SUPPLEMENTAL PRELIMINARY GEOTECHNICAL INVESTIGATION
INDEPENDENCE SUBDIVISION
PHASES 1-3
NORTH OF HILLTOP ROAD
AND COUNTY ROAD 5
ELBERT COUNTY, COLORADO

Prepared For:
CRAFT COMPANIES
1787 South Broadway, Suite 200
Denver, Colorado 80210

Attention: Eric Simpson
Project No. DN48,511-115
November 1, 2016
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SCOPE

This report presents the results of our Supplemental Preliminary Geotechnical Investigation for the Independence Subdivision, Phases 1 through 3, north of Hilltop Road and County Road 5 in Elbert County, Colorado (Fig. 1). The site is planned for residential development. The purpose of our investigation was to evaluate the subsurface conditions to assist in planning for site development and residential construction. The report includes descriptions of the soil and bedrock strata, and groundwater levels encountered in our exploratory borings and discussions of site development and construction as influenced by geotechnical conditions. The scope was described in our proposal (DN-16-0328-CM1) dated August 22, 2016.

The information contained in this report is based on our understanding of the planned development, overlot grading plans prepared by Core Consulting, subsurface conditions encountered in our exploratory borings, site observations, results of laboratory tests, engineering analysis of field and laboratory data, review of a previous Geotechnical Site Development Study prepared by Terracon (Project Number 25065378, report dated November 6, 2006), and our experience with similar projects and conditions. The criteria presented are intended for planning purposes only. Additional site-specific investigations will be required to design building foundations, floor systems, and pavements. The borings were widely spaced and are not definitive for delineating areas that might benefit from sub-excavation. If a project goal is to provide nearly all sites suitable for footing foundation, more closely spaced borings should be drilled. A summary of our findings and conclusions is presented below.

SUMMARY OF FINDINGS AND CONCLUSIONS

1. The site is judged suitable for the planned development. The primary geotechnical concerns are expansive soil and bedrock and cemented rock. Terracon’s 2006 Geotechnical Study also indicated the presence of expansive soil and bedrock. We believe there are no geotechnical constraints that preclude development.
2. Subsoils encountered in our exploratory borings consisted of nil to 13.5 feet of clay and/or sand underlain by bedrock to the maximum depth explored of 35 feet. Bedrock consisted of varying layers of claystone, sandstone and interbedded claystone/sandstone. Weathered claystone was encountered in a few of our borings. The sand and sandstone are non-expansive or low swelling. The clay and claystone are expansive.

3. Groundwater was encountered during drilling in eleven borings at depths of between 12 and 30 feet below ground surface. When the holes were checked many days later, water was measured in 16 borings at depths of about 10 to 33 feet. Groundwater levels will fluctuate seasonally and may rise after development in response to precipitation, land-use changes and landscape irrigation.

4. Sub-excavation can be considered to allow wider use of footing foundations and slab-on-grade basement floors. A preliminary estimate of excavation depths is presented on Fig. 3.

5. Footing foundations are expected on all or most lots where sub-excavation is performed and design level studies indicate that the fill was properly moisture-conditioned and compacted. If sub-excavation is not performed, footings can likely be used for about 40 percent of the total lots and drilled piers bottomed in bedrock for 60 percent.

6. Slab-on-grade basement floors will likely be suitable on all lots where sub-excavation is performed. Without sub-excavation, we estimate about 85 percent of the lots could use slab-on-grade basement floors and about 15 percent would require structurally supported floors.

7. Control of surface and subsurface drainage will be critical to the performance of foundations, slabs-on-grade and pavements. Overall surface drainage should be designed to provide rapid run-off of surface water away from structures, and off of pavements and flatwork.

SITE CONDITIONS

Independence Subdivision is planned north of Hilltop Road and County Road 5 in Elbert County, Colorado (Fig. 1). The majority of the site is undeveloped with the exception of some farm buildings and houses near the southwestern limits of the project. Phases 1-3 are located on top of a ridge. The ridge slopes to the north, east and west. The ground surface varies between elevations 6610 and 6510 feet. Tributary
drainages of Henderson Gulch are located north and south of the development. The ground surface is predominately covered with grass and weeds. The site has historically been used for agricultural purposes. We found no evidence of undocumented fill in the borings or during site observation and review of historical aerial photos.

PREVIOUS INVESTIGATIONS

Terracon prepared a Preliminary Geotechnical Engineering Report for a much larger parcel that included eleven borings in Phases 1 through 3. They reported the presence of expansive soils and bedrock. Samples swelled 2.7 to 7.8 percent when wetted under 500 psf. Sub-excavation to depths of 8 to 10 feet below basement level was presented as means to reduce swell potential of clay and claystone bedrock and to allow wider use of shallow foundations. Data from Terracon's investigation is included in Appendix C and their approximate boring locations are shown on Fig. 1. The boring log from Boring No. 38 was missing from the report we received.

PROPOSED DEVELOPMENT

Overlot grading plans prepared by Core Consulting (Job No. 15-054, 08/11/16) show that 317 single-family lots are planned. The plans indicate the majority of cuts and fills will be less than about 8 feet. We assume that residences will be one or two-story, wood-framed structures with basements. Foundation loads will be relatively light and may vary from 1,000 to 3,000 pounds per lineal foot of foundation wall. Paved streets will be constructed to provide access. Buried sanitary and storm sewer, and water lines will be constructed beneath the streets. Stormwater runoff will be conveyed to four ponds in the drainages. A wastewater reclamation facility is planned northeast of the development.
FIELD INVESTIGATION

We investigated subsurface conditions by drilling forty exploratory borings at the surveyed locations shown on Fig. 1. The borings were surveyed and staked by Core Civil. Proposed grades were not available at the time of drilling. Prior to the field investigation, we contacted the Utility Notification Center of Colorado and local sewer and water districts to identify buried utilities. The borings were drilled to depths of 25 to 35 feet below existing grade using 4-inch diameter, continuous-flight auger and a truck-mounted drill rig. Samples were obtained at 5-foot intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven with a 140-pound hammer dropping 30 inches. Our field representatives logged the soil and bedrock encountered and collected samples for laboratory tests. The depth of groundwater was checked during drilling and again several days later.

Samples were returned to our laboratory where they were examined and testing was assigned. Laboratory tests included water content, dry density, percent silt and clay-sized particles (passing No. 200 sieve), particle gradation, Atterberg limits, swell consolidation, total suction and water soluble sulfate concentration. Swell consolidation tests were performed by wetting the sample under a confining pressure near existing overburden pressure. Laboratory test results are presented in Appendix B.

SUBSURFACE CONDITIONS

Subsoils encountered in our exploratory borings consisted of nil to 13.5 feet of clay and/or sand underlain by bedrock to the maximum depth explored of 35 feet. Bedrock consisted of varying layers of claystone, sandstone and interbedded claystone/sandstone. Sandstone dominated the bedrock unit. Weathered claystone was encountered in a few of our borings. Some pertinent engineering characteristics of the soil and bedrock are described in the following paragraphs. Table A summarizes the results of our swell test program.
### TABLE A
**SUMMARY OF SWELL TEST RESULTS**

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Compression</th>
<th>Range of Measured Swell (%)*</th>
<th>Number of Samples and Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to &lt;2</td>
<td>2 to &lt;4</td>
<td>4 to &lt;6</td>
</tr>
<tr>
<td>Sand, Clayey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>66%</td>
<td>33%</td>
<td>0%</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>39%</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Weathered Claystone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
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<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Claystone</td>
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<tr>
<td></td>
<td>2</td>
<td>21</td>
<td>4</td>
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<tr>
<td></td>
<td>7%</td>
<td>80%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Interbedded Sandstone and Claystone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Sandstone</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>Overall Sample Number</td>
<td>5</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Overall Percent</td>
<td>8%</td>
<td>61%</td>
<td>20%</td>
</tr>
</tbody>
</table>

* Swell measured after wetting under approximate existing overburden pressures.

