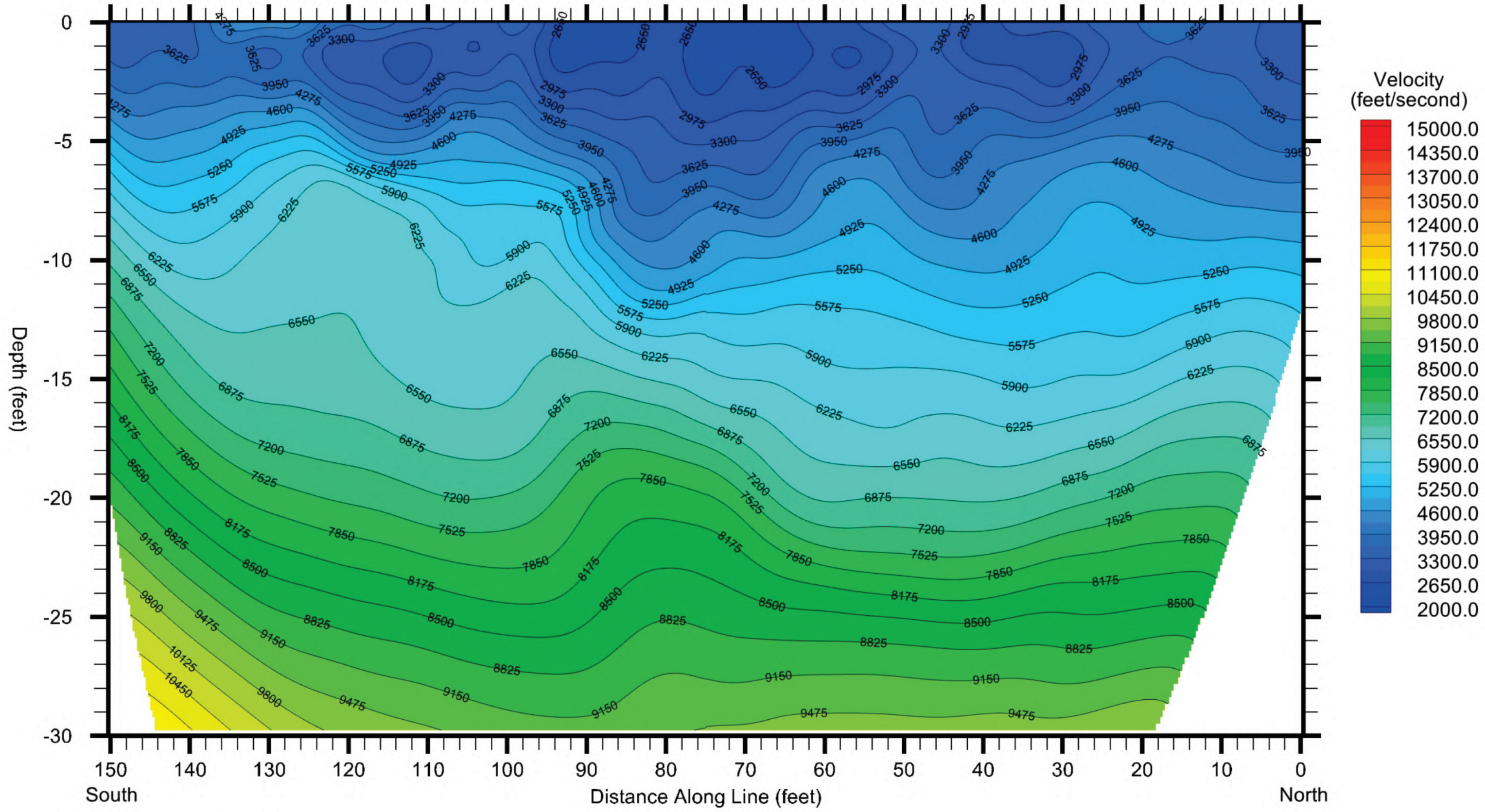
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-04 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

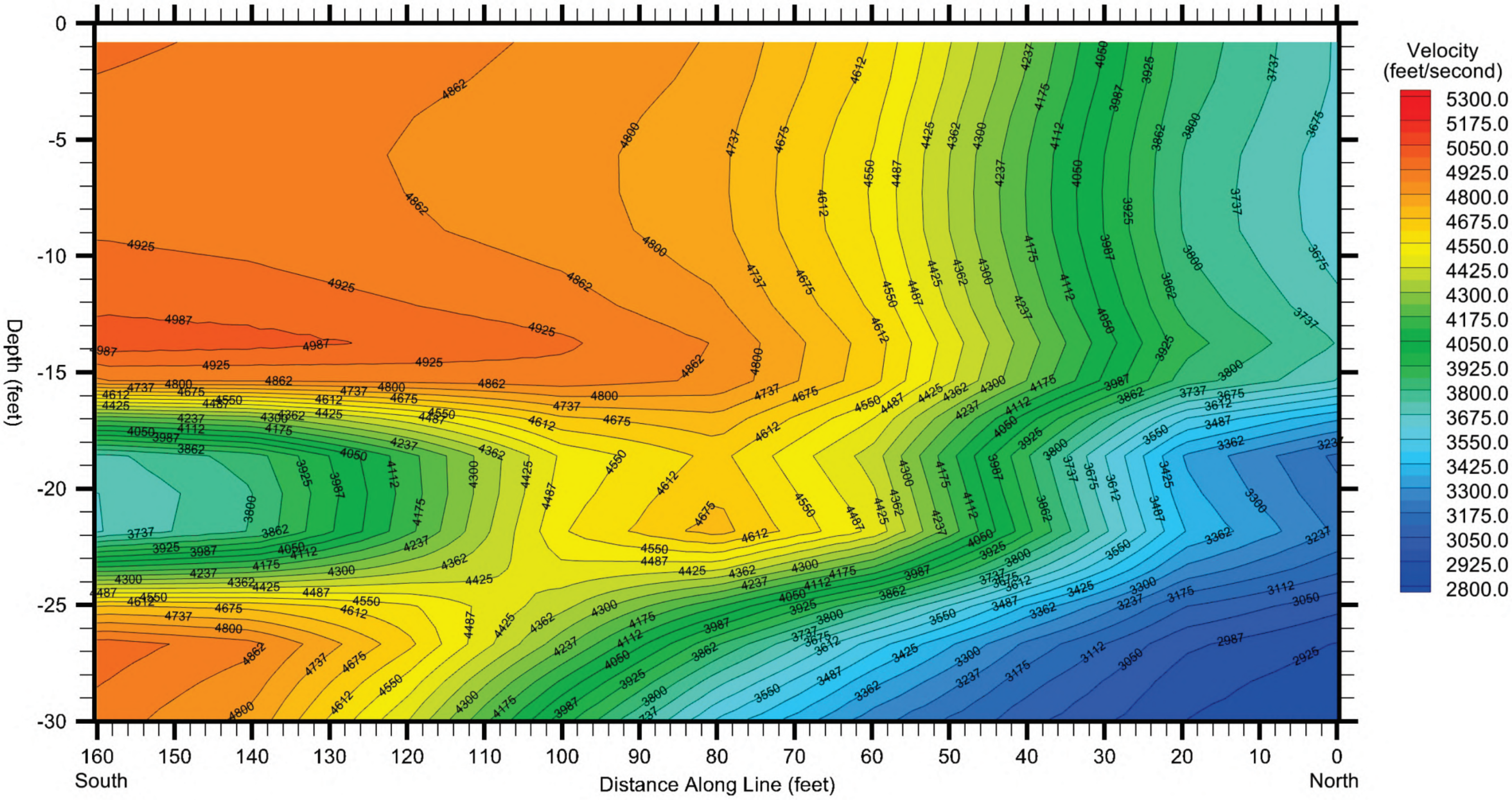
SR89 Roadway Improvements
P-Wave Refraction Seismic Tomography Survey
Line SLRW-05 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-01 2D Cross-Section

