

JUN 02 2005

**Terracon**  
Consulting Engineers & Scientists

355 South Euclid, Suite 107  
Tucson, Arizona 85719  
Phone 520.770.1789  
Fax 520.792.2539  
www.terracon.com

June 1, 2005

Presidio Engineering, Inc  
4582 North 1<sup>st</sup> Avenue  
Suite 120  
Tucson, Arizona 85718

Attn: Erin Donovan, P.E.

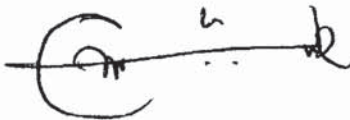
**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63055225, Addendum 1**

Terracon has received your request for an additional site plan showing the boring locations with the lot layout. We have provided the overlay of the boring locations as attached in Figure 2. The original site plan, Figure 1, was originally provided in Terracon Report Number 63045225, dated December 8, 2004, which was prepared for Standard Pacific of Tucson.

Please let us know if you have any other questions concerning these additions.

Sincerely,

**TERRACON**



David C. Mwewa, E.I.T.  
Project Engineer

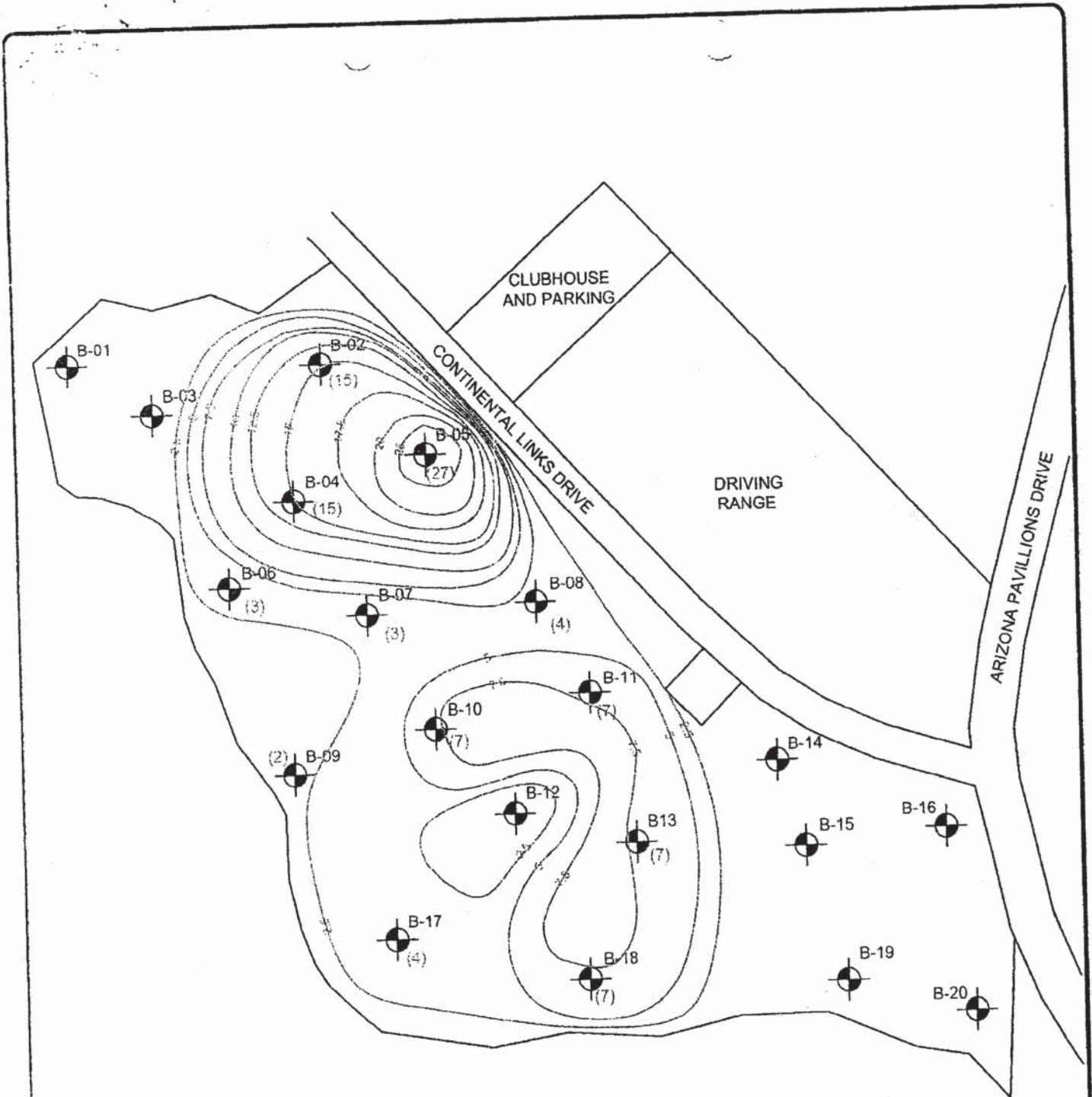


Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

Copies: (3) Addressee

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**LEGEND**

⊕ APPROXIMATE BORING

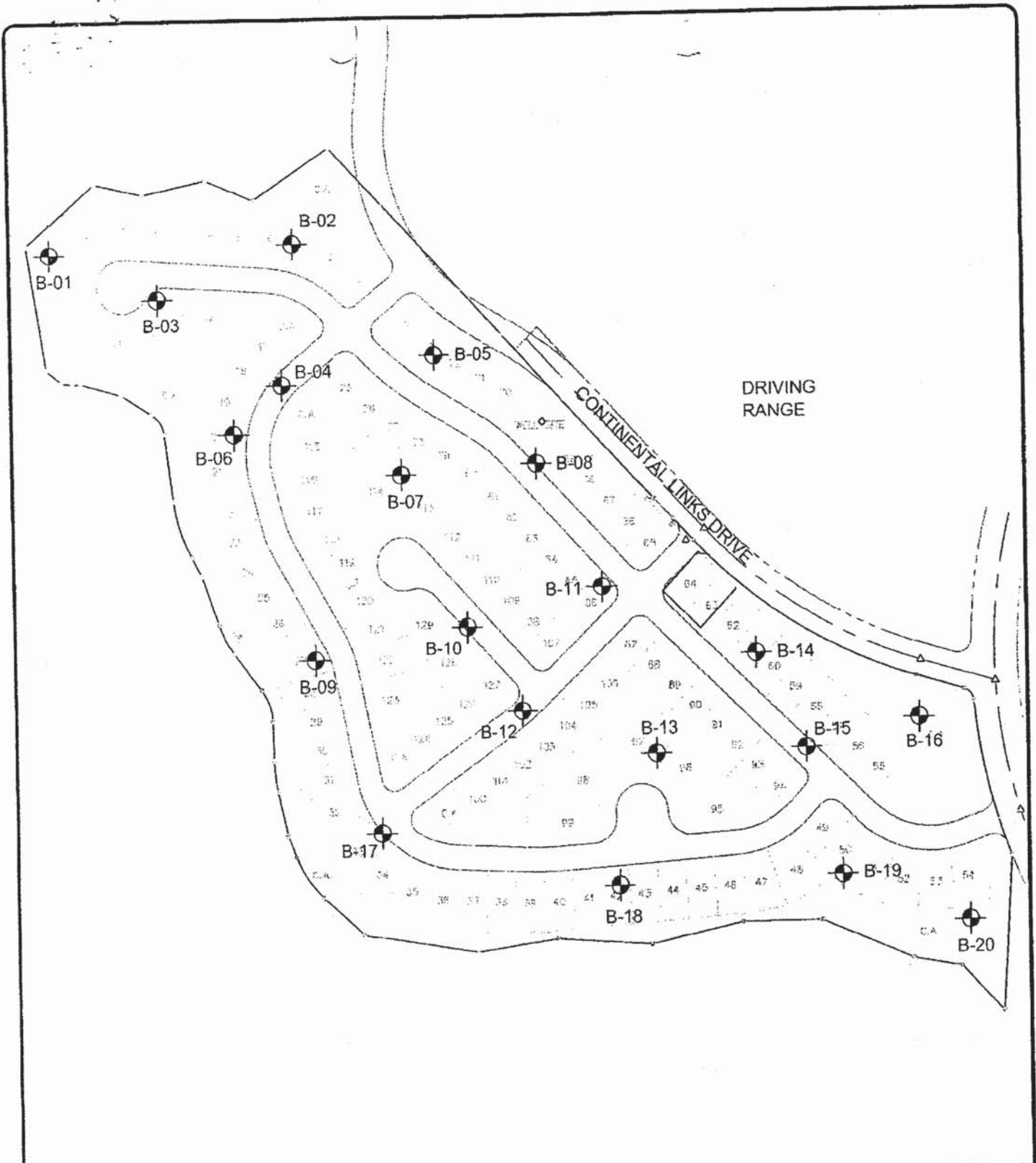
( ) APPROXIMATE DEPTH OF FILL



DIAGRAM IS FOR GENERAL LOCATION ONLY.  
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

**SITE PLAN AND BORING LOCATIONS**  
**PROPOSED PHASE I RESIDENTIAL DEVELOPMENT AT THE PINES**  
 NORTH OF CORTARO ROAD AND WEST OF INTERSTATE 10  
 MARANA, ARIZONA  
 STANDARD PACIFIC OF TUCSON

