July 20, 2015
Project No. 603956002

Ms. Linda Potter, P.E., CFM
Atkins North America
20860 North Tatum Boulevard
Phoenix, Arizona 85050

Subject: Addendum No. 1 to Geotechnical Evaluation Report
Queen Valley Flood Mitigation
Donna Drive and Jacque Drive
Queen Creek, Arizona

Dear Ms. Potter:

In accordance with our agreement dated June 25, 2015, Ninyo & Moore has performed supplemental geotechnical services related to the Queen Valley Flood Mitigation project in Queen Creek, Arizona. This letter serves as an addendum to our geotechnical report titled, "Geotechnical Evaluation, Queen Valley Flood Mitigation, Donna Drive and Jacque Drive, Queen Valley, Arizona", dated July 5, 2013. This letter presents our methodology and results of the seismic refraction surveys along the project alignment.

SCOPE OF SERVICES

The scope of our services for the project generally included:

- Conduct four seismic refraction survey lines along the planned channel alignment.
- Reduce and process the field data collected from the survey.
- Prepare this addendum letter report summarizing the results of our survey.

GEOPHYSICAL SEISMIC REFRACTION SURVEY RESULTS

Ninyo and Moore personnel conducted four seismic refraction surveys (denoted as SL-1 through SL-4) at the site on July 9, 2015 to evaluate the rippability and approximate depth to bedrock along the alignment. The approximate locations of the seismic lines are depicted on Figure 1. The seismic lines ranged from 90 to 100 feet in length.

The seismic refraction data was collected using a SmartSeis S12, high performance exploration seismograph and 12 vertical component geophones. A 16-pound hammer and metal plate were used as the seismic wave source. The seismic refraction method uses first-arrival times of refracted seismic waves in units of milliseconds to evaluate the thicknesses and seismic velocities of subsurface layers. Seismic waves generated by the hammer impacting the ground surface at a given "shot" point are refracted at boundaries separating materials of contrasting material velocities. These refracted seismic waves are then detected by a series of surface geophones and recorded with a seismograph. Each hammer shot is recorded as time zero and the elapsed time in milliseconds that the seismic compressional wave (P-wave) signals take to travel to each geophone are recorded. This information is used in conjunction with the known shot-to-geophone horizontal distances, to obtain the approximate thickness and velocity information about the subsurface materials.

The refraction method generally requires that subsurface velocities (and therefore material density) increase with depth. A layer having a velocity lower than that of the layer which overlies it will not be detectable by the seismic refraction method and, therefore, could lead to errors in the depth calculations of subsequent layers. This is known as a "velocity inversion" problem. In addition, relatively significant lateral variations in velocity, such as those which occur at buried discontinuous caliche deposits, cemented soils that are surrounded by lower velocity soils, or nested subsurface cobbles and boulders that are surrounded by lower velocity soils can also result in the misinterpretation of the subsurface conditions when using this method. These can create velocity inversion problems as these materials generally have a higher velocity than the surrounding materials, which will often mimic bedrock velocities which potentially might lead to possible erroneous interpretations of velocities and depths to bedrock.

In general, seismic wave velocities can be correlated to material density and/or rock hardness. The relationship between rippability and seismic velocity is empirical and assumes a homogenous mass for each detected layer. Possible areas of differing composition, texture, or structure may affect both the measured data and the actual rippability of the mass. The rippability

of a mass is also dependent on the excavation equipment used and the skill and experience of the equipment operator.

The rippability characteristics in Table 1 are based on our experience with similar materials. It assumes that a Caterpillar D-9 dozer ripping with a single shank is used. We emphasize that the cutoffs in this classification scheme are approximate and that soil characteristics can play a significant role in estimating excavation rates and rippability. In addition, where excavations encounter or penetrate weathered, fresh bedrock or cemented bedrock, the degree of weathering, degree of cementation (if any), or the presence or absence of fractures and/or joints, and fracture/joint spacing and orientation, also play a significant role in evaluating rock rippability. These soil and rock characteristics may also vary with location and depth. Our evaluation did not characterize the presence of bedrock fractures, joints, or bedding planes which can have an effect on rippability rate and excavatability.