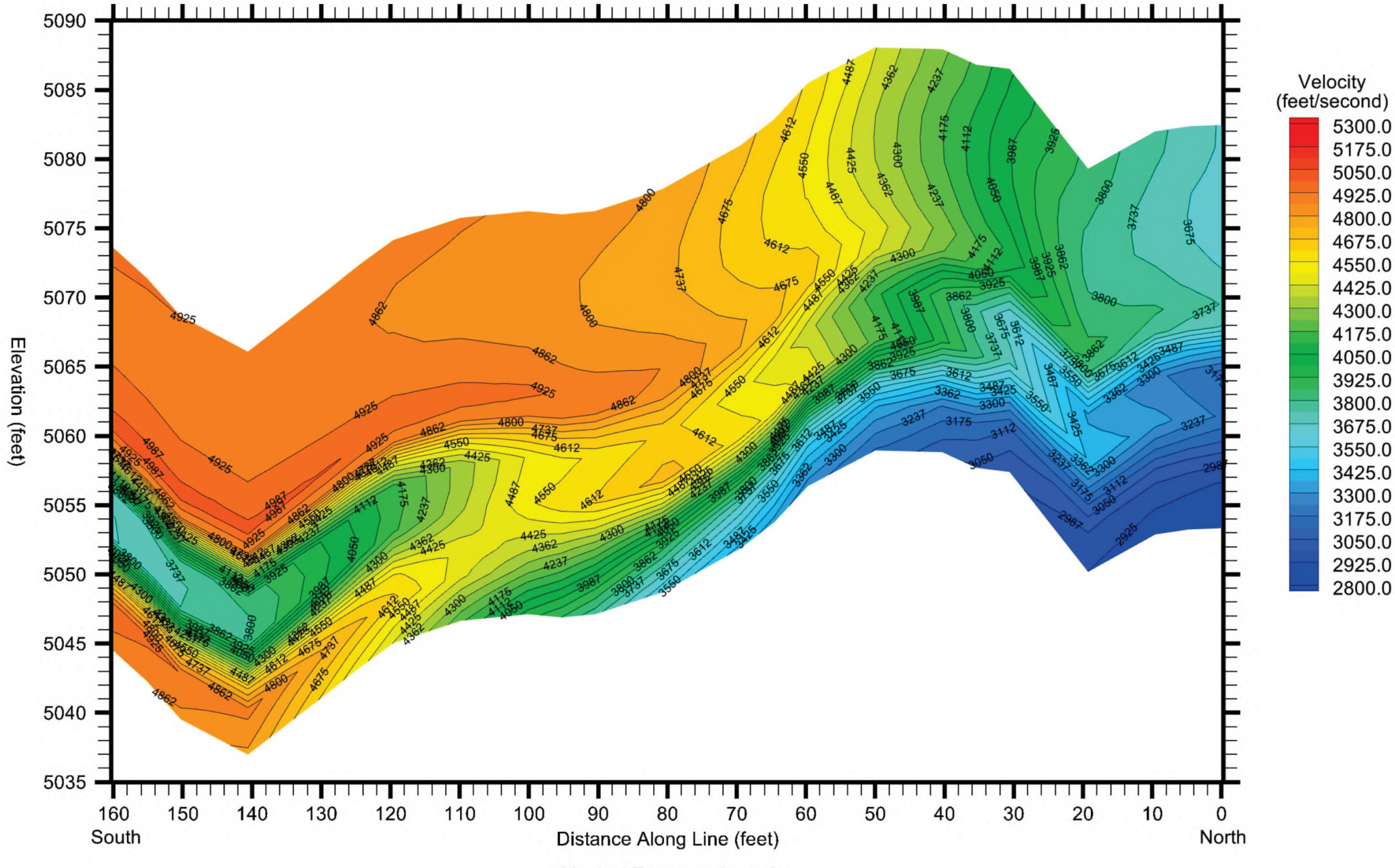


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

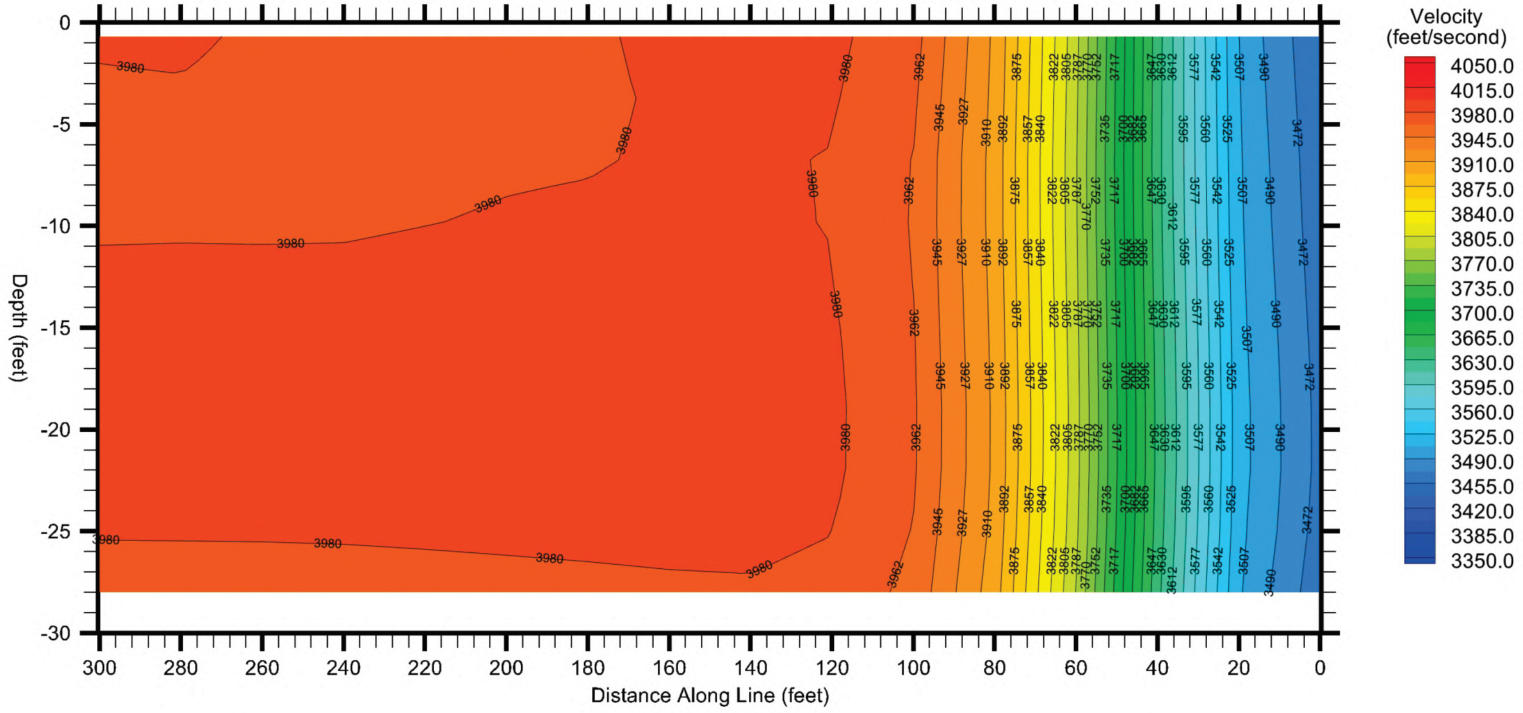
Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-01 2D Elevation Cross-Section



Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-02 2D Cross-Section

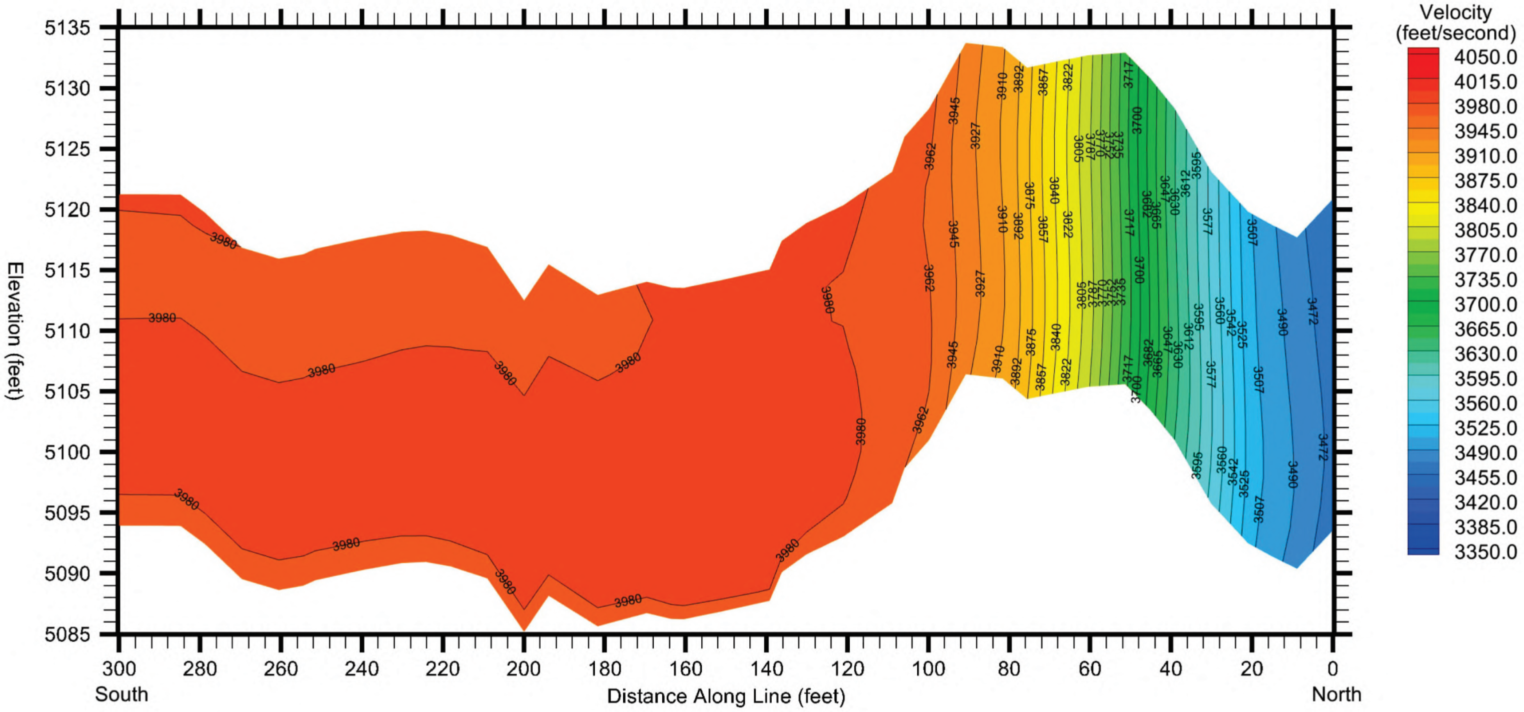


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 5

Use results with extreme caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLCS-02 2D Elevation Cross-Section

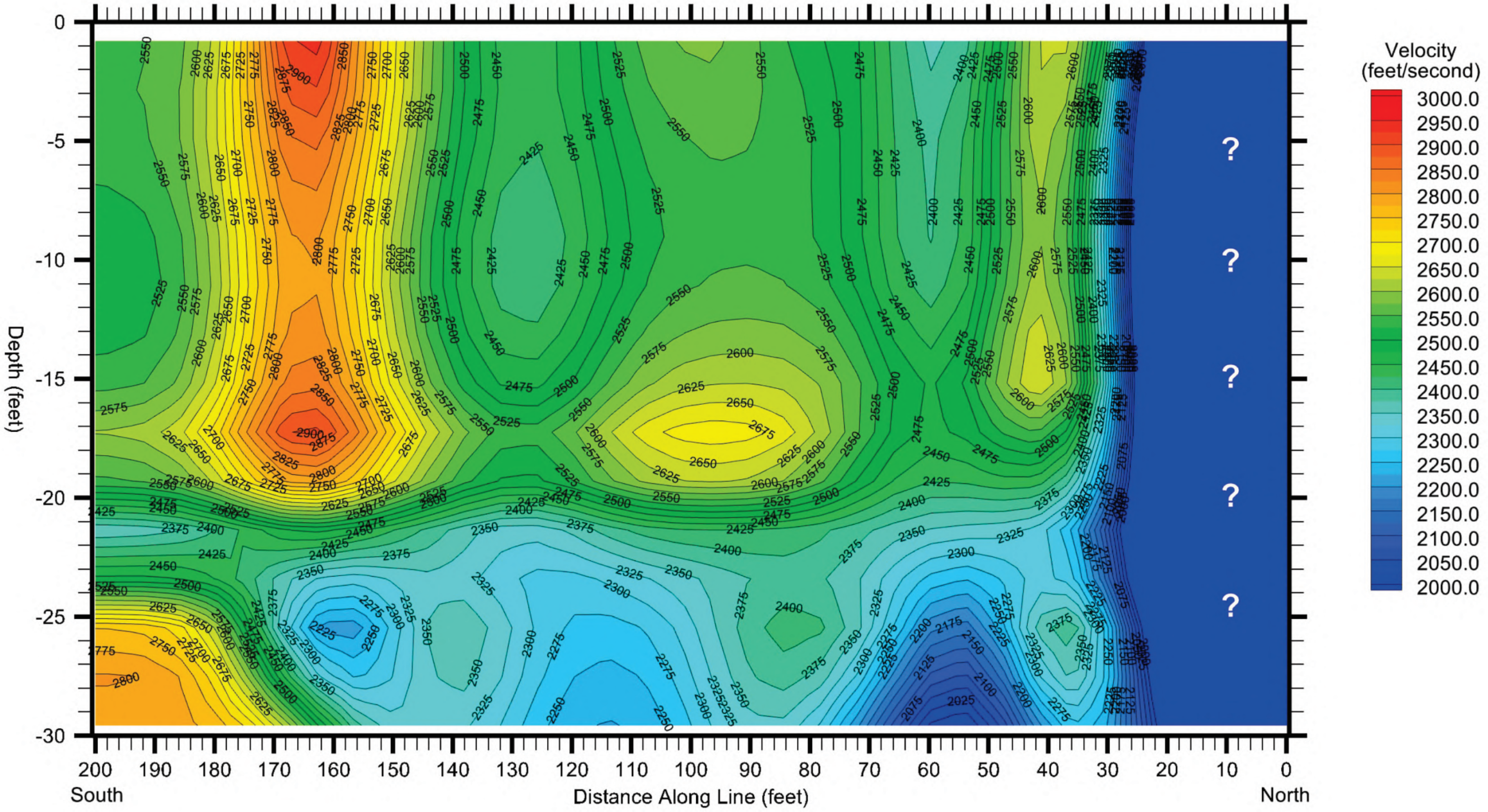


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with extreme caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-01 2D Cross-Section