Project Mngr:	OBL	<b>Terracon</b> 355 South Euclid, Suite 107 Tucson, Arizona 85719	Project No.	63045225
Designed By:			Scale:	None
Checked By:			Date:	11-23-04
Approved By:	OBL		Drawn By:	BWR(63)
File Name: n:\public\04\georept\63045225\6304225.dwg			L(Layout1)	Figure No. 1



**LEGEND**

⊕ APPROXIMATE BORING LOCATION



DIAGRAM IS FOR GENERAL LOCATION ONLY,  
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

**SITE PLAN AND BORING LOCATIONS**  
**PROPOSED PHASE I RESIDENTIAL DEVELOPMENT AT THE PINES**  
 NORTH OF CORTARO ROAD AND WEST OF INTERSTATE 10  
 MARANA, ARIZONA  
 STANDARD PACIFIC OF TUCSON

Project Mngr:	OBL	 355 South Euclid, Suite 107 Tucson, Arizona 85719	Project No.	63045225
Designed By:			Scale:	None
Checked By:			Date:	06-01-05
Approved By:	OBL		Drawn By:	DCM(63)
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JUN 08 2005

**Terracon**  
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June 6, 2005

Presidio Engineering, Inc  
4582 North 1<sup>st</sup> Avenue  
Suite 120  
Tucson, Arizona 85718

Attn: Erin Donovan, P.E.

**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63055225, Addendum 2**

Terracon has received your request for additional recommendations concerning the pavement design for Continental Links Drive. Based on anticipated traffic volumes for Continental Links Drive, the road would be classified as a collector street. The Pima County Subdivision Street Standards recommend using a minimum design structural number of 1.75 for collector streets. A minimum pavement section consisting of 3 inches of asphalt (PAG Mix No. 2) over 4 inches