CTL | THOMPSON INCORPORATED

May 12, 2022

Lennar Colorado, LLC
9193 South Jamaica Street, 4th Floor
Englewood, Colorado 80112

Subject: Soils and Foundation Summary Letter
Whisper Village (A.K.A. Arvada Point)
Lots 107-110
Arvada, Colorado
Project No. DN49,791-120-R1

HOME BUYER ADVISORY

Expansive soils and bedrock are present at this subdivision; which results in a geologic hazard. This letter describes the soil conditions on these lots more specifically. Prospective home buyers are strongly advised to read this letter and the referenced documents.

If you do not understand the risk(s) associated with the hazard and the important role you must accept to manage and mitigate the risk(s), we recommend you contact a competent geotechnical (soils) engineer for advice.

CTL | Thompson, Inc. performed a Soils and Foundation Investigation for 23 townhome buildings within Whisper Village (A.K.A. Arvada Point), and presented results in a report dated April 21, 2022. This letter presents a summary of our findings and recommendations for the subject lots. The report referenced above should be reviewed for foundation design.

Colorado is a challenging location to practice geotechnical engineering. The climate is relatively dry and the near-surface soils are typically dry and comparatively stiff. These soils and related sedimentary bedrock formations tend to react to changes in moisture conditions. Some of the soils and bedrock swell as they increase in moisture and are collectively referred to as expansive soils. Other soils can settle significantly upon wetting and are identified as collapsing soils. Much of the land available for development east of the Front Range is underlain by expansive clay or claystone bedrock near the surface. The soils that exhibit collapse are more likely west of the continental divide; however, both types of soils occur throughout the state.

Covering the ground with buildings, streets, driveways, patios, etc., coupled with lawn irrigation and changing drainage patterns, leads to an increase in subsurface moisture conditions. As a result, some soil movement is inevitable. It is critical that all recommendations in the referenced report are followed to increase the chances that the foundations and slabs-on-grade will perform satisfactorily. After construction, home owners and/or HOA/property managers must assume responsibility for maintaining the structures and use appropriate practices regarding drainage and landscaping.

In summary, the strata encountered in the borings on these lots consisted of 14 to 15 feet of fill and nil to 1-foot of weathered claystone underlain by claystone bedrock to the maximum depth explored of 25 feet. No groundwater was encountered during this investigation. The clayey soils and bedrock are expansive. Use of footings with minimum deadload is recommended. A structurally

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

supported floor should be used for all finished living areas. Further details are described in following paragraphs.

Expansive soils and bedrock are present at this site. The presence of expansive soils and bedrock constitutes a geologic hazard. There is risk that ground heave will damage slabs-on-grade and foundations. Lennar elected to perform sub-excavation of the soils and bedrock below the subject building to reduce potential swell. Our investigation indicates sub-excavation was generally effective. Sub-excavation will not eliminate potential movements. It is intended to reduce total and differential movement. It is likely some cosmetic distress will occur (dry wall cracks, slab heave and cracks, etc.). A more detailed discussion of the sub-excavation process is presented in Exhibit C. The foundations and slabs may settle if soft, compressible fill and soils are present under and close to the footings and slabs.

The risk of foundation and slab movements can be mitigated, but not eliminated by careful design, construction, and maintenance procedures. We believe the recommendations in the referenced report will help control risk of foundation and slab damage; they will not eliminate that risk. The builder and home buyers should understand that slabs-on-grade and, in some instances, foundations may be affected by the subsoils. Home owner and/or HOA/property manager maintenance will be required to control risk. We recommend the builder provide a booklet to the home buyers that describes swelling soils and includes recommendations for care and maintenance of homes constructed on expansive soils. Colorado Geological Survey Special Publication 43[1] was designed to provide this information.

Laboratory tests were performed on samples from these lots and nearby lots. Samples from these lots swelled 0.1 to 0.9 percent when wetted. Based upon results of laboratory tests and other factors, we judge ground-supported slab performance risk for these lots to be low. Exhibit A provides a discussion of slab performance risk evaluation, as well as slab installation and maintenance recommendations. We performed calculations of total potential ground heave as part of our study. The calculations indicate the ground surface on low risk lots included in this investigation could heave 1 to 5½ inches. Up to about 4½ inches of the potential heave is attributed to the expansive native clay and claystone bedrock below the fill. The calculated potential heave for these lots is 2½ to 3 inches at the ground surface. It is not certain this movement will occur. The estimated heave was based on laboratory data and represents a range of total movements. The actual movements could be higher or lower.