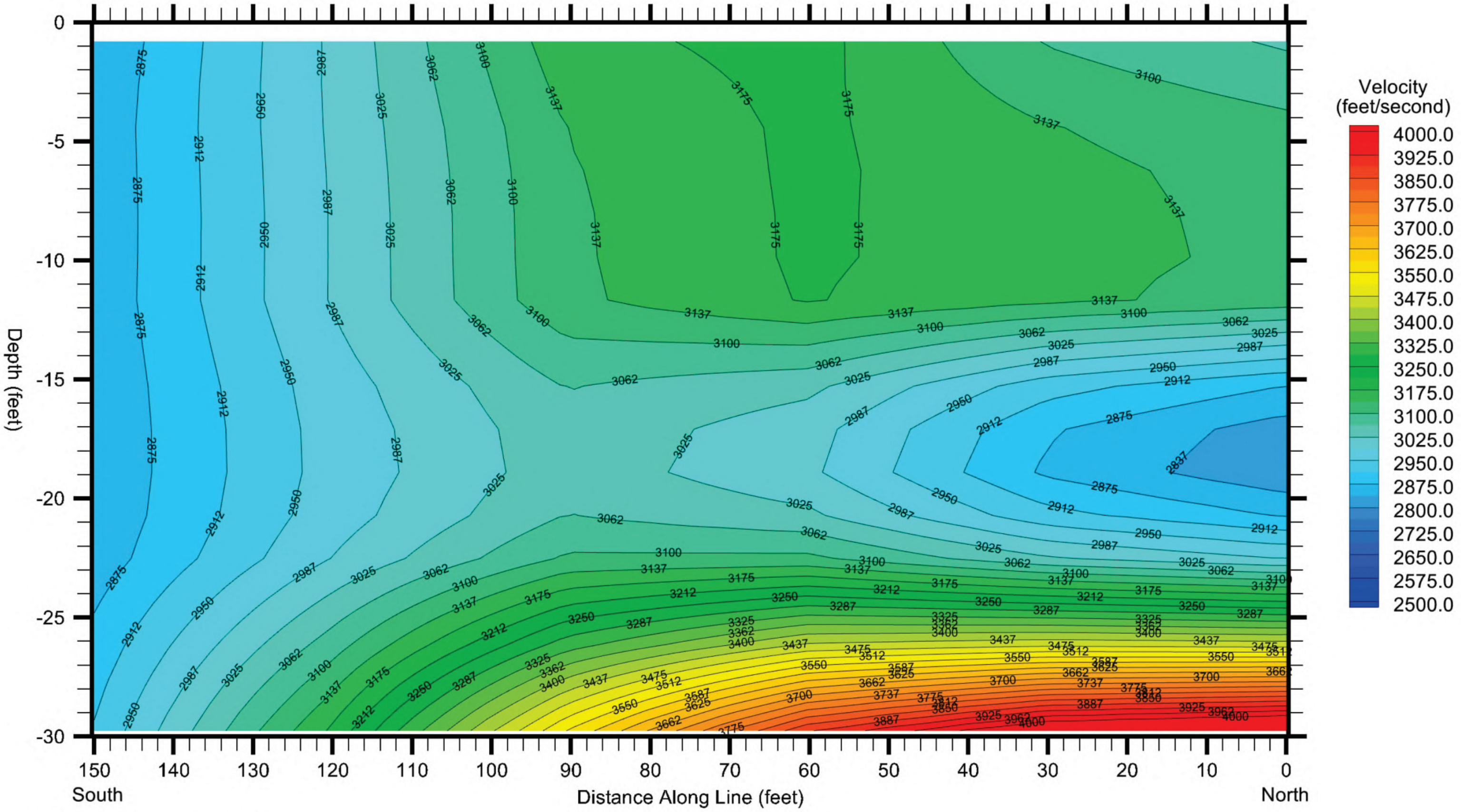


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 4

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-02 2D Cross-Section

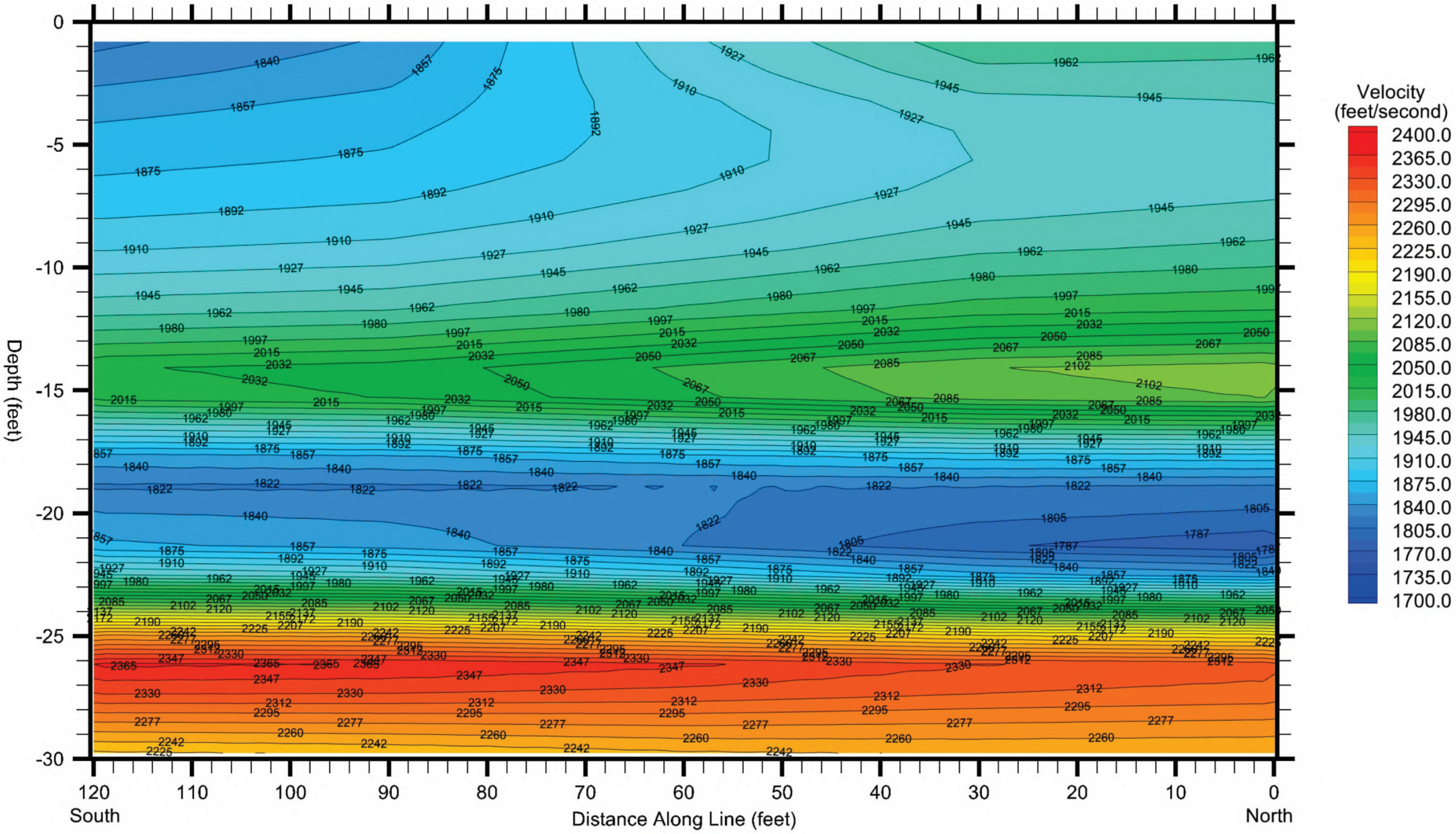


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-03 2D Cross-Section

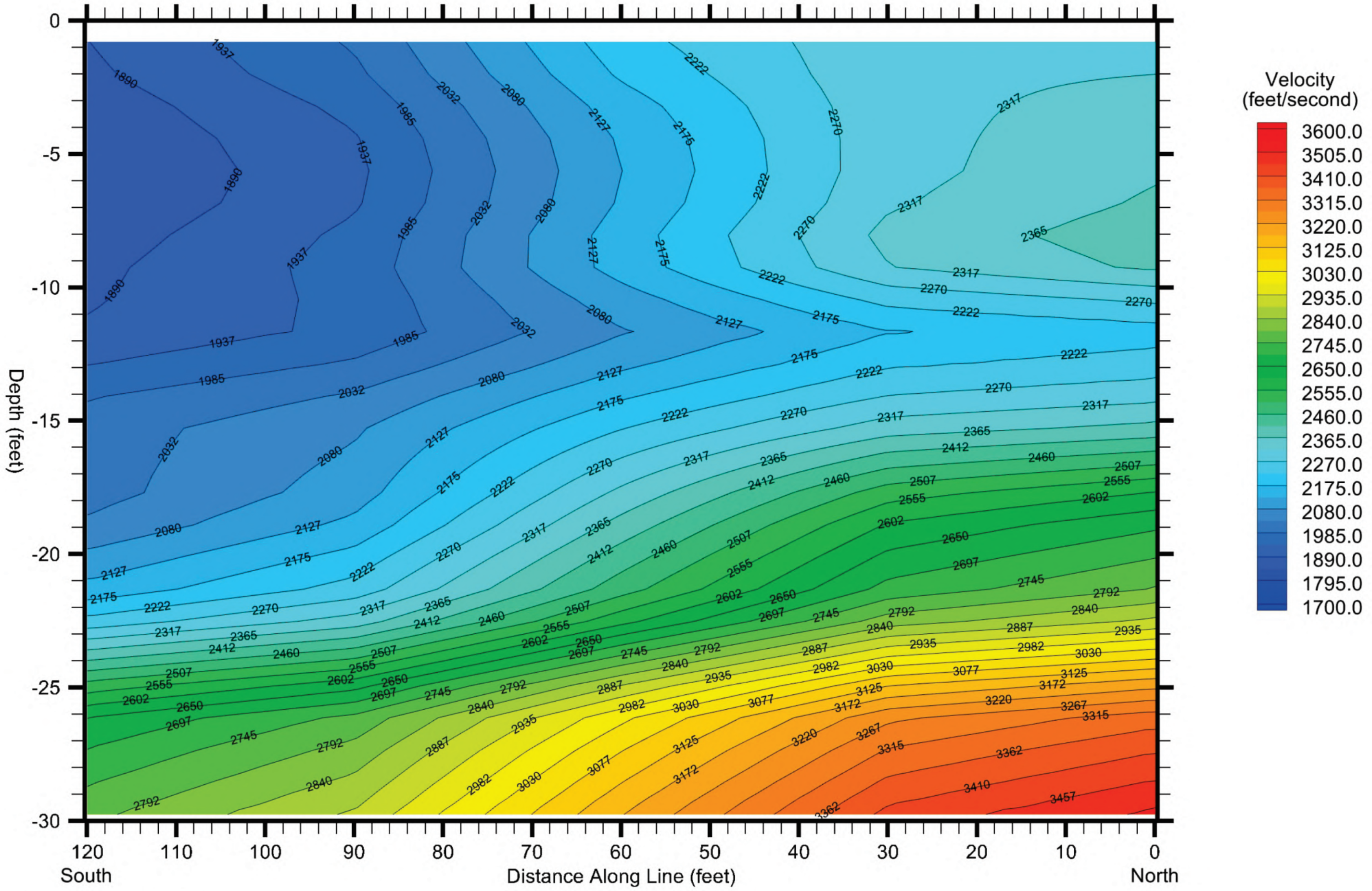


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 2.5

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-04 2D Cross-Section

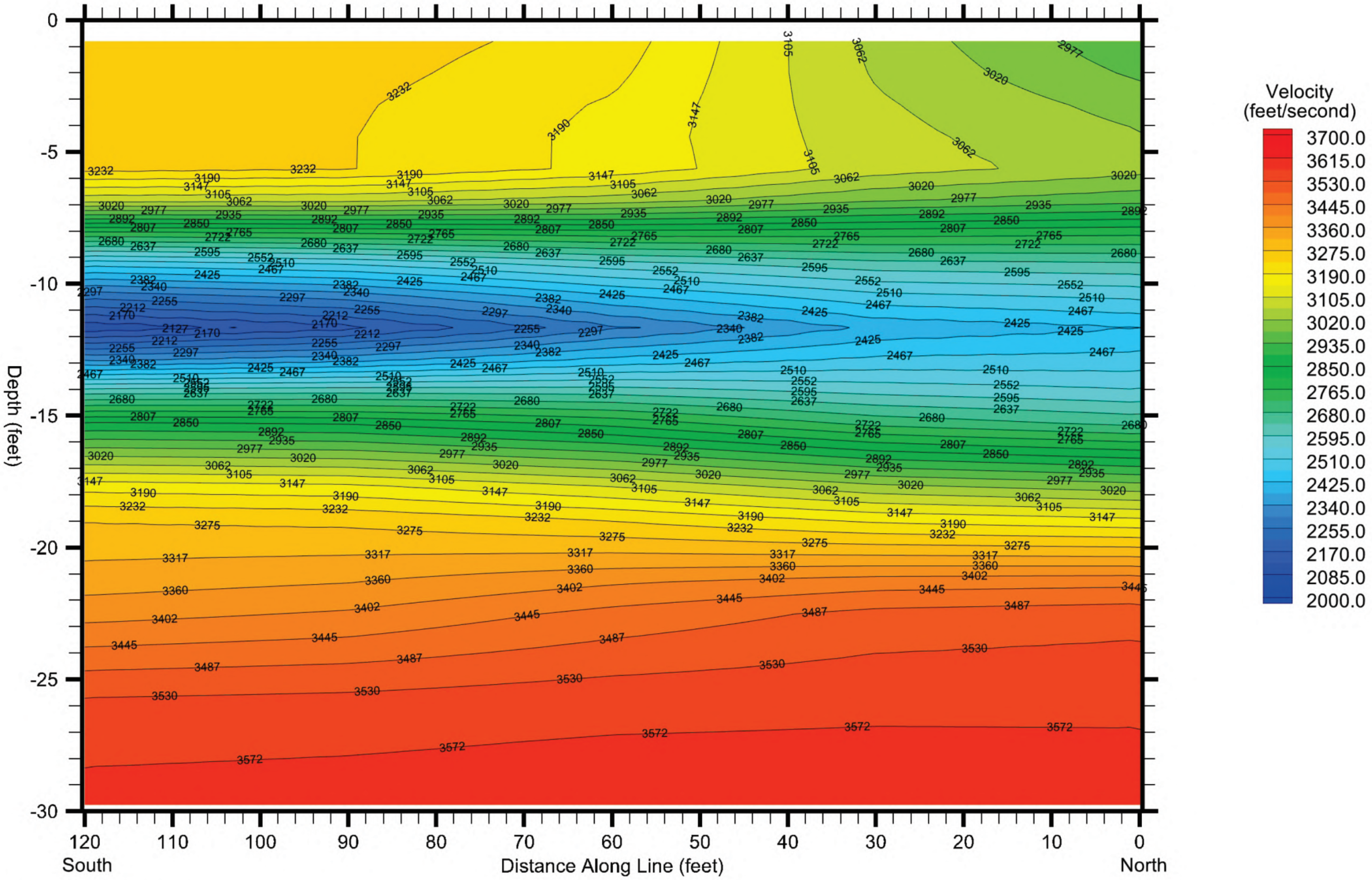


Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

SR89 Roadway Improvements
MASW Shear-Wave Survey
Line SLRW-05 2D Cross-Section



Hasbrouck Geophysics, Inc.

Vertical Exaggeration = 3

Use results with caution!

Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
Field	121	81	JS	30	2.5	617665	611560	5060
Field	119	81	JS	30	2.5	617665	611560	5060
Field	322	40	JS	15	13	617665	611560	5060
Field	326	34	SJ	10	-	617665	611560	5060
Field	216	86	JS	20	8	617665	611560	5060
Field	23	85	JS	16	7	617665	611560	5060
Field	88	32	SJ	18	-	617665	611560	5060
Field	126	85	JS	30	2	617350	610730	5100
Field	123	82	JS	50	2	617350	610730	5100
Field	201	78	JS	17	4	617350	610730	5100
Field	201	76	JS	17	4	617350	610730	5100
Field	259	71	SJ	5	-	617350	610730	5100
Field	53	82	FT	30	-	617350	610730	5100
Field	52	68	SJ	9	-	617350	610730	5100
Field	7	25	SJ	25	-	617350	610730	5100
Field	121	85	JS	50	2	617430	610950	5096
Field	131	68	FT	50	-	617430	610950	5096
Field	132	64	JS	30	3	617430	610950	5096
Field	135	63	JS	30	3	617430	610950	5096
Field	320	62	JS	18	3.5	617430	610950	5096
Field	326	52	JS	4	2.5	617430	610950	5096
Field	140	82	JS	20	2	617430	610950	5096
Field	141	84	JS	20	2	617430	610950	5096
Field	336	27	SJ	16	-	617430	610950	5096
Field	131	68	JS	18	4.5	617430	610950	5096
PC	33	48	MJ	-	-	618253	612960	5079
PC	46	52	MJ	-	-	618453	613500	5049
PC	66	60	MJ	-	-	618446	614017	5045
PC	64	65	MJ	-	-	618421	613991	5038
PC	47	66	MJ	-	-	618461	613495	5046
PC	312	68	MJ	-	-	617748	611871	5087
PC	31	70	MJ	-	-	618088	612568	5081
PC	298	71	MJ	-	-	618440	614000	5040
PC	27	72	MJ	-	-	617403	611186	5126
PC	29	73	MJ	-	-	617613	611779	5125
PC	307	73	MJ	-	-	618482	613523	5057
PC	204	74	MJ	-	-	618446	613506	5050
PC	213	75	MJ	-	-	618507	613601	5046

JS = Joint Set
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MN = Minor Structure

Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
PC	310	76	MJ	-	-	618593	613901	5038
PC	72	79	MJ	-	-	617466	611305	5110
PC	297	81	MJ	-	-	617442	611168	5095
PC	63	84	MJ	-	-	618112	612553	5069
PC	209	85	MJ	-	-	618472	613600	5048
PC	201	86	MJ	-	-	617408	611227	5093