of aggregate base course has a structural number of 1.76 and is recommended for design. Alternatively, a pavement section of 2.5 inches of asphalt over 6 inches of aggregate base course has a structural number of 1.76 and may also be used.

Please let us know if you have any other questions concerning these additions.

Sincerely,

**TERRACON**



Bryan W. Reed, E.I.T.  
Project Engineer



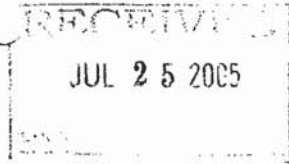
Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

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104023.03.0500



July 21, 2005

**Terracon**  
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Attn: Erin Donovan, P.E.

**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63045225, Addendum 3**

Terracon has received your request for additional recommendations concerning the deep fills present on the site. Fills as deep as 27 feet were encountered, as reported in Terracon Report Number 63045225, Dated December 8, 2004. We have been requested to provide alternative solutions, other than removing and replacing all of the fill, for building support in the areas where existing fill depths are potentially greater than 7 feet deep, see Site Plan Figure 1 and 2 in Terracon Report 63045225, Dated June 1, 2005. These options include: alternative foundations systems tolerant of potential settlement, placing geogrid reinforcement in engineered fill under building pad areas, or adding a surcharge to the fill area and allowing between 6 to 12 months for consolidation of the fill prior to home construction.

