ROCKRIDGE
GEOTECHNICAL

October 25, 2019
Project No. 19-1659

SC Riverfront, LLC
P.O. Box 377
Santa Cruz, California 95061-0377

Attention: Mr. Doug Ross

Subject: Geotechnical Consultation regarding Foundations and Ground Improvement
Proposed Riverfront Project
Front Street
Santa Cruz, California

Dear Mr. Ross,

This letter presents the results of our geotechnical consultation regarding the most appropriate foundation type and ground improvement methods for the proposed Riverfront Project to be constructed on Front Street between Broadway and Soquel Avenue. Our consultation is based our review of the subsurface data presented in the report prepared by TRC titled *Geotechnical Investigation, Riverfront Apartments Project, Santa Cruz, California*, dated March 22, 2016.

Plans are to construct a seven-story residential building over one level of below-grade parking with a finished floor about 13 feet below sidewalk grade on Front Street. Because the site slopes gently down to the east, the first level above the garage will be at grade along Front Street and about 10 feet below grade at the rear of the building. The subsurface investigation performed by TRC, which consisted of two borings and three cone penetration tests (CPTs), indicates the site is underlain by interbedded layers of loose to medium dense silty sand and loose to very dense sand to depths ranging from approximately 24 feet below the existing ground surface (bgs) near the southern end of the site to about 68 feet bgs at the northern end. Beneath the sand and silty sand is hard sandy silt that is likely weathered bedrock of the Purisma formation. Groundwater was encountered at depths of about 7-3/4 to 12-1/4 feet bgs in the borings and CPTs advanced by TRC in 2016. In their report, TRC recommends a design groundwater depth of five feet bgs.

The TRC report indicates the loose to medium dense sand and silty sand below the groundwater table is susceptible to liquefaction during a large earthquake. Estimated free-field settlements resulting from post-liquefaction reconsolidation presented in the

TRC report range from 4.9 to 15.2 inches. The report also states there is a moderate to high potential for lateral spreading to occur towards the nearby San Lorenzo River during a large earthquake. During the October 17, 1989 Loma Prieta Earthquake, the sidewalks and/or curbs in front of the site buckled and cracks formed parallel to the river in the street, but no significant evidence of lateral spreading towards the river was reported (U.S. Geological Survey Professional Paper 1551-B, 1998). Peak ground accelerations on solid ground near liquefaction sites in Santa Cruz are estimated to have been on the order of 0.47 to 0.54 times gravity (g).

Based on our review of the subsurface data in the TRC report, we concur the loose to medium dense sand and silty sand below the groundwater table is susceptible to liquefaction during a large earthquake. Soil susceptible to lateral spreading is generally limited to the top 10 to 18 feet of soil at the boring and CPT locations. Although the soil below these depths may liquefy, it is sufficiently dense to resist lateral spreading.

Although deep foundations are feasible to support the proposed building, they would be very costly because of the variable depth to suitable bearing/skin friction material (i.e., the hard sand silt/Purisma formation below the potentially liquefiable alluvium), the large downdrag loads imposed on the piles by the liquefiable soils, and potential difficulties drilling into the Purisma formation. We believe a more appropriate foundation system would consist of a mat foundation on soil strengthened with ground improvement. The ground improvement would be designed to: 1) transfer vertical loads to suitable bearing material, 2) mitigate liquefaction within the building footprint, and 3) mitigate the potential for building damage from lateral spreading that occurs outside the building footprint. In addition, the ground improvement method should not result in vibrations that may damage nearby buildings, streets and utilities.

Based on our experience, we believe the most appropriate ground improvement method for this project would consist of drilled displacement columns (DDCs). DDCs are installed by advancing a continuous flight, hollow-stem auger that mostly displaces the soil then pumping a sand-cement mixture into the hole under pressure as the auger is withdrawn. This installation method results in minimal vibrations during installation and generates little to no drilling spoils for off haul. DDCs are installed on a design-build basis. The required size, spacing, length, and strength of columns should be determined by the design-build ground improvement contractor, based on the desired level of improvement and the weight of the building. For planning purposes, it should be assumed the ground improvement elements will be spaced at six feet on center and will extend at least five feet into the Purisma formation which is approximately 24 to 68 feet below existing grade. Since about 15 to 22 feet of soil will be excavated for the below-grade levels and the mat foundation, the DDC lengths will range from less than 10 feet to about 60 feet, measured below the mat subgrade. We estimate total static settlement of a building supported on DDCs will be less than one inch and differential settlement will be less than 3/4 inch over a horizontal distance of 30 feet. We estimate total and differential settlements under seismic conditions will be less than 3/4 inch and 1/2 inch over a horizontal distance of 30 feet, respectively.

Most or all the soil beneath the front of the building that is susceptible to lateral spreading (upper 10 to 18 feet) will be removed for construction of the below-grade level and foundation. With the densification of the sand from the DDC installation, we anticipate minimal lateral movement of the soil adjacent to the DDCs along the front edge of the building will occur during a large earthquake. As a precaution, however, a 15-foot-long reinforcing cage should be installed in these DDCs.

There are other ground improvement methods that may be appropriate for this projecgt, such as soil-mix (SMX) columns. The SMX columns are installed to create cells which confine the liquefiable soil. The mat would be designed to span between the SMX columns. This method also can be installed with minimal vibrations; however, it does result in significant spoils that would have to be offhauled. It is our experience ground improvement with SMX columns is more costly than solutions with DDCs, but alternatives can be evaluated more during the project design.

We trust this letter presents the information required at this time. If you have any questions, please call.

Sincerely yours,
ROCKRIDGE GEOTECHNICAL, INC.

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