PC	303	87	MJ	-	-	618409	614013	5037
PC	249	40	MJ	-	-	617398	610670	5152
PC	34	46	MJ	-	-	618256	612963	5075
PC	28	52	MJ	-	-	617562	611161	5097
PC	62	57	MJ	-	-	617621	611269	5099
PC	26	58	MJ	-	-	617674	611429	5068
PC	30	60	MJ	-	-	618289	612605	5065
PC	38	63	MJ	-	-	618428	613434	5038
PC	210	63	MJ	-	-	618095	612595	5071
PC	306	66	MJ	-	-	617958	612007	5072
PC	216	69	MJ	-	-	616500	607887	5192
PC	18	72	MJ	-	-	617139	610127	5141
PC	18	74	MJ	-	-	617047	610332	5135
PC	113	75	MJ	-	-	617132	610019	5154
PC	243	76	MJ	-	-	617535	611058	5095
PC	246	79	MJ	-	-	617583	611211	5103
PC	121	81	MJ	-	-	617534	611584	5092
PC	33	82	MJ	-	-	617275	610843	5113
PC	129	83	MJ	-	-	618292	612906	5070
PC	123	84	MJ	-	-	618447	613473	5055
PC	32	89	MJ	-	-	617453	610757	5122
PC	131	90	MJ	-	-	617567	611241	5093
PC	208	90	MJ	-	-	616235	607768	5184
PC	306	68	MN	-	-	616251	607885	5188
PC	299	81	MN	-	-	616270	607851	5200
PC	295	87	MN	-	-	616296	607842	5200
PC	296	83	MN	-	-	616279	607831	5195
PC	295	89	MN	-	-	616302	607870	5194
PC	112	83	MN	-	-	616283	607825	5199
PC	295	79	MN	-	-	616245	607851	5195
PC	108	90	MN	-	-	616248	607831	5197
PC	236	79	MN	-	-	616308	607856	5200

JS = Joint Set
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Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
PC	220	78	MN	-	-	616248	607843	5196
PC	28	89	MN	-	-	616236	607866	5190
PC	323	38	MN	-	-	616227	607838	5190
PC	113	79	MN	-	-	616269	607823	5195
PC	332	46	MN	-	-	616292	607798	5199
PC	230	75	MN	-	-	616304	607827	5192
PC	297	79	MN	-	-	616262	607820	5196
PC	20	71	MN	-	-	616228	607827	5191
PC	119	72	MN	-	-	616251	607830	5197
PC	301	86	MN	-	-	616224	607849	5194
PC	116	82	MN	-	-	616246	607891	5186
PC	156	63	MN	-	-	616268	607865	5203
PC	119	79	MN	-	-	616215	607853	5189
PC	52	56	MN	-	-	616298	607827	5201
PC	42	82	MN	-	-	616161	607850	5168
PC	210	87	MN	-	-	616159	607846	5170
PC	25	90	MN	-	-	616154	607839	5169
PC	36	76	MN	-	-	616161	607862	5168
PC	298	69	MN	-	-	616197	607876	5171
PC	121	58	MN	-	-	616212	607884	5171
PC	343	41	MN	-	-	616229	607861	5170
PC	346	16	MN	-	-	616194	607858	5166
PC	23	85	MN	-	-	616212	607880	5171
PC	43	86	MN	-	-	616196	607876	5168
PC	43	86	MN	-	-	616181	607881	5171
PC	298	84	MN	-	-	616153	607893	5158
PC	120	76	MN	-	-	616188	607873	5169
PC	338	46	MN	-	-	616191	607885	5170
PC	335	37	MN	-	-	616211	607868	5168
PC	304	83	MN	-	-	616154	607842	5171
PC	295	86	MN	-	-	616177	607871	5173
PC	121	82	MN	-	-	616160	607842	5170
PC	113	71	MN	-	-	616164	607880	5166
PC	299	88	MN	-	-	616154	607888	5163
PC	297	87	MN	-	-	616157	607881	5167
PC	115	83	MN	-	-	617082	610437	5128
PC	121	85	MN	-	-	617078	610293	5137
PC	299	88	MN	-	-	617061	610301	5136