Considering the subsurface conditions at these lots, we recommend the proposed townhome building be constructed on a footing foundation with

[1]"A Guide to Swelling Soils for Colorado Homebuyers and Homeowners," Second Edition Revised and Updated by David C. Noe, Colorado Geological Survey, Department of Natural Resources, Denver, Colorado, 2007.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

minimum deadload. Footings should be designed for a maximum allowable soil pressure of 3,000 psf with a minimum deadload pressure of 1,000 psf. Footings should be at least 16 inches wide. Column pads should be at least 18 inches square. There should be a minimum 4-inch continuous void between the footings to concentrate the deadload, if interrupted footings are necessary. Exterior footings should be protected from frost action with at least 3 feet of cover. It is sometimes necessary to alter the foundation design based on conditions exposed during construction. The buyer can discuss the changes, if any, with the builder.

Foundation walls and grade beams that extend below grade should be designed for lateral earth pressures where backfill is not present to about the same extent on both sides of the wall. Our experience suggests foundation walls can deflect or rotate slightly under normal design loads and that this deflection typically does not affect the structural integrity of the walls. We recommend design of the foundation walls on these lots using an equivalent fluid density of at least 60 pounds per cubic foot. This value assumes slight deflection of the wall can occur, generally less than 0.5 to 1 percent of the wall height. Some minor cracking of the walls may occur.

A subsurface drain is recommended around the entire perimeter of the lowest excavation area for the townhome building. The drain should lead to a positive gravity outlet or to a sump where water can be removed with a pump. The provision of the drain will not eliminate slab movement or prevent moist conditions in crawl spaces. The pump must be maintained by the home owner.

Proper design, construction and maintenance of surface drainage are critical to the satisfactory performance of foundations, slabs-on-grade, and other improvements. Landscaping and irrigation practices will also affect performance. Exhibit B contains our recommendations for surface drainage, irrigation, and maintenance.

The concept of risk is an important aspect with any geotechnical evaluation, primarily because the methods used to develop geotechnical recommendations do not comprise an exact science. We never have complete knowledge of subsurface conditions. Our analysis must be tempered with engineering judgment and experience. Therefore, the recommendations presented in any geotechnical evaluation should not be considered risk-free. We cannot provide a guarantee that the interaction between the soils and a proposed structure will be as desired or intended. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the structure will perform satisfactorily. It is critical that all recommendations in the referenced report are followed. Home owners and/or HOA or property managers must assume responsibility for maintaining the structure and use appropriate practices regarding drainage and landscaping.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

As this letter is meant only as a summary of our findings and recommendations for the subject lot, we recommend home buyers review the Soils and Foundation Investigation from which this summary is taken.

CTL | THOMPSON, INC.

Chris Fitzsimmons
May 12 2022 11:50 AM

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

EXHIBIT A

SLAB PERFORMANCE RISK EVALUATION,
INSTALLATION AND MAINTENANCE

As part of our evaluation of the subsoils and bedrock, samples were tested in the laboratory using a swell test. In the test procedure, a relatively undisturbed sample obtained during drilling is first loaded and then flooded with water and allowed to swell. The pressure applied prior to wetting can approximate the weight of soil above the sample depth or be some standard load. The measured percent swell is not the sole criteria in assessing potential movement of slabs-on-grade and the risk of poor slab performance. The results of a swell test on an individual lot are tempered with data from surrounding lots, depth of tests, depth of excavation, soil profile, and other tests. This judgment has been described by the Colorado Association of Geotechnical Engineers (CAGE, 1996) as it relates to basement slab-on-grade floors. It can also be used to help judge performance risk for other slabs-on-grade such as garage floors, driveways, and sidewalks. The risk evaluation is considered when we evaluate appropriate foundation systems for a given site. In general, more conservative foundation designs are used for higher risk sites to control the likelihood of excessive foundation movement.

As a result of the Slab Performance Risk Evaluation, sites are categorized as low, moderate, high, or very high risk. This is a judgment of the swelling characteristics of the soils and bedrock likely to influence slab performance.

REPRESENTATIVE MEASURED SWELL
AND CORRESPONDING SLAB
PERFORMANCE RISK CATEGORIES

Slab Performance Risk Category	Representative Percent Swell* (500 psf Surcharge)	Representative Percent Swell* (1000 psf Surcharge)
Low	0 to <3	0 to <2
Moderate	3 to <5	2 to <4
High	5 to <8	4 to <6
Very High	≥ 8	≥ 6

*Note: The representative percent swell values presented are not necessarily measured values; rather, they are a judgment of the swelling characteristics of the soil and bedrock likely to influence slab performance.