**Sand**

Clean to clayey sand was encountered at the ground surface or below clay in nine of our borings. The sand was loose to dense based on results of field penetration resistance tests. Two samples compressed 1.2 and 3.8 percent and one sample did not swell when wetted under approximate overburden pressures. One sample contained 10 percent silt and clay-sized particle (passing the No. 200 sieve). The sand is judged to be non-expansive.

**Clay**

Clay was encountered at the ground surface to depths of approximately 1 to 13 feet in 26 of our borings. The clay was stiff to very stiff based on results of field penetration resistance tests. Eighteen samples swelled 0.5 to 6.4 percent when wetted under approximate overburden pressures.
Bedrock

Bedrock consisting of variable layers of claystone, weathered claystone, sandstone, and interbedded sandstone and claystone was encountered in all of the borings. Depth to bedrock varied from the ground surface down to approximately 13.5 feet. The claystone was hard to very hard and the sandstone was very hard, possibly cemented. When wetted under approximate existing overburden pressures, twenty-three claystone samples swelled 0.1 to 3.7 percent, one did not swell and two samples compressed 0.2 and 0.5 percent. Three samples of weathered claystone swelled 5.4 to 9.1 percent. Six interbedded sandstone/claystone samples swelled 0.1 to 1.7 percent. One sandstone sample swelled 0.6 percent and another sample compressed 0.4 percent. Two interbedded sandstone/claystone samples contained 42 and 44 percent silt and clay-sized particle. Eighteen samples of sandstone contained between 8 and 37 percent fines.

Groundwater

Groundwater was encountered during drilling in eleven borings at depths of between 12 and 30 feet below ground surface. When the holes were checked many days later, water was measured in 16 borings at depths of about 10 to 33 feet. There is no evidence groundwater will impact construction. Groundwater levels will fluctuate seasonally and may rise after development in response to precipitation and landscape irrigation and land-use changes.

GEOLOGIC HAZARDS AND GEOTECHNICAL CONCERNS

Site geology was investigated through review of aerial photography, geologic maps, field observations, and conditions found in our exploratory borings. A Generalized Surficial Geologic Map of the Denver 1 x 2 Quadrangle compiled by David W. Moore, et al., 2001, shows the near surface soils consist of Late Pleistocene age loess

Conditions found in our soil borings are consistent with the mapped geology.

No geologic hazards were identified that would preclude development of this site. The hazards we identified at this site include:

- Expansive Soil and Bedrock,
- Cemented rock
- Erosion, and,
- Regional Issues of Seismicity and Radioactivity.

These hazards and concerns can be mitigated with proper planning, engineering, design and construction.

**Expansive Soil and Bedrock**

The primary geologic hazard is expansive soil and bedrock. Based on the subsurface profiles, swell-consolidation test results, and our experience, we have estimated the potential heave at each boring location. Our estimates are based on proposed grades. Due to widely spaced borings and limited testing, variations from our estimates should be anticipated. Table B is a summary of the estimated potential heave.
### TABLE B
ESTIMATED POTENTIAL HEAVE AT PROPOSED GRADES

<table>
<thead>
<tr>
<th>Boring</th>
<th>Lot</th>
<th>Estimated Heave at Overlot Grade (inches)</th>
<th>Estimated Heave at anticipated Basement Level (inches)</th>
<th>Estimated Risk of Poor Basement Slab Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td></td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
<td>Low</td>
</tr>
<tr>
<td>102</td>
<td></td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
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</tr>
<tr>
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<td>&lt;0.5</td>
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</tr>
<tr>
<td>104</td>
<td></td>
<td>2.7</td>
<td>1.1</td>
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</tr>
<tr>
<td>105</td>
<td></td>
<td>1.4</td>
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<td>106</td>
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<tr>
<td>109</td>
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<td>3.6</td>
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<tr>
<td>110</td>
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<td>0.8</td>
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</tr>
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<tr>
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<td>308</td>
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<td>Low</td>
</tr>
</tbody>
</table>
Cemented Rock

Very hard (possibly cemented) sandstone was encountered consistently. Field penetration values higher than 50 blows for 2-inches of penetration were recorded frequently during sampling. Blow counts higher than approximately 50 blow for 4-inches of penetration could be difficult to excavate. Analysis indicates that very hard or cemented rock may be encountered in the vicinity of TH-302. Heavy ripping or more extensive excavation techniques may be necessary.

Erosion

Erosion potential of the site is low to moderate. Erosion potential can be expected to increase during construction, but should return to pre-construction rates or less if proper grading practices, surface drainage design, and revegetation efforts are implemented. Construction sites within the Denver metro area are subject to the U.S. Environmental Protection Agency (EPA) regulations regarding the control of storm water discharge and soil erosion. The grading design in drainages should consider the erosive power of concentrated flows.

Seismicity

The soil and bedrock are not expected to respond unusually to seismic activity. According to the 2015 International Building Code (IBC, Standard Penetration Resistance method of Section 1613.5.2), and based upon the results of our investigation, we judge the site classifies as Site Class D. The subsurface and groundwater conditions indicate nil susceptibility to liquefaction.

Radon Gas

It is normal in the Denver Metropolitan area to measure accumulations of radon gas in poorly ventilated spaces that are in contact with soil or bedrock, such as
full-depth basements. Radon gas is one of several radioactive products of the natural decay of uranium into stable lead. Since uranium is present in soils and bedrock on this site, there is a potential for radon gas accumulation in poorly ventilated spaces. Typical mitigation methods consist of sealing soil gas entry areas and ventilation of below-grade spaces. The only method to accurately evaluate radon concentrations in a closed area is to perform testing after construction. We believe it is prudent to plan contingencies for radon mitigation during design of structures, such as provision for venting of foundation drain systems.

Other Considerations

We did not identify economically valuable mineral sources in our borings. From review of available publication, economically valuable mineral resources would not be expected on the property.

SITE DEVELOPMENT

The primary geotechnical concerns that we believe will influence development and residence construction on this site are expansive soils and bedrock and potentially cemented rock. These concerns can be mitigated with proper planning, engineering, design and construction. We believe there are no geologic or geotechnical constraints at the site that would preclude development. The following sections discuss site development recommendations.

Excavation

We believe the soils penetrated by our exploratory borings can be excavated with typical heavy-duty equipment. The contractor should be familiar with applicable local, state and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. Based on our investigation and OSHA standards, we anticipate the sandy clay will classify
as Type B soil, sand as Type C, and bedrock as Type A or B. Type B soil requires a maximum slope inclination of 1:1 (horizontal to vertical), Type C requires 1½:1, and Type A requires ¾:1 for temporary excavations in dry conditions. Excavation slopes specified by OSHA are dependent upon soil types and groundwater conditions encountered. The contractor’s “competent person” should identify the soils encountered in the excavations and refer to OSHA standards to determine appropriate slopes. Stockpiles of soils and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. A professional engineer should design excavations deeper than 20 feet.

Site Grading

Prior to fill placement, all topsoil, organic matter, soft soil and deleterious material should be removed. We believe stripping will require removal of up to 6 to 8 inches of top soil. Topsoil can be used as fill in areas that will not support structures, utilities, or pavements.

Surfaces where fill is placed should be scarified to a minimum depth of 8 inches, moisture conditioned to between optimum and 3 percent above optimum moisture content for clay and within 2 percent for sands, and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698). Fill should be moisture conditioned and compacted using the same criteria. Placement and compaction of fill should be observed and tested during construction. Appendix D contains guideline grading specifications for site grading.