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Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
PC	117	80	MN	-	-	617059	610377	5143
PC	118	81	MN	-	-	617078	610363	5137
PC	293	88	MN	-	-	617027	610313	5139
PC	292	89	MN	-	-	617015	610328	5135
PC	120	84	MN	-	-	617047	610382	5141
PC	296	84	MN	-	-	617045	610402	5142
PC	292	86	MN	-	-	617032	610393	5132
PC	292	86	MN	-	-	617001	610319	5128
PC	18	69	MN	-	-	617088	610437	5127
PC	26	61	MN	-	-	617084	610407	5127
PC	16	70	MN	-	-	617094	610382	5129
PC	7	84	MN	-	-	617068	610371	5147
PC	21	73	MN	-	-	617055	610326	5142
PC	5	69	MN	-	-	617033	610342	5126
PC	196	86	MN	-	-	617043	610367	5143
PC	27	82	MN	-	-	617033	610317	5141
PC	205	68	MN	-	-	617031	610302	5130
PC	111	88	MN	-	-	617099	610012	5165
PC	296	55	MN	-	-	617021	609666	5153
PC	297	75	MN	-	-	617074	609822	5153
PC	271	39	MN	-	-	617031	609835	5170
PC	127	77	MN	-	-	617049	609962	5169
PC	122	69	MN	-	-	617084	609948	5181
PC	219	72	MN	-	-	617051	609929	5153
PC	17	78	MN	-	-	617068	609952	5176
PC	38	81	MN	-	-	617093	609986	5164
PC	117	75	MN	-	-	617067	610019	5150
PC	304	63	MN	-	-	617085	610014	5168
PC	10	83	MN	-	-	617087	609971	5170
PC	24	81	MN	-	-	617114	610106	5163
PC	295	81	MN	-	-	617124	610082	5174
PC	110	85	MN	-	-	617116	610101	5169
PC	294	87	MN	-	-	617108	610102	5161
PC	297	84	MN	-	-	617107	610117	5155
PC	312	77	MN	-	-	617094	609943	5162
PC	298	89	MN	-	-	617060	609959	5176
PC	296	85	MN	-	-	617071	610002	5161
PC	27	51	MN	-	-	617050	609869	5162

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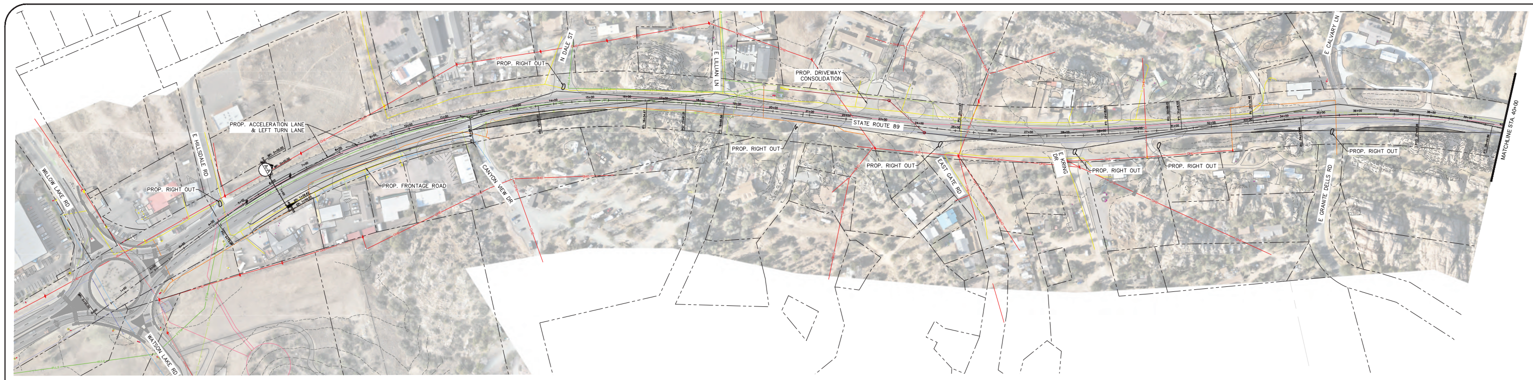
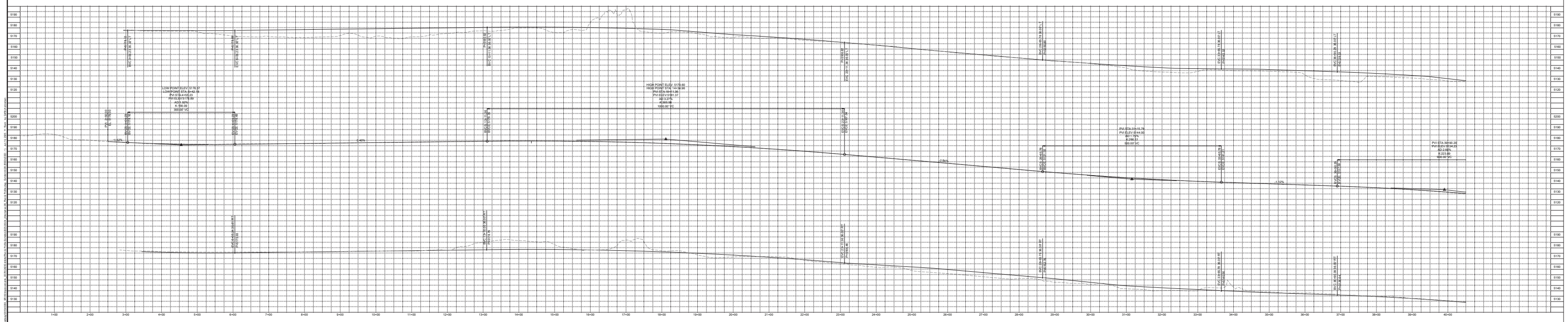
Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
PC	37	82	MN	-	-	617002	609889	5153
PC	115	89	MN	-	-	616992	609858	5157
PC	222	82	MN	-	-	617054	609939	5174
PC	296	83	MN	-	-	617049	609950	5170
PC	213	90	MN	-	-	616974	609784	5152
PC	25	80	MN	-	-	617013	609869	5167
PC	25	68	MN	-	-	617043	609914	5162
PC	20	73	MN	-	-	617045	609892	5160
PC	295	88	MN	-	-	617001	609902	5149
PC	293	87	MN	-	-	616999	609838	5164
PC	122	51	MN	-	-	617178	610228	5128
PC	287	81	MN	-	-	617234	610250	5130
PC	340	44	MN	-	-	617244	610254	5131
PC	112	77	MN	-	-	617228	610246	5131
PC	302	86	MN	-	-	617224	610259	5128
PC	318	73	MN	-	-	617137	610107	5159
PC	355	30	MN	-	-	617170	610240	5127
PC	288	81	MN	-	-	617170	610159	5141
PC	15	74	MN	-	-	617176	610026	5142
PC	316	23	MN	-	-	617154	609999	5142
PC	297	57	MN	-	-	617167	609994	5148
PC	296	78	MN	-	-	617177	610034	5141
PC	18	83	MN	-	-	617173	610017	5142
PC	4	74	MN	-	-	617163	610004	5144
PC	7	67	MN	-	-	617159	609995	5145
PC	299	79	MN	-	-	617170	610013	5144
PC	16	69	MN	-	-	617173	610249	5128
PC	210	59	MN	-	-	617219	610225	5133
PC	26	77	MN	-	-	617208	610226	5133
PC	33	89	MN	-	-	617184	610174	5133
PC	20	86	MN	-	-	617181	610170	5137
PC	28	60	MN	-	-	617171	610141	5142
PC	209	86	MN	-	-	617155	610141	5141
PC	19	80	MN	-	-	617164	610115	5147
PC	25	74	MN	-	-	617151	610106	5155
PC	116	88	MN	-	-	617158	610086	5158
PC	296	80	MN	-	-	617145	610107	5155
PC	195	87	MN	-	-	617272	611008	5103

JS = Joint Set
SJ = Single Joint
FT = Possible Fault
MJ = Major Structure
MN = Minor Structure

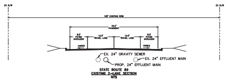
Source of Mapping	Dip Direction	Dip	Structure Type	Length (ft)	True Spacing (ft)	Coordinates (COPCS)		
						Easting	Northing	Elevation
PC	125	78	MN	-	-	617268	611013	5108
PC	300	60	MN	-	-	617265	611000	5106
PC	318	85	MN	-	-	617270	610956	5106
PC	289	48	MN	-	-	617261	610897	5127
PC	317	78	MN	-	-	617254	610905	5119
PC	304	85	MN	-	-	617188	610772	5144
PC	302	88	MN	-	-	617245	610768	5149
PC	15	77	MN	-	-	617245	610780	5136
PC	20	81	MN	-	-	617242	610715	5174
PC	309	22	MN	-	-	617159	610682	5190
PC	302	62	MN	-	-	617189	610716	5186
PC	326	6	MN	-	-	617237	610684	5166
PC	16	70	MN	-	-	617268	610725	5150
PC	22	84	MN	-	-	617256	610693	5150
PC	114	75	MN	-	-	617266	610670	5122
PC	120	86	MN	-	-	617237	610635	5140
PC	22	77	MN	-	-	617244	610719	5171
PC	11	74	MN	-	-	617204	610620	5166
PC	9	75	MN	-	-	617238	610654	5154
PC	12	72	MN	-	-	617232	610640	5151
PC	7	86	MN	-	-	617226	610677	5166
PC	122	89	MN	-	-	617181	610670	5184
PC	297	79	MN	-	-	617157	610687	5188
PC	298	76	MN	-	-	617161	610706	5185
PC	123	84	MN	-	-	617209	610621	5162
PC	130	83	MN	-	-	617189	610618	5159
PC	293	80	MN	-	-	617169	610264	5127
PC	121	82	MN	-	-	617182	610238	5128
PC	292	73	MN	-	-	617202	610223	5134
PC	295	71	MN	-	-	617195	610208	5131
PC	302	78	MN	-	-	617200	610226	5131
PC	129	82	MN	-	-	617177	610262	5130
PC	275	23	MN	-	-	617173	610240	5128

JS = Joint Set
SJ = Single Joint
FT = Possible Fault
MJ = Major Structure
MN = Minor Structure