**Alternative Foundation Systems**

**Reinforced Mat (Raft) Foundations:** As an alternative, reinforced mat foundations could be used for foundation support of the structures. The following criteria is based on the reinforced slab bearing directly on a minimum of 4 feet of engineered fill. A modulus of subgrade reaction,  $k$ , of 200 pci could be used for design and evaluation of soil-structure interaction of a reinforced mat foundation bearing fill soils. It is common to reduce the  $k$ -value to account for dimensional effects of large loaded areas. A commonly used correction is:

$$k_c = k((b+1)/2b)^2$$

Where  $k_c$  is the corrected or design modulus value and  $b$  is the mat width or tributary loaded area. However, in no case should the contact pressure of the mat exceed 750 psf. Perimeters of the mats should bear a minimum of 8 inches below adjacent grades. The raft foundation should be designed to withstand up to 3-inches of differential settlement.

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**Post-Tensioned Slab Foundation Systems (Compressible Soil Case):** Post-tensioned slab construction can be considered as an alternate foundation system for the project. The following criteria is for the area where the depth of loose existing fill varies between 7 and 27 feet and is based on the post-tensioned slab bearing directly on a minimum of 4 feet of new engineered fill. The total settlement of the engineered fill may be much larger than maximum estimated differential settlements. Post-tensioned slabs should be designed using criteria outlined by the Post-Tensioning Institute<sup>1</sup> for the compressible soil case based on the following:

- Maximum Allowable Bearing Pressure.....750 psf
- Soil Modulus of Elasticity,  $E_s$  .....2000 psi
- Edge Moisture Variation Distance,  $e_m$ 
  - Center Lift Condition ..... 5 feet
- Differential Soil Movement,  $y_m$ 
  - Center Lift Condition ..... 3 inches
- Total Soil Movement,  $\delta$  ..... 3 inches\*
- Slab-Subgrade friction coefficient,  $\mu$ 
  - on polyethylene sheeting..... 0.75
  - on cohesionless soils ..... 1.00
  - on cohesive soils..... 2.00

\*Estimated settlement based upon total structure load expressed as a uniform 750 psf pressure acting over the entire slab area.

<sup>1</sup>PTI Slab-on-Ground Committee, (1996), *Design and Construction of Post-Tensioned Slabs-on-Ground*, Post-Tensioning Institute, Second Edition.

Post-tensioned slabs, thickened or turn-down edges and/or interior beams should be designed and constructed in accordance with the requirements of the Post-Tensioning Institute and the American Concrete Institute. Perimeters of the post-tensioned slabs should bear a minimum of 12 inches below adjacent grades. Subgrades supporting a post-tensioned slab should be prepared as recommended in this report.

Anticipated differential settlement of structures founded on either raft or post-tension systems in the deep existing fill areas could be as much as 3 inches.

Underground piping within or near the proposed structures should be designed with flexible couplings, so deviations in alignment do not result in breakage or distress. Utility knockouts in foundation walls should be oversized to accommodate differential movements.

#### **Geogrid Support**

To further limit potential differential settlements, layers of geogrid may be incorporated into the engineered fill below the mat or post-tension foundations. The geogrid will add shear strength to the engineered fill and allow it to better bridge potential subsurface loose areas and voids. If this alternative is chosen, we recommend sheets of Tensar BX1200 geogrid (or equivalent) be placed within every foot lift of compacted engineered fill. This would be a total of four layers of geogrid. The geogrid should extend at least five feet beyond the perimeters of the foundations. We expect the geogrid support to limit differential settlements to 1-inch or less, however total settlement may be higher.

Underground utilities located below the foundations will need to penetrate through the layers of geogrid. This will create difficult excavation conditions for utility contractors.

#### **Pre-Loading or Surcharge**

As a third alternative the fill at the site could be pre-consolidated before construction begins by pre-loading the area with a surcharge of soil. It is our understanding that a minimum of 2 feet of fill is required on site to raise site grades. We understand approximately 70,000 cubic yards of material will be needed to raise grades. A portion of this material could be stockpiled in the deep fill area, while other areas of the site are being developed. A ten foot high surcharge pile would sufficiently stress the area to something equivalent to the anticipated loads created by

the proposed structures. We are assuming the surcharge soils will have a density of at least 100 pcf, this density should be achieved by the movement of equipment creating the pile.