Our experience indicates fill will settle under its own weight. We estimate potential settlement of about one percent of the fill thickness even if the fill is compacted to the specified criteria. Most of this settlement usually occurs during and soon after construction; for clayey fill it may continue for a longer period of time. It is important that deep fills be constructed as far in advance of residential construction as practical
to allow settlement to occur. Additional fill heave and settlement will occur after development as landscape irrigation increases the moisture of the fill.

Sub-Excavation

We have estimated isolated areas of potential ground heave of up to 4.5 inches for assumed depths of wetting of 24 feet. Very long and heavily-reinforced drilled piers and structurally supported basement floors are normally recommended for moderate to high risk sites. Sub-excavation is a ground improvement method to reduce the potential swell. A preliminary estimate of potential areas and depths of sub-excavation is shown on Fig. 3. We conservatively estimate that drilled pier foundations may be required for about 60 percent of the lots unless sub-excavation is conducted. Additional investigation is recommended to better delineate the lots that merit and don’t merit sub-excavation, if this approach is desired.

The bottom of the sub-excavated area should extend laterally at least 5 feet and preferably 10 feet outside the largest possible foundation footprints to ensure foundations are constructed over moisture-conditioned fill. Conceptual sub-excavation profiles are shown on Figs. 4 and 5. We recommend that a civil engineer create sub-excavation plans. The sub-excavation geometry should be verified by a surveyor prior to filling.

The excavation contractor should be chosen carefully to assure they have experience with fill placement at over-optimum moisture and have the necessary compaction equipment. The contractor should provide a construction disc to break down fill materials and anticipate use of push-pull scraper operations and dozer assistance. The operation will be relatively slow. In order for the procedure to be performed properly, close contractor control of fill placement to specifications is required. Sub-excavation fill should be moisture-conditioned between optimum and 3 percent above optimum moisture content with an average test moisture content each day of at least
1.5 percent above optimum. Fill should be compacted as recommended in Site Grading.

Special precautions should be taken for compaction of fill at corners, access ramps, and along the perimeters of the sub-excavation as large compaction equipment cannot easily reach these areas. Our representative should observe placement procedures and test compaction of the fill on a full-time basis. The swell of the moisture-conditioned fill should be tested during and after the fill placement. Guideline sub-excavation grading specifications are presented in Appendix D.

If the fill dries excessively prior to construction, it may be necessary to rework the upper drier materials just prior to constructing foundations. We judge the fill should retain adequate moisture for about two years and can check moisture conditions in each excavation as construction progresses, if requested.

Sub-excavation and replacement with low swell fill will likely allow use of footing foundations and enhance performance of slab-on-grade basement floor construction. Sub-excavation will also enhance performance of concrete flatwork (driveways and sidewalks) and pavements, potentially reducing warranty and maintenance costs.

**Slopes**

We recommend permanent cut and fill slopes be designed with a maximum grade of 3:1 (horizontal to vertical); a flatter slope of 4:1 is desirable to control erosion. If site constraints (property boundaries and streets) do not permit construction with recommended slopes, we should be contacted to evaluate the subsurface soils and steeper slopes.
Underdrain

With long-term development and subsequent irrigation, groundwater could develop and rise. We believe this water should be controlled. The use of an underdrain system below sanitary sewer mains and services (a.k.a. area drain) is a common method to help control groundwater and provide a gravity outlet for foundation drains. If used, the underdrain should consist of 0.75 to 1.5-inch clean, free draining gravel surrounding a perforated PVC pipe (Fig. 6). We believe use of perforated pipe below sanitary sewer mains is the most effective approach. The line should consist of perforated or slotted, rigid PVC pipe placed at a grade of at least 0.5 percent. A positive cutoff (concrete) should be constructed around the sewer pipe and underdrain pipe immediately downstream of the point where the underdrain pipe leaves the sewer trench (Fig. 7). Solid pipe should be used down gradient of this cutoff wall. The underdrains should be designed to discharge to a gravity outfall constructed with a permanent concrete headwall and trash rack. The underdrain should be installed with clean-outs. To reduce the risk of cross-connecting sewer and underdrain services, we recommend using a 4-inch diameter pipe for sewer services and 3-inch diameter pipe for the underdrain services.

Where feasible, the underdrain services should be installed deep enough so that the lowest point of the basement foundation drain can be connected to the underdrain service as a gravity outlet (Fig. 8). For non-walkout basements, the low point of the basement foundation drain may be about 2 to 3 feet deeper than the foundation excavation. For buildings with walkout basements, the low point or sump pit of the basement foundation drain will be below the frost stem wall in the rear portion of the basement. The foundation drain in a walkout basement would require a deeper underdrain service for a gravity discharge and may not be practical. For these conditions, we suggest the front portion of the foundation drain be connected to the underdrain and a sump pit used for the rear portion.
Utility Construction

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. Our experience indicates use of self-propelled compactors results in more reliable performance compared to fill compacted by a sheepsfoot wheel attachment on a backhoe or trackhoe. Trench backfill should be placed in thin, loose lifts and moisture conditioned to between optimum and 3 percent above optimum moisture content for clay and compacted to at least 95 percent of maximum dry density (ASTM D 698). Sand fill should be moisture condition to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum dry density. The placement and compaction of trench backfill should be observed and tested by our firm during construction.

Pavements

Pavement subgrade will likely consist of natural sandy clay, natural sand, sandstone, or sandy clay/claystone fill. Clay and claystone subgrade will likely classify as A-7-6 according to ASSHTO and sand subgrade will likely classify between A-2-4 and A-6. The natural sandy clay and claystone are expansive. The presence of expansive subgrade implies risk that pavements may heave and be damaged. Clay and claystone subgrade will likely require mitigation. Sub-excavation to depths of 3 feet below the bottom of pavements can be considered. We have estimated locations of pavement sub-grade sub-excavation on Fig. 3. Due to the erratic nature of the subgrade, a safe approach to sub-excavation would be to wait until a subgrade investigation and pavement design is complete.

Elbert County has mitigation requirements based on the plasticity index (PI) of the subgrade soil. No over-excavation is required where PI is less than 10, 1 foot of treatment where the PI ranges between 10 and 29, 2 feet of treatment for PI ranging
between 30 and 40 and 4 feet for soils with a PI over 40. The County may require edge drains.

The properties of the subgrade will affect pavement thickness design and expansive subgrade mitigation. Subgrade should be moisture conditioned to between 1 percent below optimum and 3 percent above optimum moisture content for clay and claystone and within 2 percent of optimum moisture content for sand and compacted to at least 95 percent of maximum dry density (ASTM D 698). Table C presents the minimum pavement sections required by Elbert County for local residential and major collector streets. We suspect that the proposed County Road 5 may classify as a minor collector according to Elbert county. The minimum values may apply for streets; perhaps with 0.5 to 1.0 inch of additional asphalt. A subgrade investigation and pavement design should be performed after grading is complete.

### TABLE C
MINIMUM PAVEMENT SECTIONS

<table>
<thead>
<tr>
<th>Roadway Classification</th>
<th>Hot Mix Asphalt Concrete (HMAC) + Aggregate Base Course (ABC)</th>
<th>Full Depth Hot Mix Asphalt Concrete (HMAC)</th>
<th>Portland Cement Concrete (PCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>3” HMAC + 6” ABC</td>
<td>5” HMAC</td>
<td>5” PCC</td>
</tr>
<tr>
<td>Major Collector</td>
<td>4” HMAC + 6” ABC</td>
<td>6” HMAC</td>
<td>6” PCC</td>
</tr>
</tbody>
</table>

Clay Borrow

We understand that some ponds are planned for the project. The ponds will need to be lined with clay and we understand that it would be ideal to source the clay from site. The strata in the area of TH-201 and TH-203 consists of clay over claystone bedrock and appears to be the best location to borrow the lining material.
BUILDING CONSTRUCTION CONSIDERATIONS

The following discussions are preliminary and are not intended for design or construction. After site grading, additional site specific investigations will be necessary to design foundations and pavements. Additional drilling is recommended to increase confidence in the sub-excavation plan.