Table 1 – Qualitative Rippability Classification

Velocity Range Feet/Second	Qualitative Rippability
0 to 2000 ft/s	Easy Ripping
2000 to 4000 ft/s	Moderate Ripping
4000 to 5500 ft/s	Difficult Ripping, Possible Blasting
5500 to 7000 ft/s	Very Difficult Ripping, Probable Blasting
Greater than 7000 ft/s	Blasting Generally Needed

It should be noted that the rippability estimates presented in Table 1 are slightly more conservative than those published in Edition 41 of the Caterpillar Performance Handbook. Accordingly, the above classification scheme should be used with discretion, and contractors should not be relieved of making their own independent evaluation of the rippability of the on-site materials prior to submitting their bids. It should also be noted that, as a general rule of thumb, the effective depth of evaluation for a seismic refraction traverse is approximately one-third to one-fifth the length of the refraction line.

Table 2 lists the average velocities and depths estimated from the seismic refraction traverses conducted during this evaluation. The estimated layer profiles are presented in Figures 2 through 5, which are attached. The lengths of the seismic refraction lines are listed, with their interpretations, in Table 2. The estimated rippability is based on the result of our seismic survey result, site observations, and experiences with similar materials.

It should be noted that gravel, cobbles and possible boulders were observed at the surface near the Survey Lines SL-1 and SL-2. Piles of cobbles and boulders were observed near Survey Lines SL-3 and SL-4, which were located in the middle of the wash. A layer of cemented material approximately 400 feet long was also observed near Survey Line SL-4. These conditions may impose additional difficulty to excavate, and, as such, slow the excavation rate. The contractor should be prepared for such conditions.

Table 2 – Seismic Refraction Results

Traverse No. and Length	Approximate Velocity Feet/Second	Approximate Depth to Bottom of Layer (range in feet below ground surface)	Estimated Rippability
SL-1 110 feet	1,300 2,400 3,200	<4 4 - 10 > 10	Easy Ripping Moderate Ripping Moderate Ripping
SL-2 90 feet	1,900 3,700 5400	<3.5 3.5 – 16 >16	Easy Ripping Moderate Ripping Difficult Ripping
SL-3 90 feet	2,400 3,800 4,800	<3 3 – 9 >9	Moderate Ripping* Moderate Ripping* Difficult Ripping*
SL-4 90 feet	4,500 3,900**	<2 >2	Difficult Ripping* Moderate Ripping*

*The presence of cobbles and boulders may slow excavation rate
**This velocity is estimated due to the presence of cemented layer on top

It should be noted that gravel, cobbles and possible boulders were observed at the surface near the Survey Lines SL-1 and SL-2. Piles of cobbles and boulders were observed near Survey Lines

SL-3 and SL-4, which were located in the middle of the wash. A layer of cemented material approximately 400 feet long was also observed near Survey Line SL-4. These conditions may impose additional difficulty to excavate, and, as such, slow the excavation rate. The contractor should be prepared for such conditions.

LIMITATIONS

The field evaluation and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of mankind at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the Client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the Client is undertaken at said parties' sole risk.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Jeffrey S. Rodgers, PE, PG
Senior Project Engineer

Registered Professional Engineer (Civil) CERTIFICATE NO. 60171 JEFFREY S. RODGERS Date Signed 7/20/15 ARIZONA U.S.A. Expires 9/30/18

Steven D. Nowaczyk, PE
Managing Principal Engineer

Registered Professional Engineer (Civil) CERTIFICATE NO. 34866 STEVEN D. NOWACZYK Date Signed 7-20-15 ARIZONA U.S.A. Expires 06-30-2018

JSR/SDN/tlp

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Figures
Figure 1 – Seismic Survey Locations
Figures 2 through 5 – Seismic Refraction Profiles

Source: NAVTEQ, 12/06/14.