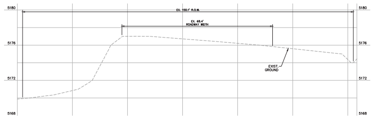




SECTION VIEWS



STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

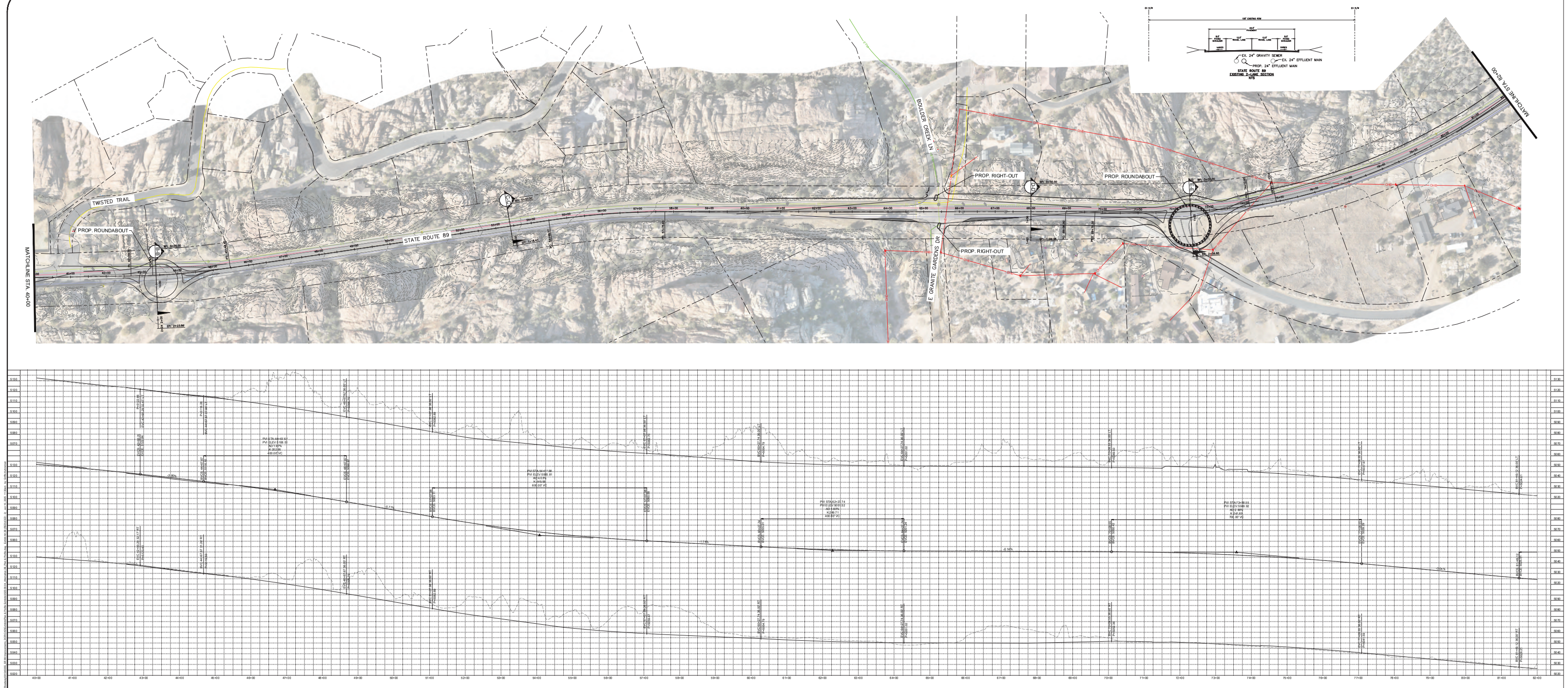


SECTION VIEW A-A

GRAPHIC SCALE IN FEET
0 30' 60' 120'

6/4/2025

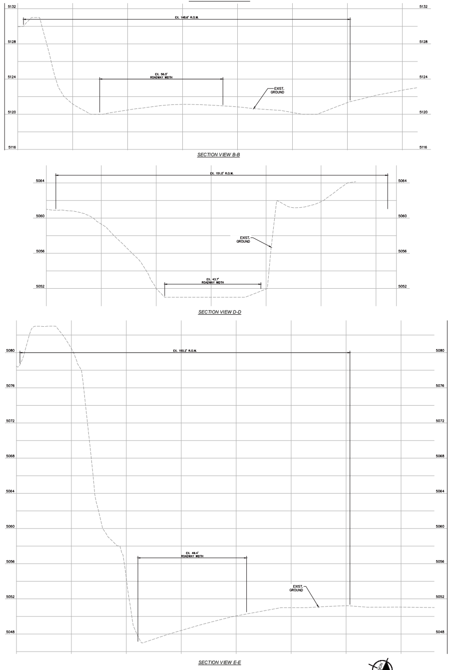
STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 2B EXHIBIT



STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 2B EXHIBIT

SECTION VIEWS



SECTION VIEW B-B

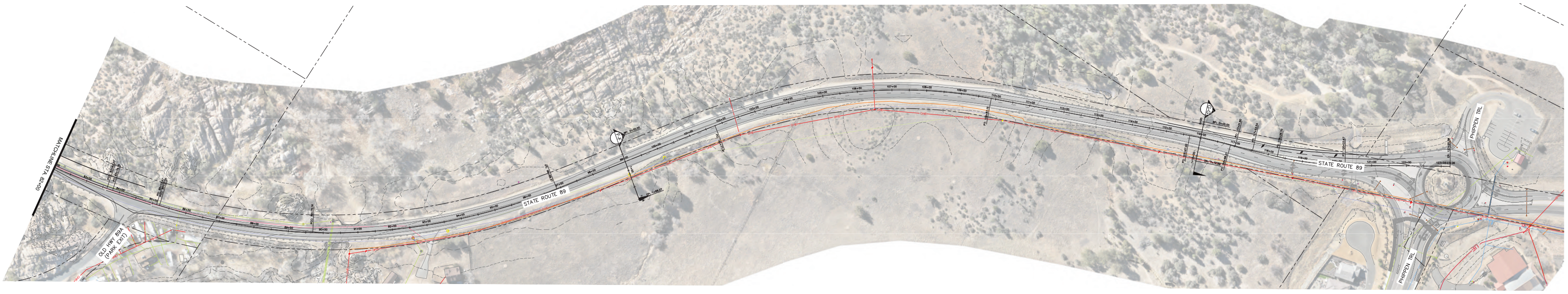
SECTION VIEW D-D

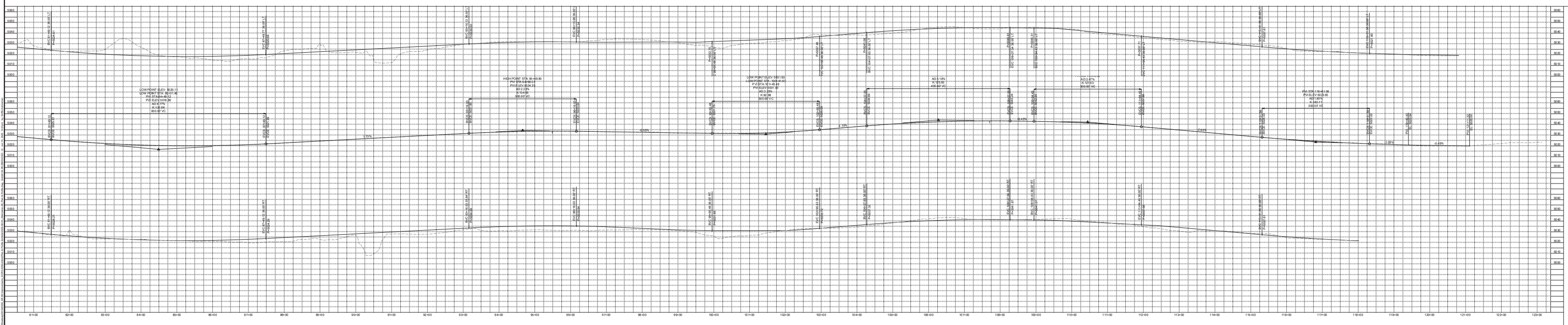
SECTION VIEW E-E

NORTH

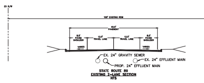
GRAPHIC SCALE IN FEET
0 30' 60' 120'

6/4/2025

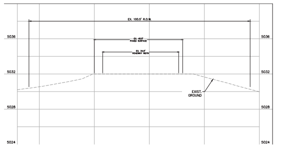




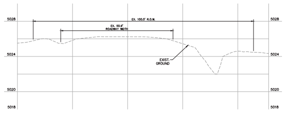
SECTION VIEWS



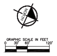
STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS



SECTION VIEW F-F



SECTION VIEW G-G



6/4/2025

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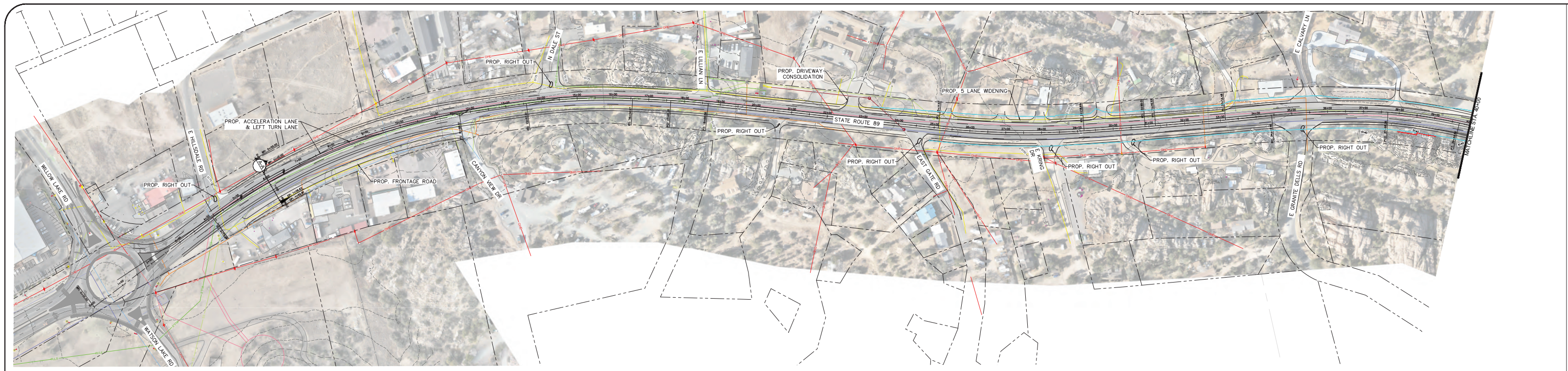
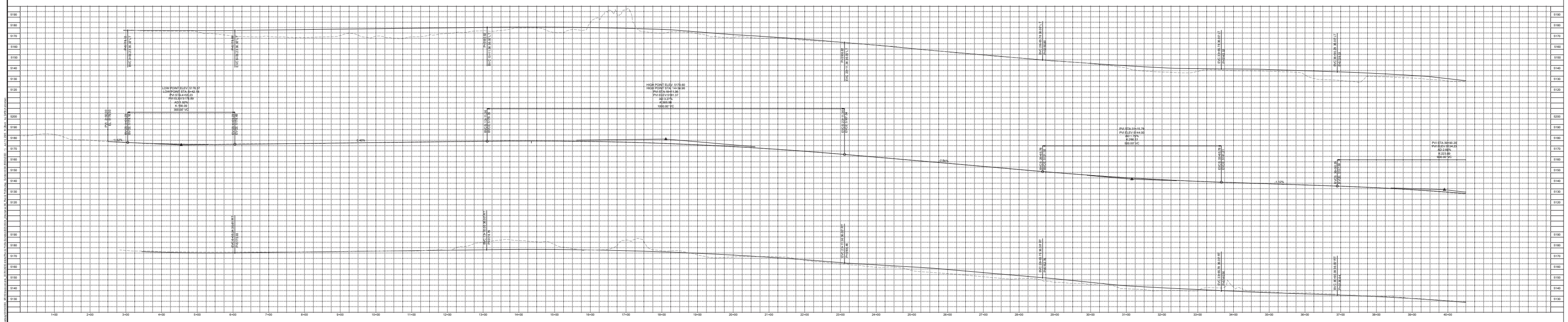
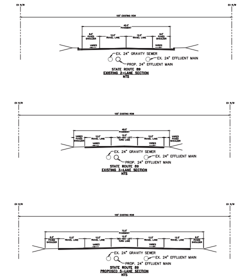
STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 2B EXHIBIT