CTL | Thompson also performs potential heave calculations to aid in our judgement. We typically perform swell tests by wetting samples under a pressure which approximates the in-situ pressure. We use the potential heave calculations as a further basis to assess risk. The risk is considered when we evaluate appropriate foundation systems for a given site. In general, more conservative foundation designs are used for higher risk sites to control the likelihood of excessive foundation movement.

The rating of slab performance risk on a site as low or high is not absolute. Rather, this rating represents a judgment. Movement of slabs may occur with time in low, moderate, high, and very high risk areas as the expansive soils respond to increases in moisture content. Overall, the severity and frequency of slab damage usually is greater in high and very high rated areas. Heave of slabs-on-grade of 3 to 5 inches is not uncommon in areas rated as high or very high risk. On low and moderate risk sites, slab heave of 1 to 2 inches is considered normal and we believe in the majority of instances, movements of this magnitude constitute reasonable slab

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

performance. Slabs can be affected on all sites. On lots rated as high or very high risk, there is more likelihood of need to repair, maintain or replace garage floors and exterior flatwork.

The home buyer should be advised slabs-on-grade may move and crack due to heave or settlement and that there may be maintenance costs associated during and after the builder warranty period. Heave or settlement may require maintenance of finish details to control damage. Our experience suggests that soil moisture increases below residence sites due to covering the ground with buildings and exterior flatwork, coupled with the introduction of landscape irrigation. In most cases, slab movements (if any) resulting from this change occur within three to five years.

For portions of the buildings where conventional slabs-on-grade are used, we recommend the following precautions. These measures will not keep slabs-on-grade from heaving; they tend to mitigate damages due to slab heave.

1. Slab-on-grade floor construction should be limited to areas such as garages where slab movement and cracking are acceptable to the builder and home buyer.

2. The International Residential Code (IRC) states that a 4-inch base course layer consisting of clean graded sand, gravel, crushed stone or crushed blast furnace slag shall be placed beneath below grade floors (unless the underlying soils are free-draining), along with a vapor retarder. Installation of the base course and vapor retarder is not common in this area. Historically, there has been some concern that installation of clean base course could allow wetting of expansive soils to spread from an isolated source.

   IRC states that the vapor retarder can be omitted where approved by the building official. The merits of installation of a vapor retarder below floors slabs depend on the sensitivity of floor coverings and building use to moisture. A properly installed vapor retarder is more beneficial below concrete slab-on-grade floors where floor coverings, painted floor surfaces, or products stored on the floor will be sensitive to moisture. The vapor retarder is most effective when concrete is placed directly on top of it, rather than placing a sand or gravel leveling course between the vapor retarder and the floor slab. placement of concrete on the vapor retarder may increase the risk of shrinkage cracking and curling. Use of concrete with reduced shrinkage characteristics including minimized water content, maximized coarse aggregate content, and reasonably low slump will reduce the risk of shrinkage cracking and curling. Considerations and recommendations for the installation of vapor retarders below concrete slabs are outlined in Section 5.2.3.2 of the 2015 American Concrete Institute (ACI) Committee 302, “Guide to Concrete Floor and Slab Construction (ACI 302.1R-15)”.

3. Conventional slabs should be separated from exterior walls and interior bearing members with a slip joint that allows free vertical movement of the slabs. These joints must be maintained by the home buyer and/or HOA or property manager to avoid transfer of movement.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

4. Underslab plumbing should be thoroughly pressure tested during construction for leaks and be provided with flexible couplings. Gas and waterlines leading to slab-supported appliances should be constructed with flexibility. The homebuyer and/or HOA or property manager must maintain these connections.

5. Slab bearing partitions should be minimized. Where such partitions are necessary, a slip joint (or float) allowing at least 3 inches of free vertical slab movement should be used. Doorways should also be designed to allow vertical movement of slabs. To limit damage in the event of movement, sheetrock should not extend to the floor. The homebuyer and/or HOA or property manager should monitor partition voids and other connections and re-establish the voids before they close to less than 1/2-inch.

6. Plumbing and utilities that pass through slabs should be isolated from the slabs. Heating and air conditioning systems should be provided with flexible connections capable of at least 3 inches of vertical movement so floor movement is not transmitted to the ductwork. These connections must be maintained by the homebuyer and/or HOA or property manager.