N

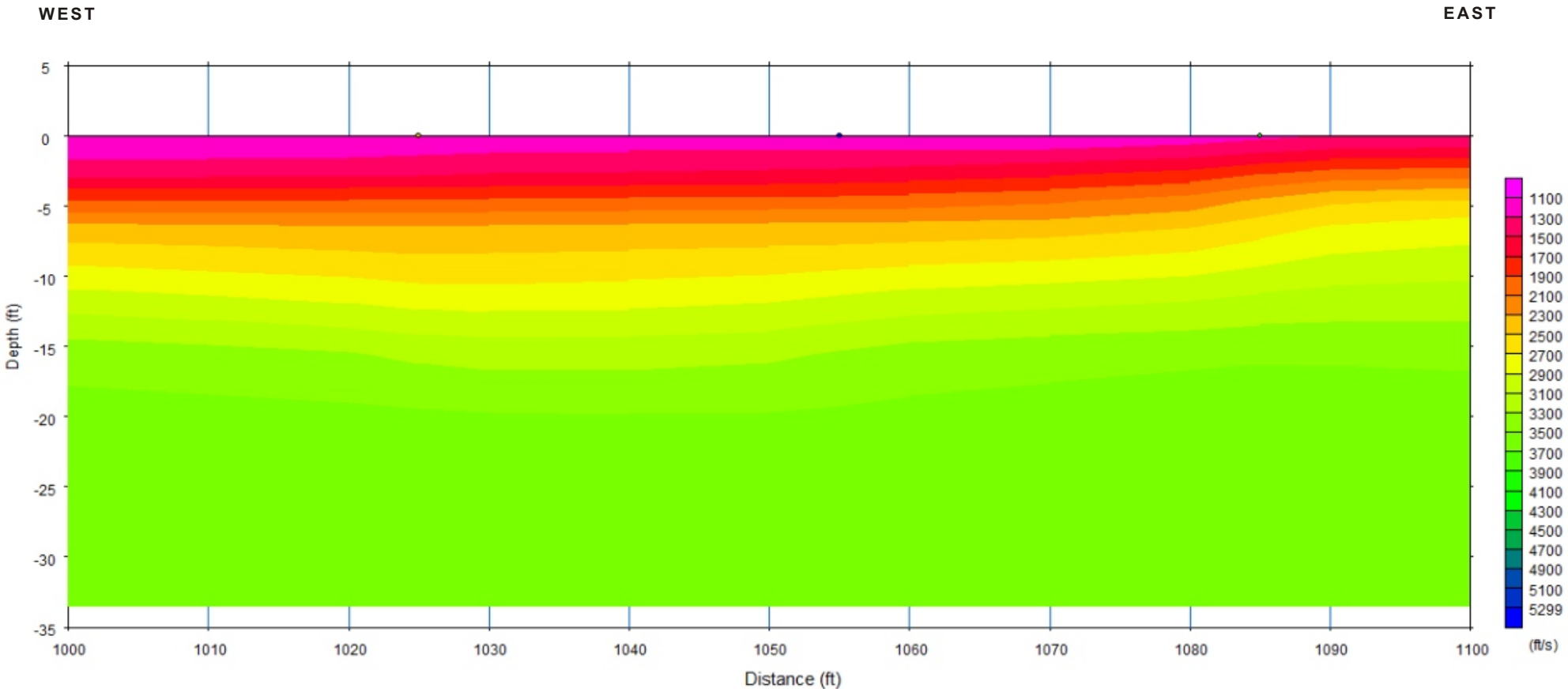
0 230

Approximate Scale:
1 inch = 230 feet

Note: Dimensions, directions, and locations are approximate.