Foundations

Site soils generally include expansive soil and bedrock at depths that will affect foundation performance. Footing foundations can likely be used in low swell areas. We estimate that footing foundations can be used in about 40 percent of the site without the need for sub-excavation. Drilled piers bottomed in bedrock are typically used where moderate to very high swell soil and bedrock. We judge drilled piers are possible for about 60 percent of the site, unless sub-excavation is conducted. For soil conditions like those encountered at this site, long (30 to 35 feet), heavily reinforced piers are anticipated for high or very high swell lots. Dewatering and/or casing of piers may be required. Footing foundations can be used as an alternative to drilled piers in areas with moderate to very high swelling soils, provided sub-excavation is conducted. The estimated sub-excavation depths are presented in Fig. 3.

Preliminary Basement Floor Slab Performance Risk

The results of the laboratory testing, subsoil profiles, heave estimates, and our experience with residential construction and performance were used to provide a preliminary evaluation of basement floor slab performance risk. Slab performance risk evaluation is an engineering judgment that is used as a predictor of the general magnitude of potential slab-on-grade heave and the risk of poor slab-on-grade performance. As shown on Fig. 2, if no sub-excavation is performed we judge there is low risk of poor basement slab performance at 85 percent of the borings, moderate risk at
7.5 percent, and high risk at 7.5 percent. Moderate and high risk areas should be reduced to low after sub-excavation.

Floor Systems

Structurally supported floors should be used in all finished, non-basement living areas. Slab-on-grade basement floors may be considered on low and some moderate risk areas where potential heave is acceptable to the builder and buyers. Structurally-supported basement floors should be used on lots with high or very high risk of poor basement floor slab performance. We estimate slab-on-grade floors can be used at about 85 percent of the lots and structural floors at about 15 percent without sub-excavation. Sub-excavation should allow use of slab-on-grade basement floors at all lots where it is performed. The following precautions will be required to reduce the potential for damage due to movement of slabs-on-grade placed at this site:

1. Isolation of the slabs from foundation walls, columns and other slab penetrations;
2. Voiding of interior partition walls to allow for slab movement without transferring the movement to the structure;
3. Flexible water and gas connections to allow for slab movement. A flexible plenum above furnaces will be required; and
4. Proper surface grading and foundation drain installation to reduce water availability to sub-slab and foundation soils.

Below-Grade Construction

Surface water can penetrate relatively permeable, backfill soils and collect in relatively impermeable excavations causing wet or moist conditions. Foundation drains will be necessary around all below-grade areas. Foundation drains should be connected to an underdrain system and/or sump pit and pump system. Basement walls should be designed to resist lateral earth pressures.
Concrete

Concrete that comes into contact with soils can be subject to sulfate attack. We measured water-soluble sulfate concentrations of less than 0.01 percent to 0.11 percent in six samples with an average concentration of about 0.05 percent. For this level of sulfate concentration, ACI 332-08 Code Requirements for Residential Concrete indicates there are no special requirements for sulfate resistance. Superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious materials ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high water tables. Concrete should have a total air content of 6 percent ± 1.5 percent. We advocate all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams) be damp-proofed.

Surface Drainage

The performance of this development will be significantly influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each residence. Drainage should be planned so that surface runoff is directed away from foundations and is not allowed to pond adjacent to or between buildings, or over pavements. Attention should be paid to compact the soils behind curb and gutter adjacent to the streets and in utility trenches. If surface drainage between preliminary development and construction phases is neglected, future performance of the roadways, flatwork and foundations may be poor. When considering landscaping for common areas, we recommend the use of xeriscaping that requires little initial or long-term watering.
RECOMMENDED FUTURE INVESTIGATIONS

Based on the results of the investigations and the proposed development, we recommend the following investigations be performed:

1. Additional drilling and testing to better delineate areas that would benefit from sub-excavation, if sub-excavation is desired;
2. Geotechnical investigation of embankment dams, storm water structures and ponds if needed by the civil or structural engineer;
3. Subgrade investigation and pavement design after site grading;
4. Design-level soils and foundation investigations after grading; and
5. Construction testing and observation for site development and residential building construction.

GEOTECHNICAL RISK

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. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the structures and improvements will perform satisfactorily. It is critical that all recommendations in this report are followed during construction.

LIMITATIONS

Our borings were widely spaced to provide a general picture of subsurface conditions for preliminary planning of development and residence construction. We
believe this investigation was conducted in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing under similar conditions. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or analysis of the influence of subsurface conditions on the project, please call.

CTL | THOMPSON, INC.

Alexander C. Franceski, E.I.T.
Staff Engineer

Reviewed by:

Matthew D. Monteith, P.E.
Geotechnical Project Engineer

Ronald M. McOmber
CEO & Chairman

ACF:MDM:RMM/ot
(3 copies)

Via email:  eric@craftcompaniesllc.com
LEGEND:

TH-101  LOCATION OF EXPLORATORY BORING

- SUB-EXCAVATION DOES NOT APPEAR MERITTED
- SUB-EXCAVATION APPEARS MERITTED TO ALLOW WIDER USE OF FOOTINGS
  (10) INDICATES SUB-EXCAVATE 10- FEET BELOW EXISTING GRADE
- [5]  INDICATES SUB-EXCAVATE 5- FEET BELOW BASEMENTS

ROUGH ESTIMATE OF PAVEMENT
SUB-GRADE SUB-EX, 3 FEET

NOTE: THIS ESTIMATE IS BASED ON DATA FROM WIDELY-SPACED BORINGS. ADDITIONAL DRILLING AND TESTING IS RECOMMENDED TO BETTER EVALUATE SUB-EXCAVATION EXTENT IF THIS MITIGATION APPROACH IS SELECTED.

CONSTRUCTION DATE: 9/11/2002

PRELIMINARY ESTIMATE OF EXCAVATION

Fig. 3
Conceptual
Sub-excavation
Profile

Fig. 4
Conceptual Sub-excavation Profile
(Walk-out Basement) Fig. 5
PVC SOLID UNDERDRAIN PIPE. SIZE VARIES. PVC PIPE AND FITTINGS CONFORMING TO ASTM 3034, SDR 35.

SANITARY SEWER

4" NON-PERFORATED CORRUGATED POLYETHYLENE PIPE (ASTM F 405).

RESIDENCE FOUNDATION DRAIN.

6" MIN.

6" MIN.

PROVIDE GEOTEXTILE FABRIT BETWEEN WASHED ROCK AND SEWER BEDDING.

4" NON-PERFORATED CORRUGATED POLYETHYLENE PIPE (ASTM F 405).

WASHED ROCK MAXIMUM SIZE: 1" LESS THAN 3 PERCENT PASSING THE NO. 200 SIEVE.

SPECIFIED TRENCH WIDTH

NOTE: NOT TO SCALE.
NOTE:
The concrete cutoff wall should extend into the undisturbed soils outside the underdrain and sanitary sewer trench a minimum distance of 12 inches.
Verify that elevation of underdrain will provide adequate drop from foundation drain to underdrain, particularly where deeper excavations occur (where structural floors are planned).