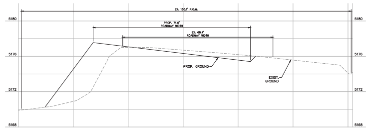
SECTION VIEWS



STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

STATE ROUTE 89
EXISTING 3-LANE SECTION
NTS

STATE ROUTE 89
PROPOSED 5-LANE SECTION
NTS



SECTION VIEW A-A

6/4/2025

STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 3B EXHIBIT

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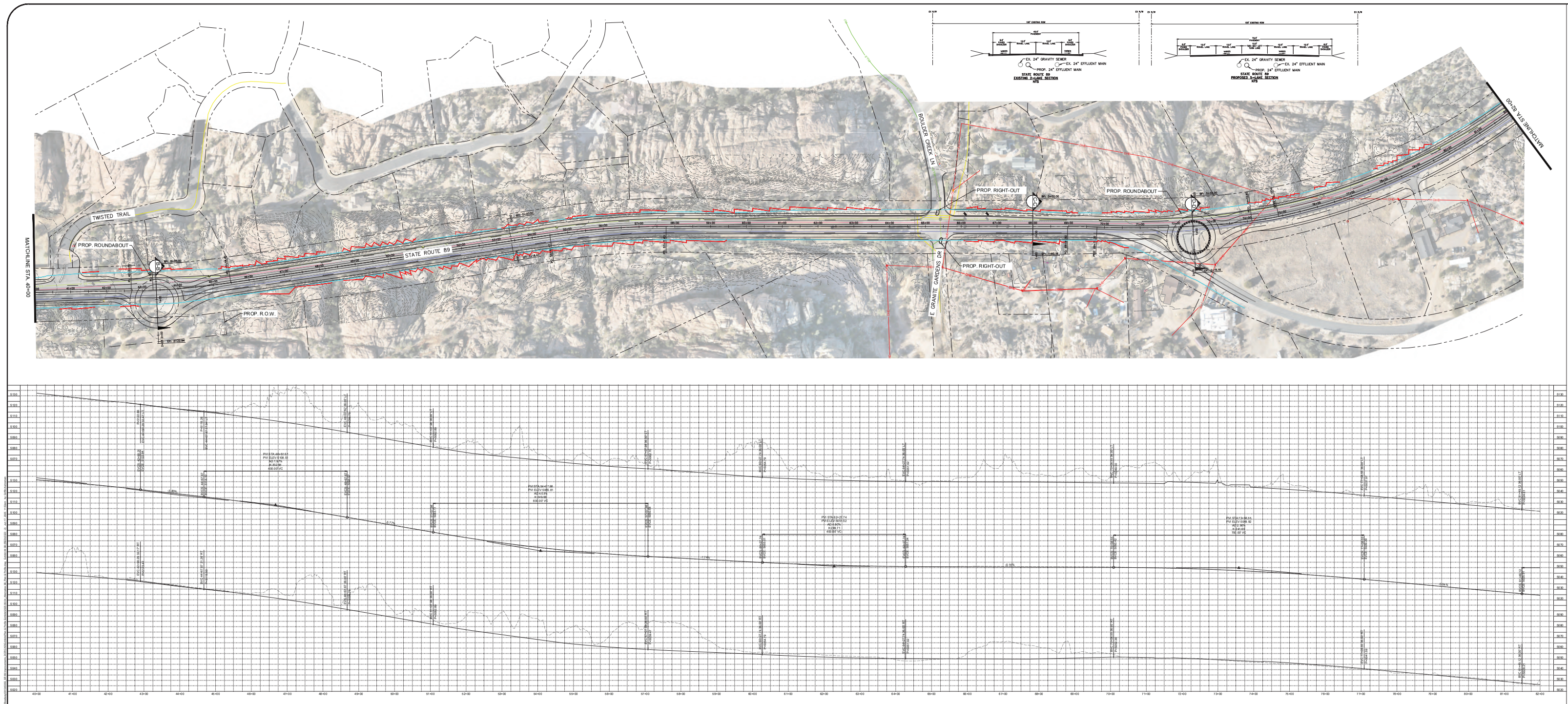
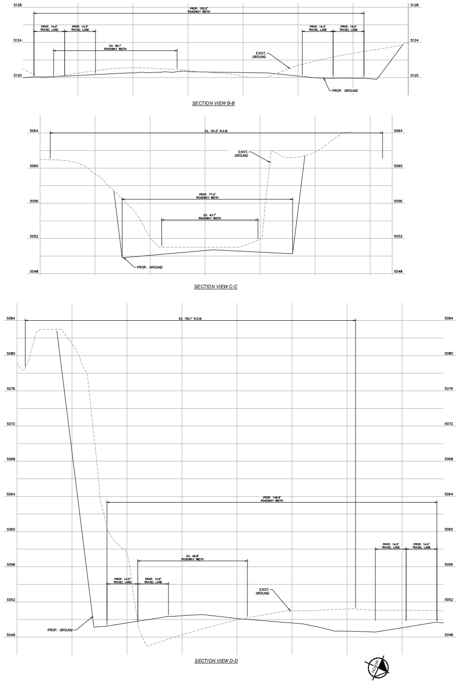


STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

STATE ROUTE 89
PROPOSED 5-LANE SECTION
NTS

SECTION VIEWS



SECTION VIEW B-B

SECTION VIEW C-C

SECTION VIEW D-D

NORTH

GRAPHIC SCALE IN FEET
0 30' 60' 120'

6/4/2025

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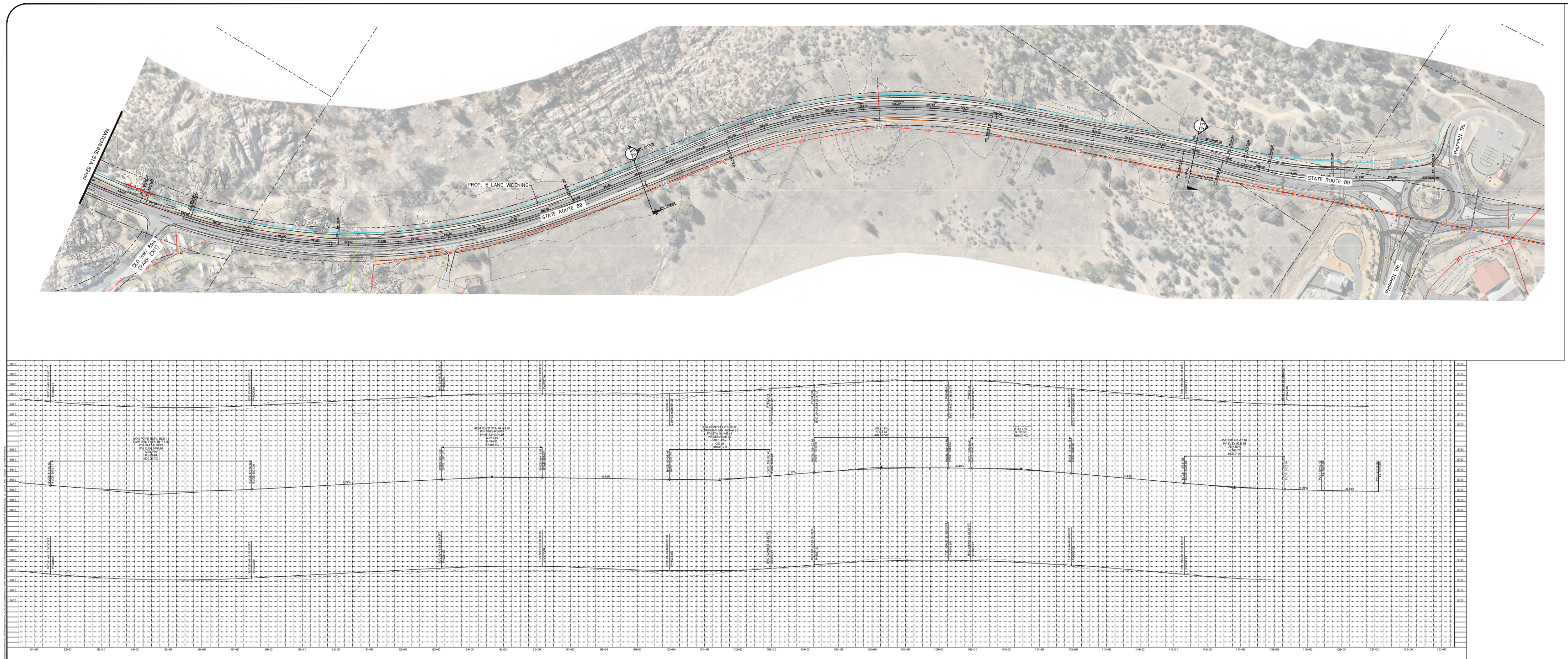
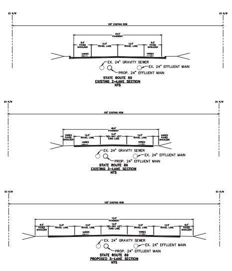
STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 3B EXHIBIT



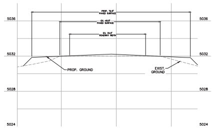
SECTION VIEWS



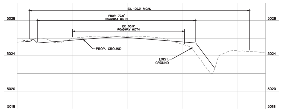
STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

STATE ROUTE 89
EXISTING 3-LANE SECTION
NTS

STATE ROUTE 89
PROPOSED 5-LANE SECTION
NTS



SECTION VIEW E-E



SECTION VIEW F-F

GRAPHIC SCALE IN FEET
0 30' 60' 120'

6/4/2025

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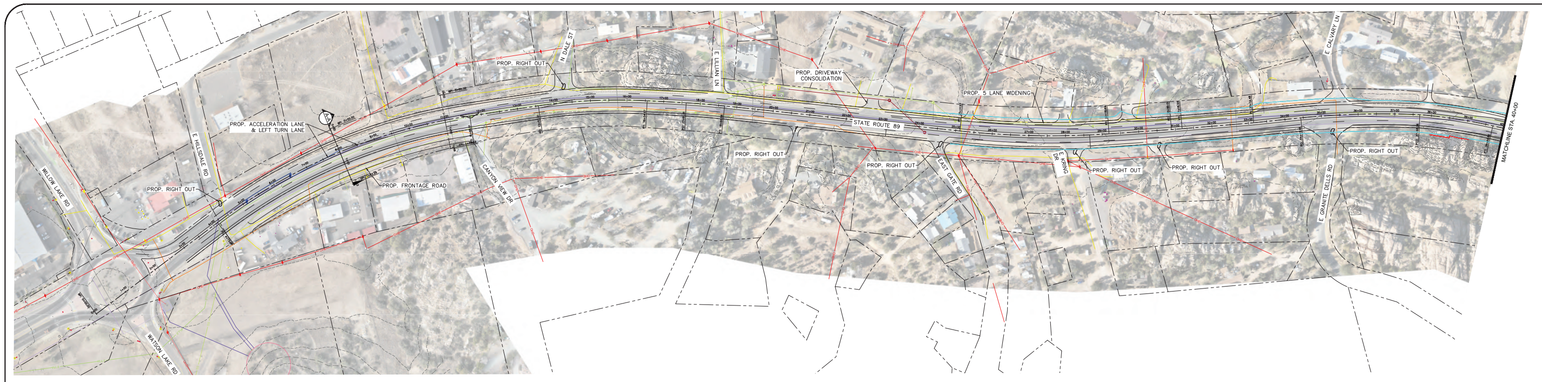
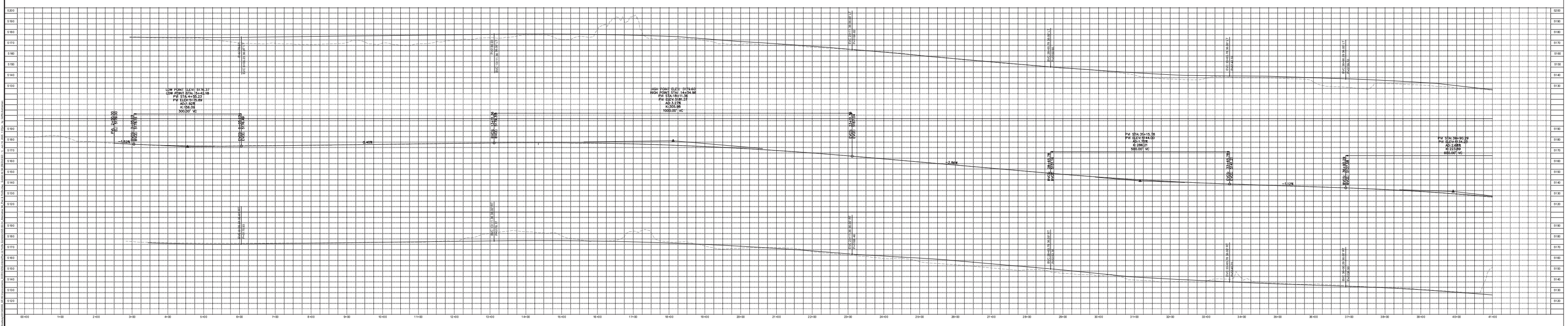
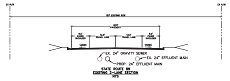
STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 3B EXHIBIT