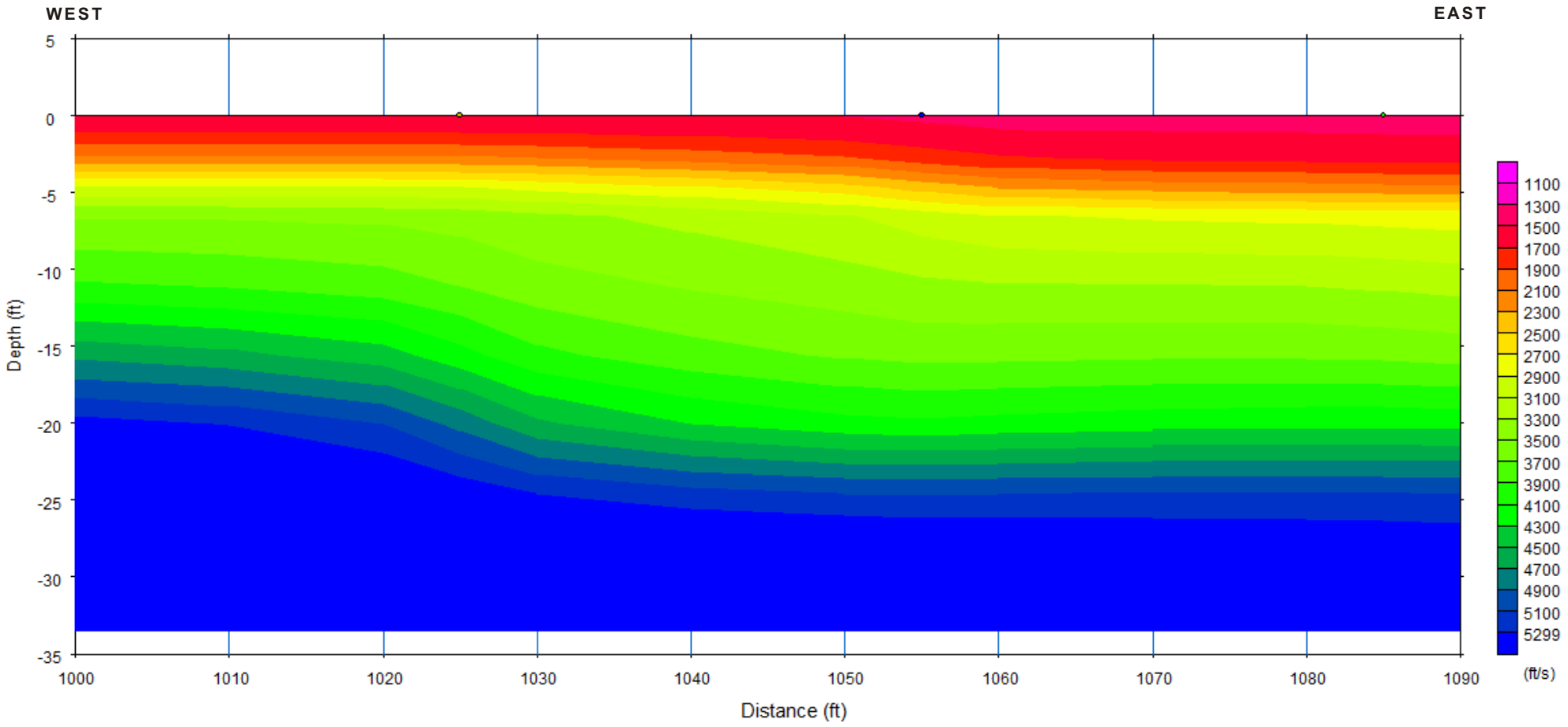
file no: 3956ssm0715

Ninyo & Moore		SEISMIC SURVEY LINE MAP	FIGURE
PROJECT NO: 603956002	DATE: 7/15	QUEEN VALLEY FLOOD MITIGATION QUEEN VALLEY, ARIZONA	1