Not to Scale
APPENDIX A

SUMMARY LOGS OF EXPLORATORY BORINGS
SUMMARY LOGS OF EXPLORATORY BORINGS
SUMMARY LOGS OF EXPLORATORY BORINGS

CRAFT COMPANIES
INDEPENDENCE SUBDIVISION, PHASES 1-3
PROJECT NO. DN48-511-115

FIG. A-4
SUMMARY LOGS OF EXPLORATORY BORINGS

CRAFT COMPANIES
INDEPENDENCE SUBDIVISION, PHASES 1-3
PROJECT NO. DN48,511-115

FIG. A-6
SUMMARY LOGS OF EXPLORATORY BORINGS

CRAFT COMPANIES
INDEPENDENCE SUBDIVISION, PHASES 1-3
PROJECT NO. DN48,511-115

FIG. A- 7
SUMMARY LOGS OF EXPLORATORY BORINGS

CRAFT COMPANIES
INDEPENDENCE SUBDIVISION, PHASES 1-3
PROJECT NO. DN48511-115

FIG. A- 8
SUMMARY LOGS OF EXPLORATORY BORINGS

Craft Companies
Independence Subdivision, Phases 1-3
Project No. DN49.511-115

FIG. A-9
LEGAL:\nCLAY, SANDY, STIFF TO VERY STIFF, MOIST, BROWN (CL).
SAND, CLAYEY, LOOSE TO MEDIUM DENSE, SLIGHTLY MOIST, BROWN, GRAY (SC).
SAND, CLEAN TO SLIGHTLY SILTY, MEDIUM DENSE, SLIGHTLY MOIST, BROWN, GRAY (SP, SP-5M).
WEATHERED CLAYSTONE, MOIST, BROWN, RUST.
BEDROCK, CLAYSTONE, HARD, MOIST, BROWN.
BEDROCK, SANDSTONE, CLEAN TO CLAYEY, HARD, MOIST, BROWN, TAN.
BEDROCK, INTERBEDDED CLAYSTONE/SANDSTONE, HARD, MOIST, BROWN.

DRIVE SAMPLE: THE SYMBOL 50/9 INDICATES 50 BLOWS OF AN AUTOMATIC 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 9 INCHES.

WATER LEVEL MEASURED AT TIME OF DRILLING.

NOTES:
2. BORING LOCATIONS AND ELEVATIONS WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM REFERENCING THE TEMPORARY BENCHMARK SHOWN ON FIG. 1.
3. WC INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (pcf).
   SW - INDICATES SWELL WHEN WETTED UNDER APPLIED PRESSURE (%).
   COM - INDICATES COMPRESSION WHEN WETTED UNDER APPLIED PRESSURE (%).
   LL - INDICATES LIQUID LIMIT.
   PI - INDICATES PLASTICITY INDEX
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   UC - INDICATES UNCONFined COMpressive STRENGTH (psf).
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT (%).
   pF - INDICATES SOIL SUCTION VALUE (pF).
4. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS CONTAINED IN THIS REPORT.
APPENDIX B
LABORATORY TEST RESULTS
Swell Consolidation Test Results

FIG. B-1

**Sample of INTERBEDDED CLAYSTONE/SANDSTONE**
**From TH-103 AT 14 FEET**

**DRY UNIT WEIGHT = 122 PCF**
**MOISTURE CONTENT = 14.4 %**

**Sample of CLAY, SANDY (CL)**
**From TH-104 AT 4 FEET**

**DRY UNIT WEIGHT = 104 PCF**
**MOISTURE CONTENT = 7.6 %**
Test Results

Swell Consolidation

Sample of WEATHERED CLAYSTONE
From TH-104 AT 9 FEET

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

DRY UNIT WEIGHT = 109 PCF
MOISTURE CONTENT = 13.4 %
**Swell Consolidation Test Results**

**Sample of INTERBEDDED CLAYSTONE/SANDSTONE**

- **Dry Unit Weight:** 114 PCF
- **Moisture Content:** 15.8%
- **From:** TH-104 at 14 feet

**Sample of CLAY, SANDY (CL)**

- **Dry Unit Weight:** 119 PCF
- **Moisture Content:** 8.2%
- **From:** TH-105 at 4 feet

**FIG. B-3**

*EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING*
Sample of INTERBEDDED CLAYSTONE/SANDSTONE

DRY UNIT WEIGHT = 104 PCF

From TH-108 AT 14 FEET

MOISTURE CONTENT = 15.5%

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

FIG. B-4
Swell Consolidation Test Results

Sample of WEATHERED CLAYSTONE
From TH-109 AT 4 FEET

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 14.7 %
**Swell Consolidation Test Results**

**FIG. B-6**

**Sample of INTERBEDDED CLAYSTONE/SANDSTONE**

**From TH-109 AT 9 FEET**

- **DRY UNIT WEIGHT:** 109 PCF
- **MOISTURE CONTENT:** 11.3%

**Sample of CLAYSTONE**

**From TH-110 AT 24 FEET**

- **DRY UNIT WEIGHT:** 109 PCF
- **MOISTURE CONTENT:** 18.7%
Swell Consolidation Test Results

FIG. B-7

Sample of CLAY, SANDY (CL)
From TH-111 AT 4 FEET

DRY UNIT WEIGHT = 108 PCF
MOISTURE CONTENT = 17.6 %

Sample of CLAY, SANDY (CL)
From TH-112 AT 4 FEET

DRY UNIT WEIGHT = 111 PCF
MOISTURE CONTENT = 7.1 %
Sample of CLAYSTONE

From TH-115 AT 14 FEET

APPLIED PRESSURE - KSF

COMPRESSION % EXPANSION

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Dry unit weight = 110 PCF
Moisture content = 19.0 %

Sample of CLAYSTONE

From TH-115 AT 19 FEET

APPLIED PRESSURE - KSF

COMPRESSION % EXPANSION

ADDITIONAL COMPRESSION UNDER CONSTANT PRESSURE DUE TO WETTING

Dry unit weight = 112 PCF
Moisture content = 15.1 %

Swell Consolidation Test Results
Swell Consolidation Test Results

Sample of CLAYSTONE
From TH-115 AT 24 FEET
DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 17.4%

Sample of INTERBEDDED CLAYSTONE/SANDSTONE
From TH-116 AT 24 FEET
DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 17.3%
Swell Consolidation Test Results

**Sample of CLAYSTONE**

From **TH-117 AT 14 FEET**

**APPLIED PRESSURE - KSF**

**COMPRESSION % EXPANSION**

**Dry Unit Weight = 116 PCF**

**Moisture Content = 16.2%**

**Sample of CLAYSTONE**

From **TH-117 AT 19 FEET**

**APPLIED PRESSURE - KSF**

**COMPRESSION % EXPANSION**

**Dry Unit Weight = 107 PCF**

**Moisture Content = 20.1%**

FIG. B-10
Swell Consolidation Test Results

Sample of CLAY, SANDY (CL) From TH-119 AT 9 FEET

Dry Unit Weight = 122 PCF
Moisture Content = 8.5%

Sample of CLAYSTONE From TH-119 AT 9 FEET

Dry Unit Weight = 108 PCF
Moisture Content = 18.9%
Sample of CLAYSTONE

Dry Unit Weight = 115 PCF

From TH-119 AT 14 FEET

Moisture Content = 15.4%

Compression % Expansion

Expansion Under Constant Pressure Due to Wetting

Swell Consolidation Test Results

FIG. B-12
Swell Consolidation Test Results

Sample of CLAY, SANDY (CL) from TH-201 AT 4 FEET

DRY UNIT WEIGHT = 117 PCF
MOISTURE CONTENT = 13.0 %

FIG. B-13
Sample of CLAY, SANDY (CL)
From TH-201 AT 9 FEET
DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 15.7 %