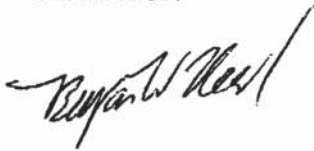
Once the final height of the surcharge has been reached, settlement monuments should be placed on the surface of the of surcharge pile. Settlement monuments should be embedded at least 2 to 3 feet in the surface of the surcharge soil and set in concrete. We recommend at least 15 monuments be set across the site, preferably in a regular grid pattern.

The settlement monuments should be surveyed every 2 weeks and measured to the nearest 0.001 of a foot. The benchmark should be located well away from the fill and the impact of any potential settlement. Terracon should be given the survey data to evaluate when construction should begin. We would expect between 4 to 7 inches of settlement of the fill material to occur over a period of 6 to 12 months. However if the earthwork is performed relatively slowly, much of the settlement could occur during fill placement. Determination of when construction should begin should be based on settlement monitoring data.

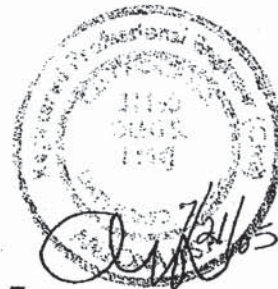
All recommendations given in our previous report are still valid. If you have any questions regarding this report, please contact us.

Sincerely,

**TERRACON**



Bryan W. Reed, E.I.T.  
Project Manager



Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

Copies: (3) Addressee

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104023.03.0500

RECEIVED  
AUG 01 2005

**Terracon**  
Consulting Engineers & Scientists

July 27, 2005

Presidio Engineering, Inc  
4582 North 1<sup>st</sup> Avenue  
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Tucson, Arizona 85718

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Attn: Erin Donovan, P.E.

**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63045225, Addendum 4**

Terracon has received your request for clarification of the lots and areas affected by the deep fills at the site. It appears based on our exploration that the area with fill deeper than 7 feet will affect the following lots:

Lot 1	Lot 16	Lot 73
Lot 2	Lot 17	Lot 74
Lot 3	Lot 18	Lot 75
Lot 4	Lot 19	Lot 76
Lot 5	Lot 70	Lot 77
Lot 6	Lot 71	Lot 78
Lot 15	Lot 72	Lot 115


All recommendations given in our previous report are still valid. If you have any questions regarding this report, please contact us.

Sincerely,

**TERRACON**



Bryan W. Reed, E.I.T.  
Project Manager



Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

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October 19, 2005

Presidio Engineering, Inc  
4582 North 1<sup>st</sup> Avenue  
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Tucson, Arizona 85718

**Terracon**  
Consulting Engineers & Scientists

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Tucson, Arizona 85719  
Phone 520.770.1789  
Fax 520.792.2539  
www.terracon.com

Attn: Erin Donovan, P.E.

**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63045225, Addendum 5**

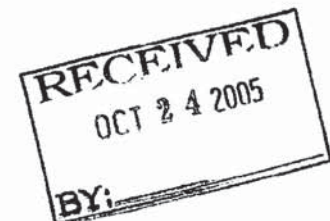
Terracon has received your request for post-tensioned foundation design criteria for areas of the site outside of the areas with the deepest existing fills.

In Addendum No. 4 to the geotechnical report, dated July 27, 2005, we identified the lots we expect to be affected by deep uncontrolled existing fills. We stated the following lots would be affected:

Lot 1	Lot 16	Lot 73
Lot 2	Lot 17	Lot 74
Lot 3	Lot 18	Lot 75
Lot 4	Lot 19	Lot 76
Lot 5	Lot 70	Lot 77
Lot 6	Lot 71	Lot 78
Lot 15	Lot 72	Lot 115

The recommendations in Addendum No. 3, dated July 21, 2005, provided alternatives to removing all the existing fill and replacing it with engineered fill. We understand that Standard Pacific Homes is considering the alternative of placing four feet of engineered fill in this area and designing post-tensioned slabs with the criteria provide in Addendum 3.