7. Roofs that overhang a patio or porch should be constructed on the same foundation as the residence. Isolated piers or pads may be installed beneath a roof overhang provided the slab is independent of the foundation elements. Patio or porch roof columns may be positioned on the slab, directly above the foundation system, provided the slab is structural and supported by the foundation system. Structural porch or patio slabs should be constructed to reduce the likelihood that settlement or heave will affect the slab by placing loose backfill under the structurally supported slab or constructing the slab over void-forming materials.

8. Patio and porch slabs without roofs and other exterior flatwork should be isolated from the foundation. Movements of slabs should not be transmitted to the foundation. Decks are more flexible and more easily adjusted in the event of movement.

9. Frequent control joints should be provided in conventional slabs-on-grade to reduce problems associated with shrinkage cracking and curling. Panels that are approximately square generally perform better than rectangular areas. We suggest an additional joint about 3 feet away from and parallel to foundation walls.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

EXHIBIT B

SURFACE DRAINAGE,
IRRIGATION AND MAINTENANCE

Performance of foundations and concrete flatwork is influenced by the moisture conditions existing within the foundation soils. Surface drainage should be designed to provide rapid runoff of surface water away from proposed residences. Proper surface drainage and irrigation practices can help control the amount of surface water that penetrates to foundation levels and contributes to settlement or heave of soils and bedrock that support foundations and slabs-on-grade. Positive drainage away from the foundation and avoidance of irrigation near the foundation also help to avoid excessive wetting of backfill soils, which can lead to increased backfill settlement and possibly to higher lateral earth pressures, due to increased weight and reduced strength of the backfill. CTL | Thompson, Inc. recommends the following precautions. The home buyer and/or HOA or property manager should maintain surface drainage and, if an irrigation system is installed, it should substantially conform to these recommendations.

1. Wetting or drying of the open foundation excavations should be avoided.

2. Excessive wetting of foundation soils before, during and after construction can cause heave or softening of foundation soils and result in foundation and slab movements. Proper surface drainage around and between the buildings is critical to control wetting.

3. The ground surface surrounding the exterior of each residence should be sloped to drain away from the building in all directions. We recommend a minimum constructed slope of at least 6 inches in the first 10 feet (5 percent) in landscaped areas around each townhome building. The recommended slope is for the soil surface slope, not surface of landscaping rock.

   Between buildings that are separated by a distance of less than 20 feet, the constructed slope should generally be at least 5 percent to the swale used to convey water out of this area.

4. Construction of retaining walls and decks adjacent to the residence should not alter the recommended slopes and surface drainage around the residence. Ground surface under the deck should be compacted and slope away from the residence. A 10-mil plastic sheeting and landscaping rock is recommended above the ground under the decks to reduce water dripping from the deck causing soil erosion and/or forming depressions under the deck. The plastic sheeting should direct water away from the residence. Retaining walls should not flatten the surface drainage around the residence and block or impede the surface runoff.

5. Swales used to convey water across yards and between buildings should be sloped so that water moves quickly and does not pond for extended periods of time. We suggest minimum slopes of about 2 to 2.5 percent in grassed areas and about 2 percent where landscaping rock or other materials are present. If slopes less than about 2 percent are necessary, concrete-lined channels or plastic pipe should be used. Fence posts, trees, and retaining walls should not impede the runoff in the swale.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

6. Backfill around the foundation walls should be moistened and compacted.

7. Roof downspouts and drains should discharge well beyond the limits of all backfill. Splash blocks and/or extensions should be provided at all downspouts so water discharges onto the ground beyond the backfill. We generally recommend against burial of downspout discharge. Where it is necessary to bury downspout discharge, solid, rigid pipe should be used and it should slope to an open gravity outlet. Downspout extensions, splash blocks and buried outlets must be maintained by the home owner and/or HOA or property manager.

8. The importance of proper home owner and/or HOA or property manager irrigation practices cannot be over-emphasized. Irrigation should be limited to the minimum amount sufficient to maintain vegetation; application of more water will increase likelihood of slab and foundation movements. Landscaping should be carefully designed and maintained to minimize irrigation. Plants placed close to foundation walls should be limited to those with low moisture requirements. Irrigated vegetation, sump pump discharge pipes, sprinkler valve boxes, and roof downspout terminations should not be located within 5 feet of the foundation. Sprinklers should not discharge within 5 feet of foundations.

9. Plastic sheeting should not be placed beneath landscaped areas adjacent to foundation walls or grade beams. Geotextile fabric will inhibit weed growth yet still allow natural evaporation to occur.