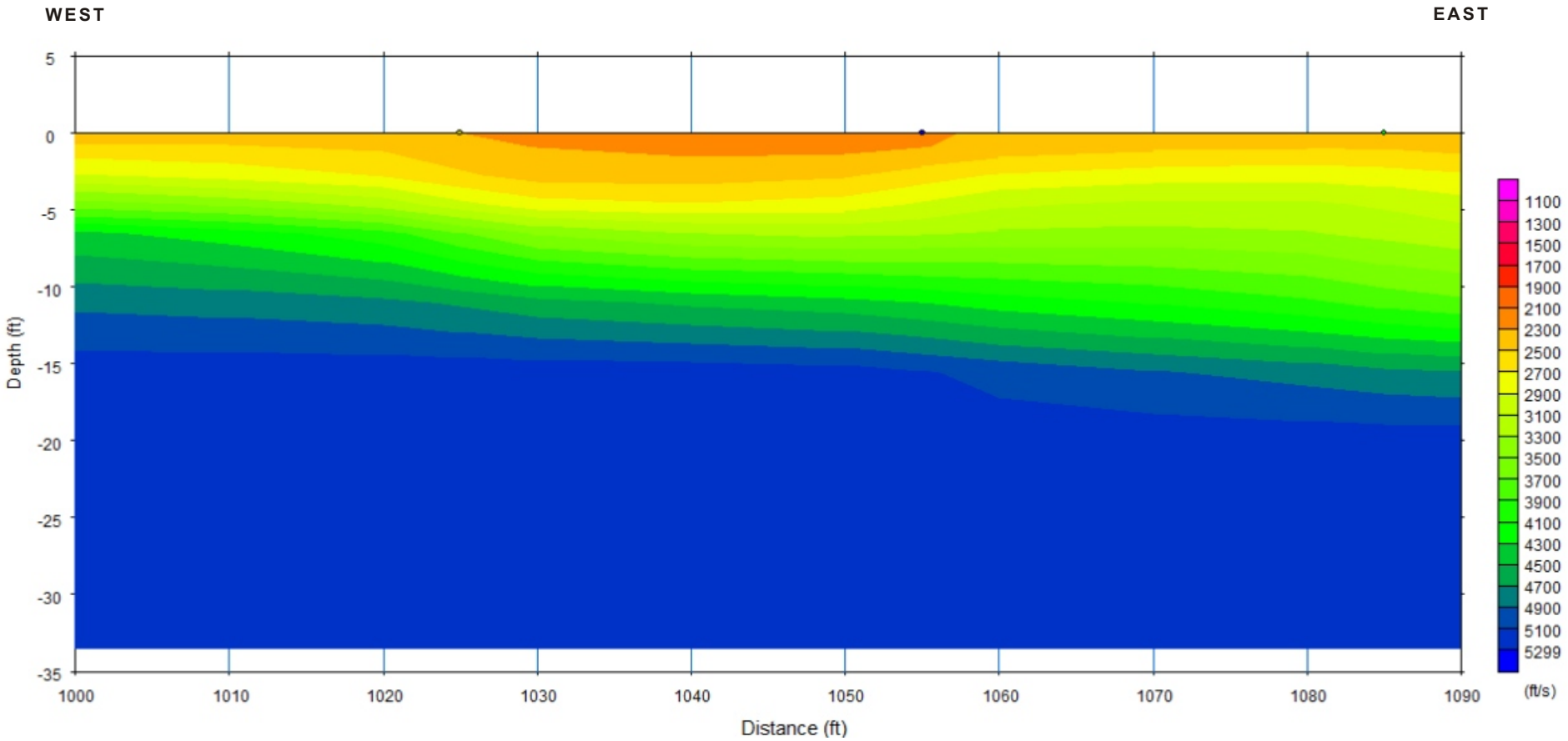
Ninyo & Moore	SEISMIC REFRACTION PROFILE SL-1	FIGURE
PROJECT NO: 603956002 / DATE: 7/15	QUEEN VALLEY FLOOD MITIGATION QUEEN VALLEY, ARIZONA	2