For the areas outside the above-referenced lots (outside the deep fills, where the post-tensioned foundations will bear on a minimum of 2 feet of engineered fill) we are providing the following design criteria:



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**Post-Tensioned Slab Foundation Systems (Compressible Soil Case):** Post-tensioned slabs should be designed using criteria outlined by the Post-Tensioning Institute<sup>1</sup> for the compressible soil case based on the following:

- Maximum Allowable Bearing Pressure..... 1000 psf
- Soil Modulus of Elasticity,  $E_s$  ..... 2000 psi
- Edge Moisture Variation Distance,  $e_m$ 
  - Center Lift Condition ..... 5 feet
- Differential Soil Movement,  $y_m$ 
  - Center Lift Condition ..... 3/4 inches
- Total Soil Movement,  $\delta$  ..... 3/4 inches\*
- Slab-Subgrade friction coefficient,  $\mu$ 
  - on polyethylene sheeting..... 0.75
  - on cohesionless soils ..... 1.00
  - on cohesive soils ..... 2.00

\*Estimated settlement based upon total structure load expressed as a uniform 750 psf pressure acting over the entire slab area.

<sup>1</sup>PTI Slab-on-Ground Committee, (2003), *Design and Construction of Post-Tensioned Slabs-on-Ground*, Post-Tensioning Institute, Second Edition.

Post-tensioned slabs, thickened or turn-down edges and/or interior beams should be designed and constructed in accordance with the requirements of the Post-Tensioning Institute and the American Concrete Institute. Perimeters of the post-tensioned slabs should bear a minimum of 12 inches below adjacent grades. Subgrades supporting a post-tensioned slab should be prepared as recommended in this report.

All recommendations given in our previous report are still valid. If you have any questions regarding this report, please contact us.

Sincerely,

TERRACON



Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

Copies: (1) Addressee  
(1) Standard Pacific Homes, Attn: Jeff Curtin  
(1) Borm Engineers, Attn: Bobbie Brown

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June 1, 2005

Presidio Engineering, Inc  
4582 North 1<sup>st</sup> Avenue  
Suite 120  
Tucson, Arizona 85718

Attn: Erin Donovan, P.E.

**RE: Geotechnical Engineering Report  
Phase I Residential Development at the Pines Golf Course  
North of Cortaro Road and West of Interstate 10  
Marana, Arizona  
Terracon Project No. 63055225, Addendum 1**

Terracon has received your request for an additional site plan showing the boring locations with the lot layout. We have provided the overlay of the boring locations as attached in Figure 2. The original site plan, Figure 1, was originally provided in Terracon Report Number 63045225, dated December 8, 2004, which was prepared for Standard Pacific of Tucson.

Please let us know if you have any other questions concerning these additions.