Sample of CLAYSTONE
From TH-201 AT 19 FEET
DRY UNIT WEIGHT = 109 PCF
MOISTURE CONTENT = 19.1 %

Swell Consolidation Test Results
FIG. B-14
FIG. B-15

APPLIED PRESSURE - KSF

Sample of CLAYSTONE
From TH-201 AT 24 FEET

DENSITY WEIGHT = 114 PCF
MOISTURE CONTENT = 15.8 %

Swell Consolidation
Test Results

FIG. B-15
Sample of CLAY, SANDY (CL) DRY UNIT WEIGHT = 103 PCF
From TH-203 AT 4 FEET MOISTURE CONTENT = 18.8 %

Swell Consolidation Test Results FIG. B-16

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

CRAFT COMPANIES
INDEPENDENCE SUBDIVISION, PHASES 1-3
PROJECT NO. DN48,511-115
S:\PROJECTS\48500\DN48511.000 Independence\115\2. Reports\R1\dn48511-115-r1-x1(swell).xlsx
Sample of CLAY, SANDY (CL) FROM TH-203 AT 9 FEET
DRY UNIT WEIGHT = 114 PCF
MOISTURE CONTENT = 15.6%

Sample of CLAYSTONE FROM TH-203 AT 14 FEET
DRY UNIT WEIGHT = 115 PCF
MOISTURE CONTENT = 15.9%
Swell Consolidation
Test Results
FIG. B-18

**Sample of CLAYSTONE**

- **From:** TH-203 at 19 feet
- **Applied Pressure - KSF:**
  - **APPLIED PRESSURE - KSF**
  - **MOISTURE CONTENT:** 10.9%
  - **DRY UNIT WEIGHT:** 106 PCF

**Sample of CLAYSTONE**

- **From:** TH-204 at 19 feet
- **Applied Pressure - KSF:**
  - **APPLIED PRESSURE - KSF**
  - **MOISTURE CONTENT:** 19.1%
  - **DRY UNIT WEIGHT:** 111 PCF
Swell Consolidation Test Results

**FIG. B-19**

**Sample of CLAYSTONE**

From TH-204 AT 24 FEET

**Dry Unit Weight = 110 PCF**

**Moisture Content = 20.2%**

**Sample of CLAY, SANDY (CL)**

From TH-205 AT 4 FEET

**Dry Unit Weight = 94 PCF**

**Moisture Content = 10.2%**
Swell Consolidation Test Results

FIG. B-20

**Sample of SAND, CLAYEY (SC)**
- **From TH-205 AT 9 FEET**
- **DRIY UNIT WEIGHT = 114 PCF**
- **MOISTURE CONTENT = 5.7%**

**Sample of SAND, CLAYEY (SC)**
- **From TH-206 AT 4 FEET**
- **DRIY UNIT WEIGHT = 111 PCF**
- **MOISTURE CONTENT = 7.7%**

(additional graph and text)
Sample of INTERBEDDED CLAYSTONE/SANDSTONE

DRY UNIT WEIGHT = 116 PCF

From TH-207 AT 14 FEET

MOISTURE CONTENT = 15.1 %

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

FIG. B-21
Sample of CLAY, SANDY (CL)
DRY UNIT WEIGHT = 112 PCF
From TH-208 AT 4 FEET
MOISTURE CONTENT = 11.9 %

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF

Swell Consolidation Test Results

FIG. B-22
Sample of CLAY, SANDY (CL) DRY UNIT WEIGHT = 113 PCF

From TH-208 AT 9 FEET

MOISTURE CONTENT = 10.1%

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF

Swell Consolidation Test Results

FIG. B-23
Swell Consolidation Test Results

Sample of CLAY, SANDY (CL)
From TH-209 AT 4 FEET

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Compression % Expansion

Applied Pressure - KSF

Dry Unit Weight = 103 PCF
Moisture Content = 11.3 %
Sample of CLAYSTONE
From TH-209 AT 19 FEET
DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 18.3 %

Sample of CLAYSTONE
From TH-209 AT 24 FEET
DRY UNIT WEIGHT = 111 PCF
MOISTURE CONTENT = 19.2 %

Swell Consolidation Test Results

FIG. B-25
Sample of CLAYSTONE

From TH-209 AT 29 FEET

APPLIED PRESSURE - KSF

DRY UNIT WEIGHT = 107 PCF

MOISTURE CONTENT = 19.3 %

NO MOVEMENT DUE TO WETTING

Swell Consolidation Test Results

FIG. B-26
Sample of SAND, CLAYEY (SC)

DRY UNIT WEIGHT = 95 PCF

From TH-210 AT 4 FEET

MOISTURE CONTENT = 8.2 %

APPLIED PRESSURE - KSF

ADDITIONAL COMPRESSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

FIG. B-27
Sample of WEATHERED CLAYSTONE

DRY UNIT WEIGHT = 108 PCF

From TH-211 AT 4 FEET

MOISTURE CONTENT = 15.0 %

APPLIED PRESSURE - KSF

Expansion under constant pressure due to wetting

Compression % Expansion

Swell Consolidation Test Results

FIG. B-28
Swell Consolidation Test Results

FIG. B-29

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF

Sample of CLAY, SANDY (CL)

From TH-212 AT 4 FEET

DRY UNIT WEIGHT = 114 PCF

MOISTURE CONTENT = 12.9 %
Swell Consolidation Test Results

**FIG. B-30**

**Sample of CLAYSTONE From TH-212 AT 14 FEET**

- **Dry Unit Weight:** 114 PCF
- **Moisture Content:** 15.2%

**Sample of CLAYSTONE From TH-212 AT 19 FEET**

- **Dry Unit Weight:** 110 PCF
- **Moisture Content:** 19.1%
Swell Consolidation Test Results

Sample of CLAYSTONE from TH-213 AT 4 FEET
- DRY UNIT WEIGHT = 112 PCF
- MOISTURE CONTENT = 15.4 %

Sample of SANDSTONE from TH-213 AT 9 FEET
- DRY UNIT WEIGHT = 123 PCF
- MOISTURE CONTENT = 12.3 %
Swell Consolidation Test Results

**FIG. B-32**

**Sample of CLAYSTONE**
- **From**: TH-301 AT 24 FEET
- **Dry Unit Weight**: 114 PCF
- **Moisture Content**: 15.1 %

**Sample of CLAY, SANDY (CL)**
- **From**: TH-302 AT 4 FEET
- **Dry Unit Weight**: 110 PCF
- **Moisture Content**: 12.4 %
Swell Consolidation Test Results

**Test Results**

**Swell Consolidation**

**Sample of**

- **CLAY, SANDY (CL)**
  - **APPLIED PRESSURE - KSF**
  - **TH-302 AT 9 FEET**
  - **DRY UNIT WEIGHT = 112 PCF**
  - **MOISTURE CONTENT = 11.2%**

**Sample of**

- **CLAY, SANDY (CL)**
  - **APPLIED PRESSURE - KSF**
  - **TH-303 AT 4 FEET**
  - **DRY UNIT WEIGHT = 98 PCF**
  - **MOISTURE CONTENT = 9.0%**
Sample of CLAYSTONE

DRY UNIT WEIGHT = 118 PCF

From TH-303 AT 14 FEET

MOISTURE CONTENT = 14.6 %

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

FIG. B-34
Sample of CLAY, SANDY (CL)