file no: 3956ss0715a



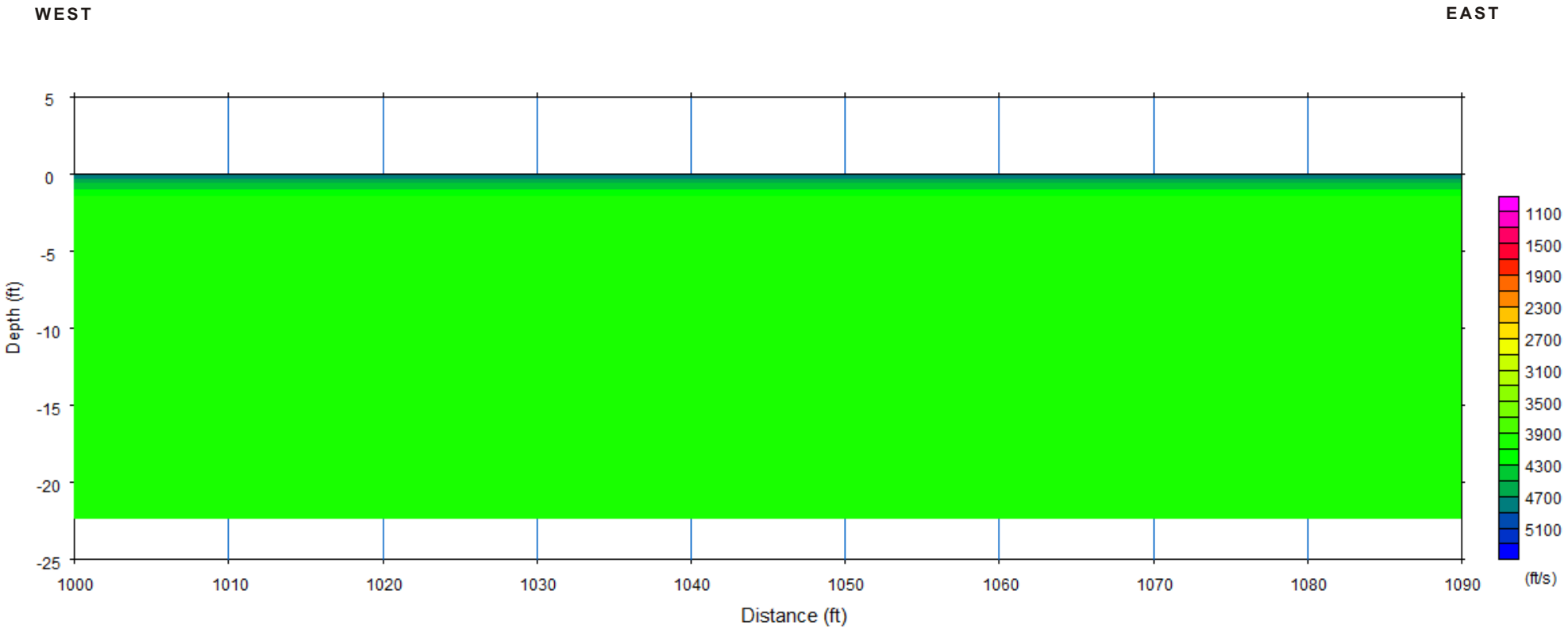
Ninyo & Moore	SEISMIC REFRACTION PROFILE SL-2	FIGURE
PROJECT NO: 603956002 / DATE: 7/15	QUEEN VALLEY FLOOD MITIGATION QUEEN VALLEY, ARIZONA	3

file no: 3956ss0715b



Ninyo & Moore	SEISMIC REFRACTION PROFILE SL-3	FIGURE
PROJECT NO: 603956002 / DATE: 7/15	QUEEN VALLEY FLOOD MITIGATION QUEEN VALLEY, ARIZONA	4

file no: 3956ss0715c



Ninyo & Moore		SEISMIC REFRACTION PROFILE SL-4	FIGURE
PROJECT NO: 603956002	DATE: 7/15	QUEEN VALLEY FLOOD MITIGATION QUEEN VALLEY, ARIZONA	5

file no: 3956ss0715d