Sincerely,

**TERRACON**



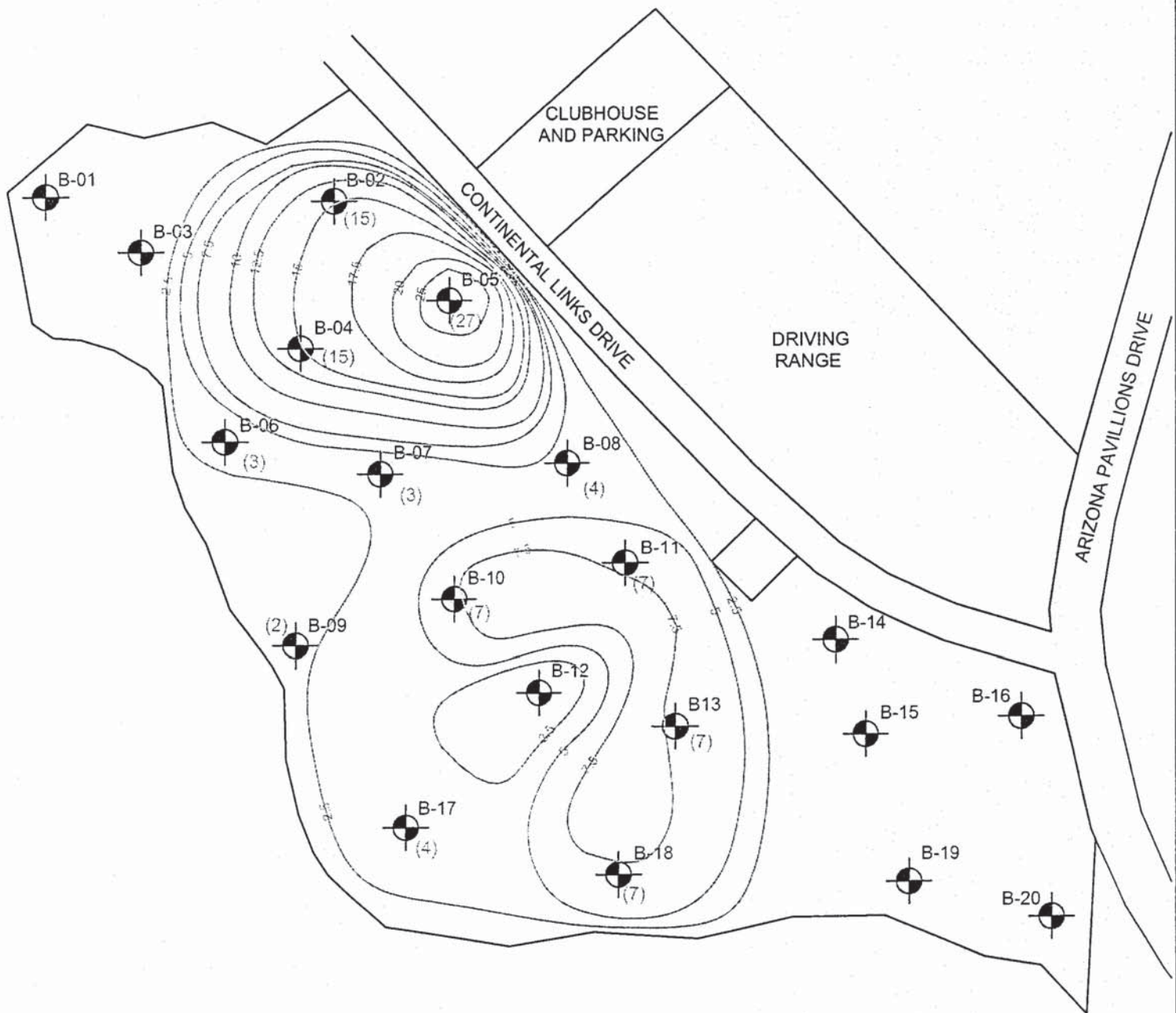
David C. Mwewa, E.I.T.  
Project Engineer