Dry Unit Weight = 98 PCF

From TH-305 AT 4 FEET

Moisture Content = 11.5%

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF

Swell Consolidation Test Results

FIG. B-35
Swell Consolidation
Test Results

FIG. B-36

Sample of SANDSTONE
From TH-305 AT 24 FEET
DRY UNIT WEIGHT = 120 PCF
MOISTURE CONTENT = 13.4%

Sample of CLAYSTONE
From TH-306 AT 4 FEET
DRY UNIT WEIGHT = 107 PCF
MOISTURE CONTENT = 17.8%
**Swell Consolidation Test Results**

### Sample of CLAYSTONE

- **Dry Unit Weight**: 115 PCF
- **Moisture Content**: 17.7%

From TH-306 AT 9 FEET

### Sample of CLAYSTONE

- **Dry Unit Weight**: 107 PCF
- **Moisture Content**: 20.6%

From TH-306 AT 29 FEET
Sample of CLAYSTONE
From TH-306 AT 34 FEET
DRY UNIT WEIGHT = 110 PCF
MOISTURE CONTENT = 18.9 %

Sample of CLAYSTONE
From TH-308 AT 14 FEET
DRY UNIT WEIGHT = 111 PCF
MOISTURE CONTENT = 18.0 %

Swell Consolidation Test Results
FIG. B-38
Gradation Test Results

Sample of SANDSTONE
From TH - 101 AT 14 FEET

SANDSTONE GRAVEL
2% SAND 87%
SILT & CLAY 11% LIQUID LIMIT
PLASTICITY INDEX

Sample of SANDSTONE
From TH - 119 AT 4 FEET

SANDSTONE GRAVEL
1% SAND 84%
SILT & CLAY 15% LIQUID LIMIT
PLASTICITY INDEX
Sample of SANDSTONE
From TH - 209 AT 14 FEET

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<th>Percent Passing</th>
<th>Percent Retained</th>
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Sample of SANDSTONE
From TH - 306 AT 19 FEET

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Gradation Test Results

FIG. B-40
Sample of SANDSTONE GRAVEL
From TH - 307 AT 9 FEET

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Sample of SANDSTONE GRAVEL
From TH - 307 AT 9 FEET

Gradation Test Results

FIG. B-41
## TABLE B - I

### SUMMARY OF LABORATORY TEST RESULTS

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<th>BORING</th>
<th>DEPTH (ft)</th>
<th>MOISTURE CONTENT (%)</th>
<th>DRY DENSITY (pcf)</th>
<th>SWELL TEST DATA</th>
<th>SWELL COMPRESSION (%)</th>
<th>APPLIED PRESSURE (psf)</th>
<th>SWELL PRESSURE (psf)</th>
<th>SUCTION VALUE (psf)</th>
<th>SOLUBLE SULFATE CONTENT (%)</th>
<th>PASSING NO. 200 SIEVE (%)</th>
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<tr>
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<td>MOISTURE CONTENT (%)</td>
<td>DRY DENSITY (pcf)</td>
<td>SWELL (%)</td>
<td>COMPRESSION (%)</td>
<td>APPLIED PRESSURE (psf)</td>
<td>SWELL SUCTION VALUE (psf)</td>
<td>SOIL SUCTION VALUE (%)</td>
<td>SULFATE CONTENT (%)</td>
<td>PASSING NO. 200 SIEVE (%)</td>
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<td>CLAYSTONE</td>
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</tbody>
</table>
APPENDIX C

TERRACON – EXPLORATORY BORING LOGS
### Log of Boring No. 36

**Client:** Timber Ridge, LLC  
**Site:** Elbert County, Colorado  
**Project:** Bentley Ranch

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sampled</th>
<th>Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RS 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RS 2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RS 3</td>
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<td>RS 6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>RS 7</td>
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</tbody>
</table>

**Description:**
- **SANDSTONE, fine to medium grained, medium to very hard, weakly cemented, white, dry to moist, varies to CLAYEY SANDSTONE**
- **CLAYEY SAND, medium grained, loose, brown, dry**
- **SILTY SAND, fine to medium grained, medium dense, brown, moist**

Stopped boring at 25 feet.

---

### Log of Boring No. 37

**Client:** Timber Ridge, LLC  
**Site:** Elbert County, Colorado  
**Project:** Bentley Ranch

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sampled</th>
<th>Tests</th>
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<tbody>
<tr>
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<td>RS 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RS 2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RS 3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RS 4</td>
<td></td>
</tr>
</tbody>
</table>

**Description:**
- **CLAYEY SAND, fine to coarse grained, loose, brown, moist**
- **CLAYEY SAND, medium grained, loose, brown, dry**
- **SANDSTONE, fine to medium grained, medium hard to very hard, weakly cemented, white to gray, dry to moist, varies to moderate thinning**

Stopped boring at 25 feet.

---

### Log of Boring No. 39

**Client:** Timber Ridge, LLC  
**Site:** Elbert County, Colorado  
**Project:** Bentley Ranch

<table>
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</thead>
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<tr>
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<td>RS 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RS 2</td>
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<td>3</td>
<td>RS 3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RS 4</td>
<td></td>
</tr>
</tbody>
</table>

**Description:**
- **SANDSTONE, fine to medium grained, hard to very hard, weakly cemented, white, dry, mild iron staining**
- **SANDY CLAY, very slow, brown, dry, mildly calcareous**

Stopped boring at 25 feet.

---

### Log of Boring No. 40

**Client:** Timber Ridge, LLC  
**Site:** Elbert County, Colorado  
**Project:** Bentley Ranch

<table>
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<th>Tests</th>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>RS 2</td>
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<td>RS 3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RS 4</td>
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</tr>
</tbody>
</table>

**Description:**
- **SANDY CLAYSTONE, medium hard, white to light gray, moist**
- **CLAYSTONE, hard, gray, dry to moist, mild iron staining**
- **SANDSTONE, fine to medium grained, very hard, weakly cemented, white, dry**

Stopped boring at 25 feet.
### LOG OF BORING NO. 45

**CLINT** | Timber Ridge, LLC  
**SITE** | Elbert County, Colorado  
**PROJECT** | Bentley Ranch  

<table>
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<th>DESCRIPTION</th>
<th>SAMPLES</th>
<th>TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLAYY LEAN CLAY, hard, black, dry</td>
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<td></td>
</tr>
<tr>
<td>LEAN CLAY with sand, very stiff, light brown, dry to moist</td>
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<td></td>
</tr>
<tr>
<td>CLAYSTONE with sand, medium hard to hard, brown, light brown, dry to moist, mild iron staining</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stopped boring at 26 feet

**WATER LEVEL OBSERVATIONS, ft**  
- BORING STARTED: 10-15-05
- BORING COMPLETED: 10-16-05

**APPROVED** | MEA JOB # 25053279

---

### LOG OF BORING NO. 46

**CLINT** | Timber Ridge, LLC  
**SITE** | Elbert County, Colorado  
**PROJECT** | Bentley Ranch  

<table>
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<th>DESCRIPTION</th>
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<th>TESTS</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>SANDSTONE, fine to coarse grained, medium hard to very hard, weakly cemented, off white, dry to moist</td>
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<td></td>
</tr>
<tr>
<td>CLAYSTONE with sand, medium hard, brown, dry to moist</td>
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</table>

Stopped boring at 25 feet

**WATER LEVEL OBSERVATIONS, ft**  
- BORING STARTED: 10-15-05
- BORING COMPLETED: 10-16-05

**APPROVED** | MEA JOB # 25053279

---

### LOG OF BORING NO. 47

**CLINT** | Timber Ridge, LLC  
**SITE** | Elbert County, Colorado  
**PROJECT** | Bentley Ranch  

<table>
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<th>TESTS</th>
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</thead>
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<td></td>
</tr>
<tr>
<td>SANDSTONE, fine to medium grained, medium hard to hard, white, dry</td>
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</table>