10. The design and construction criteria for foundations and floor system alternatives were compiled with the expectation that all other recommendations presented in this report related to surface and subsurface drainage, landscaping irrigation, backfill compaction, etc. will be incorporated into the project. It is critical that all recommendations in this report are followed.

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

EXHIBIT C

MITIGATION OF EXPANSIVE SOILS AND BEDROCK THROUGH SUB-EXCAVATION WHISPER VILLAGE (A.K.A. ARVADA POINT) ARVADA, COLORADO

Much of the soils and underlying bedrock found beneath the Front Range area of Colorado are expansive; they swell when wetted. Deep sub-excavation of these clayey soils and bedrock is seen as an appropriate mitigation method in areas where expansive materials are present. Excavation destroys the fractures and non-uniform structure of the near-surface soils and bedrock. The excavation typically extends about 10 feet below anticipated foundation levels, although deeper or shallower sub-excavations are sometimes used. For Whisper Village, the excavation was planned to bottom about 12 to 18 feet below pre-development grades. (Fig. 1).

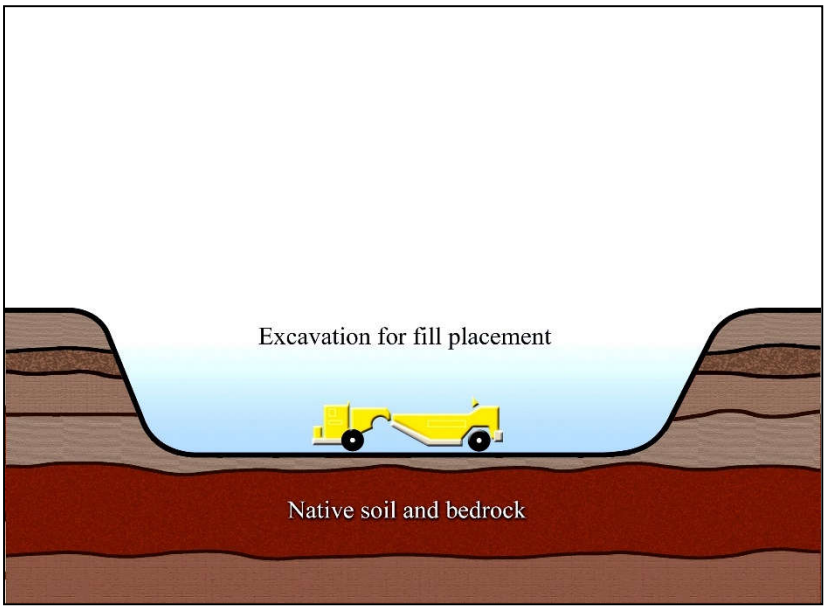

Figure 1

The excavated soils and bedrock are compacted in thin, nearly horizontal layers (Fig. 2). Water is mixed with the materials as they are placed to "pre-swell" the expansive soils and reduce potential future swell. On projects where deep sub-excavation has been employed, testing of the soils, bedrock, and backfill has demonstrated that significant reduction in swelling characteristics can be achieved.

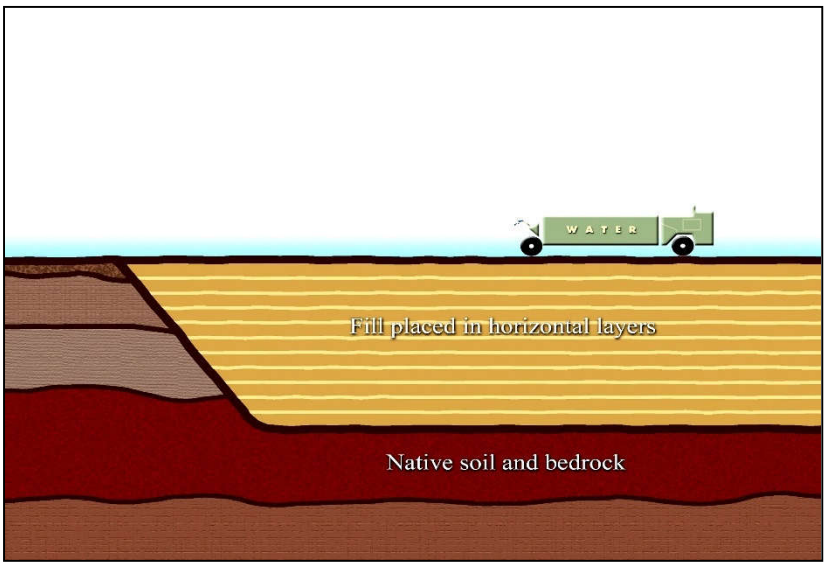

Figure 2

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT

The sub-excavation approach mitigates the influence of expansive materials on man-made improvements and structures in several ways. The weight of the fill helps to resist potential heave of the underlying natural materials. The fill acts like a cushion to spread movement over a larger area, reducing damaging movements near the ground surface (Fig. 3). The fill also covers the site with a thick layer of compacted material that limits penetration of water to the underlying natural soils and/or bedrock.