Oleg B. Lysyj, P.E.  
Geotechnical Services Manager

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**LEGEND**

⊕ APPROXIMATE BORING

( ) APPROXIMATE DEPTH OF FILL




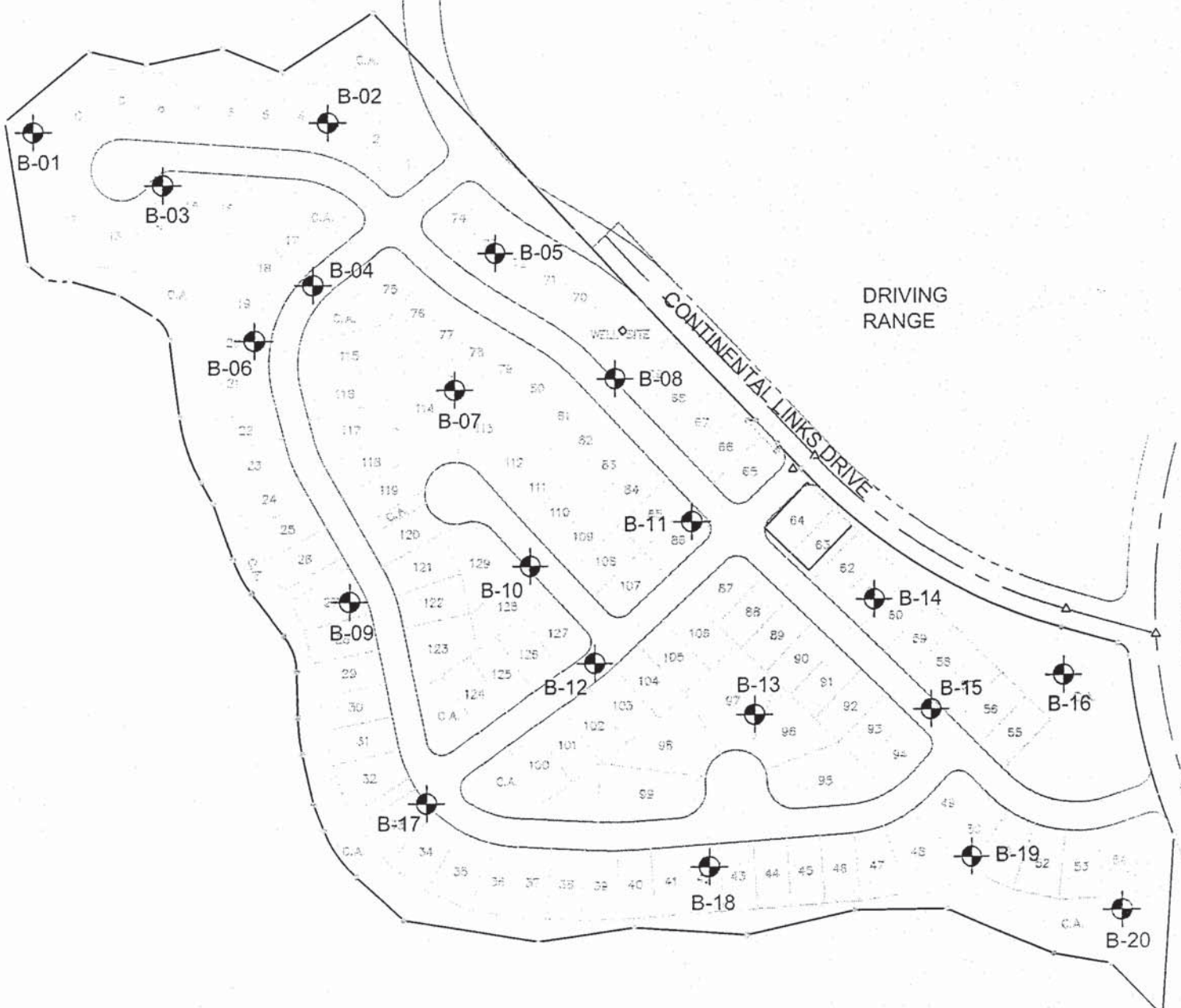
<b>SITE PLAN AND BORING LOCATIONS</b> <b>PROPOSED PHASE I RESIDENTIAL DEVELOPMENT AT THE PINES</b> NORTH OF CORTARO ROAD AND WEST OF INTERSTATE 10 MARANA, ARIZONA STANDARD PACIFIC OF TUCSON		
Project Mngr:	OBL	Project No. 63045225
Designed By:	 355 South Euclid, Suite 107 Tucson, Arizona 85719	Scale: None
Checked By:		Date: 11-23-04
Approved By:		OBL
File Name: n:\public\04georept\63045225\6304225.dwg L(Layout1)		Figure No. 1

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**LEGEND**

⊕ APPROXIMATE BORING LOCATION



DIAGRAM IS FOR GENERAL LOCATION ONLY,  
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

<b>SITE PLAN AND BORING LOCATIONS</b> <b>PROPOSED PHASE I RESIDENTIAL DEVELOPMENT AT THE PINES</b> NORTH OF CORTARO ROAD AND WEST OF INTERSTATE 10 MARANA, ARIZONA STANDARD PACIFIC OF TUCSON				
Project Mngr:	OBL	 355 South Euclid, Suite 107 Tucson, Arizona 85719	Project No.	63045225
Designed By:			Scale:	None
Checked By:			Date:	06-01-05
Approved By:	OBL		Drawn By:	DCM(63)
File Name: n:\public\04georept\63045225\6304225.dwg		L(Layout1)	Figure No.	<b>2</b>