Stopped boring at 35 feet

**WATER LEVEL OBSERVATIONS, ft**  
- BORING STARTED: 10-15-05
- BORING COMPLETED: 10-16-05

**APPROVED** | MEA JOB # 25053279

---

### LOG OF BORING NO. 48

**CLINT** | Timber Ridge, LLC  
**SITE** | Elbert County, Colorado  
**PROJECT** | Bentley Ranch  

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<th>TESTS</th>
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<tbody>
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</table>

Stopped boring at 35 feet

**WATER LEVEL OBSERVATIONS, ft**  
- BORING STARTED: 10-15-05
- BORING COMPLETED: 10-16-05

**APPROVED** | MEA JOB # 25053279
<table>
<thead>
<tr>
<th>CLIENT</th>
<th>Timber Ridge, LLC</th>
<th>PROJECT</th>
<th>Bentley Ranch</th>
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| SITE                  | Elbert County, Colorado |

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<th>DESCRIPTION</th>
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<tr>
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<td>SEDIMENT LOG</td>
<td>DESCRIPTION</td>
<td>SEDIMENT LOG</td>
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<tr>
<td>5 RS 8</td>
<td>500</td>
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**WATER LEVEL OBSERVATIONS**

- BORING STARTED: 10-18-00
- BORING COMPLETED: 10-18-00
- WATER LEVEL OBSERVATIONS: 8
- APPROVED: MEA JOB # 2509379

**Notes:**
- The boundaries depicted on the maps likely represent the property boundaries.
APPENDIX D
GUIDELINE SITE GRADING SPECIFICATIONS
Independence, Phases 1-3
Elbert County, Colorado
GUIDELINE SITE GRADING SPECIFICATIONS
Independence, Phases 1-3
Elbert County, Colorado

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlots elevations. These specifications shall also apply to compaction of excess cut materials that may be placed outside of the development boundaries.

2. GENERAL

The Soils Engineer shall be the Owner's representative. The Soils Engineer shall approve fill materials, method of placement, moisture contents and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content (0 to 3 percent above optimum moisture content for clays and within 2 percent of optimum moisture content for sands) and compacted to not less than 95 percent of maximum dry density as determined in accordance with ASTM D698.

6. FILL MATERIALS

Fill soils shall be free from organics, debris or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than six (6) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SW, SP, GP, GC and GM are acceptable. Concrete, asphalt, organic matter and other deleterious materials or debris shall not be used as fill.
7. MOISTURE CONTENT

Fill material classifying as CH and CL shall be moisture conditioned to between optimum and 3 percent above optimum moisture content. Granular soils classifying as SC, SM, SW, SP, GP, GC and GM shall be moisture conditioned to within 2 percent of optimum moisture content as determined from Proctor compaction tests. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disc the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill shall be compacted to at least 95 percent of the maximum density as determined in accordance with ASTM D 698. At the option of the Soils Engineer, soils classifying as SW, GP, GC, or GM may be compacted to 95 percent of maximum density as determined in accordance with ASTM D 1557 or 70 percent relative density for cohesionless sand soils. Fill materials shall be placed such that the thickness of loose materials does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.

Compaction as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Engineer for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Soils Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

9. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is no appreciable amount of loose soils on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to
5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

10. **PLACEMENT OF FILL ON NATURAL SLOPES**

Where natural slopes are steeper than 20 percent in grade and the placement of fill is required, benches shall be cut at the rate of one bench for each 5 feet in height (minimum of two benches). Benches shall be at least 10 feet in width. Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

11. **DENSITY TESTS**

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is not within specification, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

12. **SEASONAL LIMITS**

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates that the moisture content and density of previously placed materials are as specified.

13. **NOTICE REGARDING START OF GRADING**

The Contractor shall submit notification to the Soils Engineer and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

14. **REPORTING OF FIELD DENSITY TESTS**

Density tests made by the Soils Engineer, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, and percentage compaction shall be reported for each test taken.

15. **DECLARATION REGARDING COMPLETED FILL**

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, and was placed in general accordance with the specifications.
APPENDIX E
GUIDELINE SITE GRADING SPECIFICATIONS
(SUB-EXCAVATION)
Independence, Phases 1-3
Elbert County, Colorado

Note: This guideline is intended for use with sub-excavation. If sub-excavation is not selected, the guidelines in Appendix E should be followed.
1. **DESCRIPTION**

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of materials that may be placed outside of the development boundaries.

2. **GENERAL**

The Soils Engineer shall be the Owners representative. The Soils Engineer shall approve fill materials, method of placement, moisture content and percent compaction, and shall give written approval of the completed fill.

3. **CLEARING JOB SITE**

The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill where the material will support structures of any kind.

4. **SCARIFYING AREA TO BE FILLED**

All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features which would prevent uniform compaction.

5. **COMPACTING AREA TO BE FILLED**

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content, (optimum to 3 percent above optimum) and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698.

6. **FILL MATERIALS**

Fill soils shall be free from vegetable matter or other deleterious substances, and shall not contain rocks having a diameter greater than six (6) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SP, GP, GC and GM are acceptable. Concrete, asphalt, and other deleterious materials or debris shall not be used as fill.

7. **MOISTURE CONTENT**

Fill materials shall be moisture treated to within limits of optimum moisture content specified in “Moisture Content and Density Criteria”. Sufficient laboratory compaction tests...
shall be made to determine the optimum moisture content for the various soils encountered in borrow areas or imported to the site.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor will be required to rake or disc the fill to provide uniform moisture content throughout the fill.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desire results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACATION OF FILL MATERIALS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density given in “Moisture Content and Density Criteria”. Fill materials shall be placed such that the thickness of loose material does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Soils Engineer for soils classifying as CL, CH or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Soils Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

9. MOISTURE CONTENT AND DENSITY CRITERIA

Fill material shall be substantially compacted to at least 95 percent of maximum ASTM D 698 (AASHTO T 99) dry density at optimum to 3 percent above optimum moisture content. Additional criteria for acceptance are presented in DENSITY TESTS.

10. DENSITY TESTS

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof not within specifications, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.
Allowable ranges of moisture content and density given in MOISTURE CONTENT AND DENSITY CRITERIA are based on design considerations. The moisture shall be controlled by the Contractor so that moisture content of the compacted earth fill, as determined by tests performed by the Soils Engineer, shall be within the limits given. The Soils Engineer will inform the Contractor when the placement moisture is less than or exceeds the limits specified and the Contractor shall immediately make adjustments in procedures as necessary to maintain placement moisture content within the specified limits, to satisfy the following requirements.

A. Moisture

1. The average moisture content of material tested each day shall not be less than 1.5 percent over optimum moisture content.

2. Material represented by samples tested having moisture lower than optimum will be rejected. Such rejected materials shall be reworked until moisture equal to or greater than 1 percent above optimum is achieved.

B. Density

1. The average dry density of material tested each day shall not be less than 95 percent of maximum ASTM D 698 dry density.

2. No more than 10 percent of the material represented by the samples tested shall be at dry densities less than 95 percent of maximum ASTM D 698 dry density.

3. Material represented by samples tested having dry density less than 93 percent of maximum ASTM D 698 dry density will be rejected. Such rejected materials shall be reworked until a dry density equal to or greater than 95 percent of maximum ASTM D 698 dry density is obtained.

11. INSPECTION AND TESTING OF FILL

Inspection by the Soils Engineer shall be sufficient during the placement of fill and compaction operations so that they can declare the fill was placed in general conformance with specifications. All inspections necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates the moisture content and density of previously placed materials are as specified.
13. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under “Density Tests” above, shall be submitted progressively to the Owner. Dry density, moisture content and percentage compaction shall be reported for each test taken.