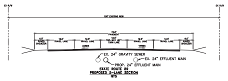


STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 5B EXHIBIT

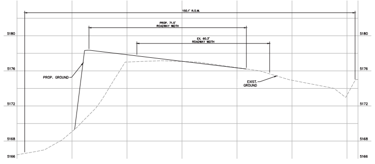
SECTION VIEWS



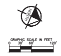
STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS



STATE ROUTE 89
PROPOSED 5-LANE SECTION
NTS



SECTION VIEW A-A



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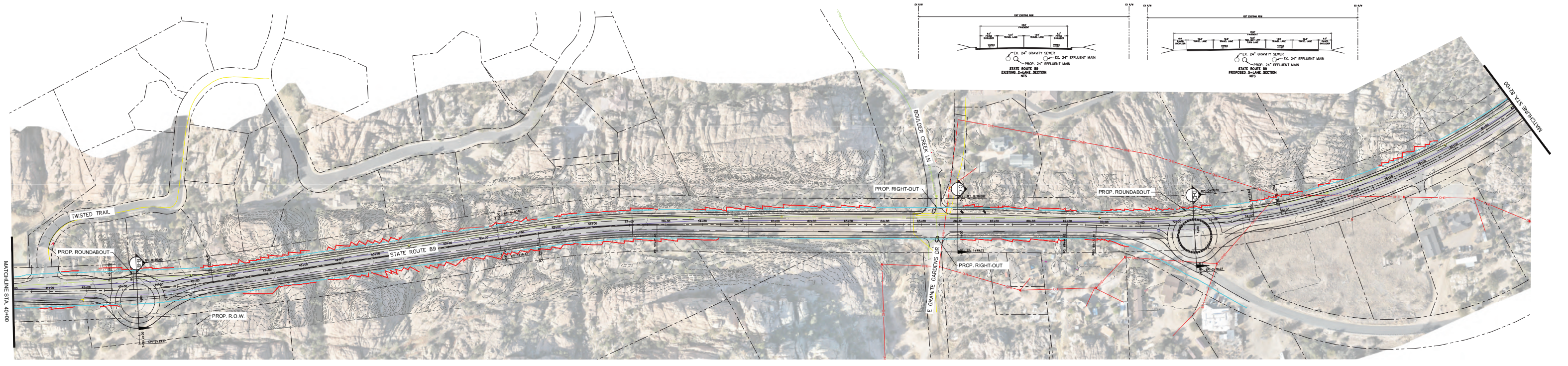

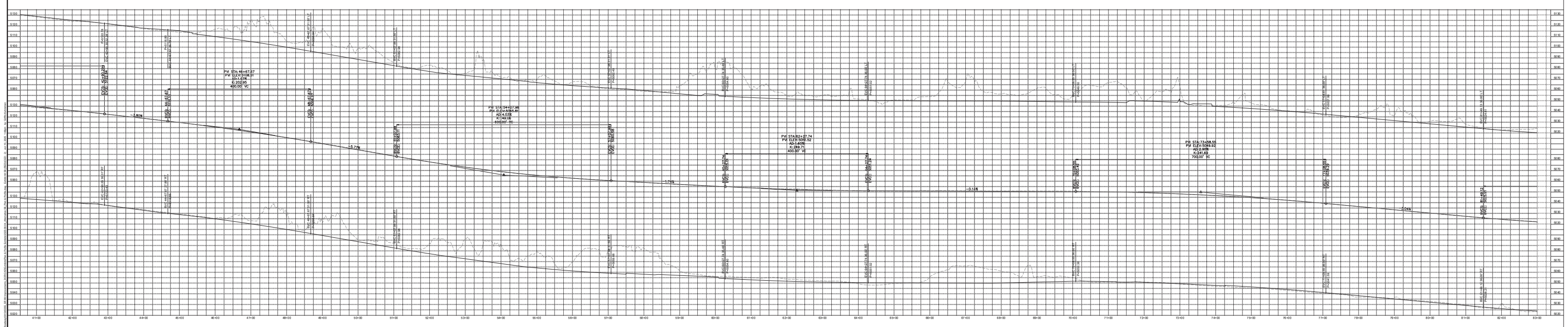

STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 5B EXHIBIT

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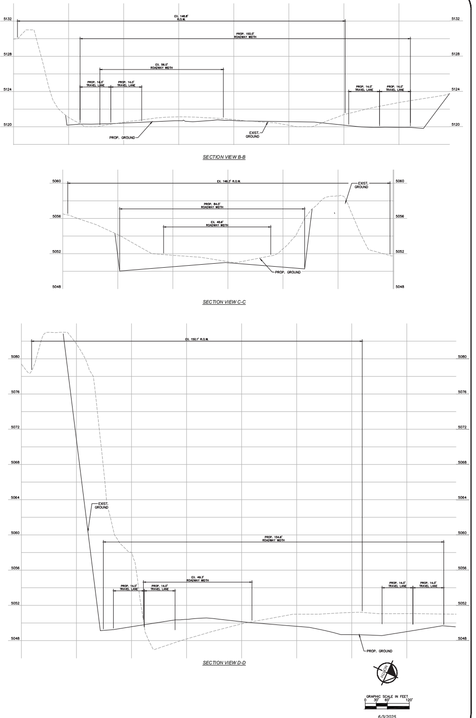
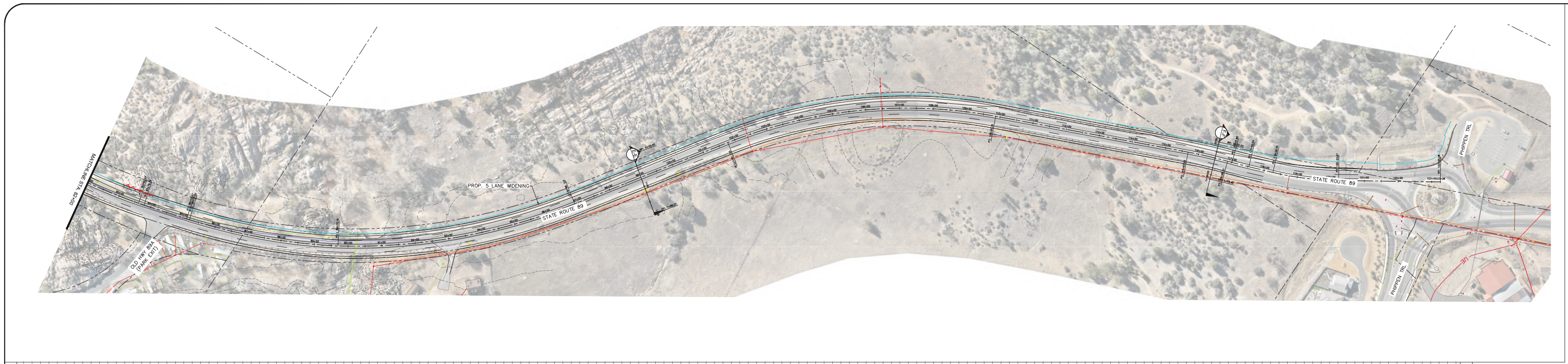
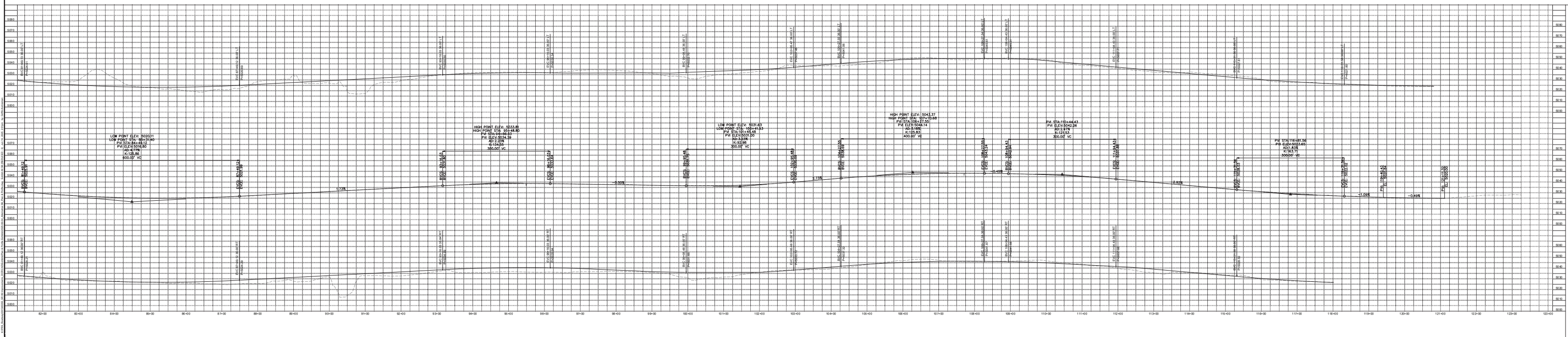
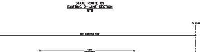
SECTION VIEWS





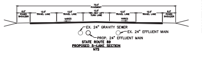


SECTION VIEWS

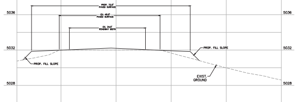


STATE ROUTE 89
EXISTING 2-LANE SECTION
NTS

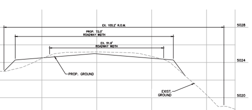
STATE ROUTE 89
EXISTING 3-LANE SECTION
NTS



STATE ROUTE 89
PROPOSED 5-LANE SECTION
NTS



SECTION VIEW E-E



SECTION VIEW F-F

GRAPHIC SCALE IN FEET
0 30' 60' 120'

6/3/2025

STATE ROUTE 89 ROADWAY IMPROVEMENTS ALTERNATIVE 5B EXHIBIT

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