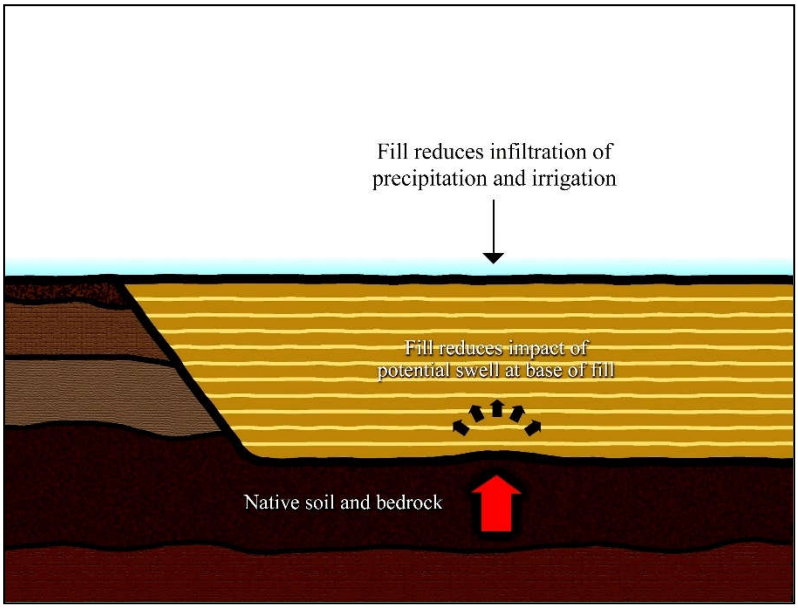

Figure 3

The sub-excavation process can provide greater stability for streets, sidewalks, driveways, and buried utilities (Fig. 4), if the sub-excavated layer extends beneath these improvements. Foundation drains around basements and underdrains below sanitary sewer mains (if installed within the subdivision) also help to collect irrigation and precipitation water that seeps into the ground. Home owner irrigation practices are critical to the overall performance of foundations and concrete flatwork and are discussed in more detail in Exhibit B.

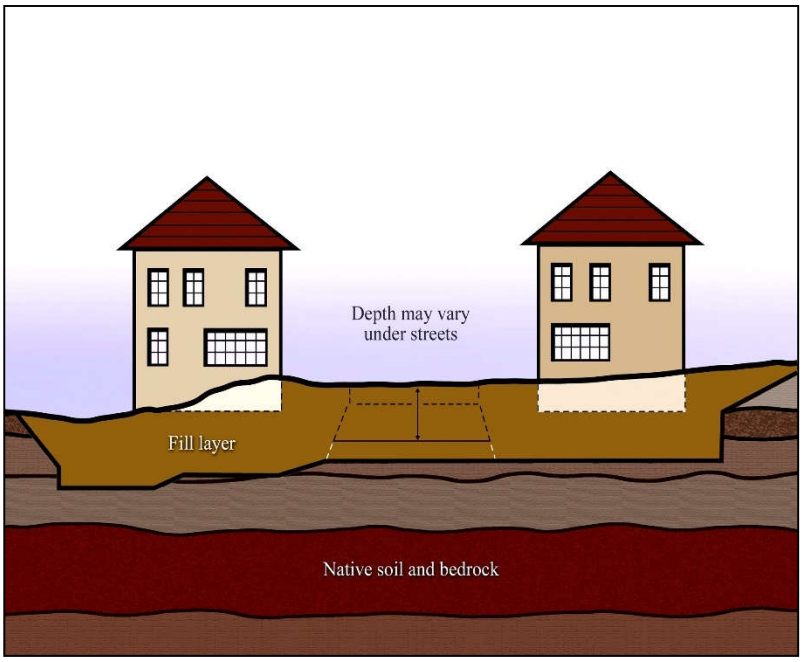

Figure 4

CITY OF ARVADA
ANY CHANGE OR DEVIATION FROM THESE PLANS MUST BE APPROVED BY ARVADA BUILDING DEPARTMENT