CTL | THOMPSON
INCORPORATED

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

SOILS AND FOUNDATION INVESTIGATION
SUNRISE VILLAGE DUPLEXES
11301 WEST 72ND AVENUE
ARVADA, COLORADO

Prepared for:

SUNRISE VILLAGE, LLC
6143 South Willow Drive, Suite 300
Greenwood Village, Colorado 80111

Attention: Stephen Sundberg

Project No. DN49,355.001-120-R1

January 21, 2021

1971 West 12th Avenue | Denver, Colorado 80204 | Phone: 303-825-0777 | Fax: 303-825-4252

TABLE OF CONTENTS

SCOPE

This report presents the results of our Soils and Foundation Investigation for Sunrise Village, twelve duplex residences (24 units) planned at 11301 West 72nd Avenue in Arvada, Colorado (Fig. 1 and Photo 1). The purpose of our investigation was to evaluate the subsurface conditions to provide geotechnical design and construction recommendations for the buildings. The scope was described in a Contract Modification (DN 20-0379-CM1) dated November 6, 2020.

This report is based on conditions found in our exploratory borings, results of field and laboratory tests, engineering analysis of field and laboratory data, previous investigations, and our experience. The report contains descriptions of the strata and groundwater found in the exploratory borings, discussion of foundation and floor support alternatives, and recommended design and construction criteria for foundations, floor systems, and subsurface and surface drainage. The recommendations are based on the construction as currently planned. Revisions to the planned construction could affect our recommendations. If the construction will differ from the descriptions herein, we should be contacted to review our recommendations and determine if revisions are needed. A summary of our conclusions and recommendations follows, with more detailed discussion and design criteria provided in the report.

SUMMARY

1. Strata encountered in our exploratory borings consisted of about 6.5 to 13 feet of sandy clay, clayey sand, and interlayered clay/sand underlain by claystone, sandstone, and interbedded claystone/sandstone bedrock. The soils are non-expansive or low swelling and the bedrock is non-expansive or low to moderately swelling.

2. Groundwater was encountered in four borings during drilling at depths of 2 to 12 feet. When holes were checked several days later, water was measured at depths of about 2 to 15 feet in all twelve holes. We understand that you are not planning to install an interceptor drain up-gradient of the homes. Based on planned finished floor elevations, basements will require

permanent dewatering systems and ground stabilization (Fig. 3). Dewatering systems should be designed with a sump and pump. Groundwater and soft, wet soil will be encountered in most excavations for basements and deep utilities. Homes without basements can use structural slabs-on-void or joists over a crawl space without ground stabilization. Water levels may fluctuate seasonally and rise in response to precipitation, landscape irrigation, and flow in the ditch to the north of the site.

3. The presence of shallow groundwater and expansive soil and bedrock are recognized geologic hazards. If basements are planned, it is crucial that dewatering systems be carefully maintained. We believe the recommendations in this report will help to control risk of damage; they will not eliminate the risk. Slabs-on-grade and, in some instances, foundations may be damaged by heave or settlement.

4. For duplexes where the groundwater level is within 3 to 5 feet of basement floor, excavations will encounter soft, moist to wet soil. Considering the variable groundwater levels measured, we believe it is prudent to provide the details discussed in this paragraph for all buildings where basements are planned. We recommend excavations be done with low impact equipment such as long-reach backhoes to limit rutting due to wheel traffic and to provide room for a woven or grid geotextile and at least 10 inches of drain rock below foundations and floor slabs. The foundation drain pipes can be installed on the geotextile prior to placing the rock, for later completion of the sump and outfall. A slight excavation slope toward the sump is recommended to promote drainage at the base of the gravel layer.

5. We recommend Lots 21/22 and 23/24 use drilled pier foundations to reduce risks due to expansive soil and bedrock. All other buildings can use footing foundations if desired. Design and construction criteria are presented in the report. A representative of our firm should observe footing excavations.

6. Residences without basements should have a structurally supported main floor over a void or crawlspace. Swell tests indicate low risk of poor performance of slab-on-grade basement floors for ten of twelve buildings, and moderate risk on Lots 21-24. For the low-risk lots, we judge potential heave at the basement level of up to about 2 inches is possible. For Lots 21-24, we estimate up to 3 inches of potential heave is possible at the basement level. Actual heave will likely be less than our calculations suggest. Structurally supported basement floors should be used if no movement can be tolerated. Slab-on-grade garage floors, driveways and exterior flatwork may experience movement and cracking.

7. We recommend foundation drains around the lowest level of all residences. Basement window wells should have gravel and pipes connected to the foundation drains.

8. Surface drainage should be designed, constructed, and maintained to provide rapid removal of surface runoff away from the proposed residences and off nearby pavements and flatwork. Conservative irrigation practices should be followed to avoid excessive wetting.

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

SITE CONDITIONS

Sunrise Village is located at 11301 West 72nd Avenue in Arvada, Colorado (Fig. 1 and Photo 1). The site is bordered by private residential lots to the east and west, West 72nd Avenue to the south, and sports fields associated with Oberon Middle School to the north. An irrigation or drainage ditch runs along the northern edge of the site. The ground surface is covered with grass and cattails, and slopes gently to the southwest toward West 72nd Avenue. Available Google Earth aerial photographs indicate the site has been vacant since 1993, except for a few small storage structures and a mobile home which have been present since that time.

Photo 1 – Google Earth Satellite Imagery, October 2019

PROPOSED CONSTRUCTION

We were provided with site plans prepared by Baseline Corp showing the site will consist of 12 duplex buildings (24 residential units), access drives, a park, an underground detention pond, and a water quality pond (Fig. 1). Grading plans show a few feet of cut or up to about 13 feet of fill will be needed to form the lots for construction. We understand the duplexes will have one or two stories and that basements are being considered and attached garages are planned. Finished floor elevations will vary from 5510.85 to 5522.0. We assume basement foundation walls will be about 9 feet high and excavations may bottom about 10 feet below the first floor.

PREVIOUS INVESTIGATIONS

We performed a Preliminary Geotechnical Investigation for the site under our Project No. DN49,355-115 (report dated March 27, 2018). We drilled and sampled five exploratory borings within the residential lots and two shallow borings along West 72nd Avenue to evaluate conditions for future pavement widening. Subsurface conditions consisted of about 2 to 16 feet of natural sandy clay and clayey sand underlain by claystone and sandstone bedrock. Groundwater was measured at depths of about 1 to 7 feet below existing grades, or approximate elevations 5499 to 5515 feet. Shallow groundwater and expansive soil and bedrock were judged to be the primary geotechnical concerns.

Four additional borings were drilled to allow construction of temporary monitoring wells, as described in a letter dated September 18, 2020 (Project No. DN49,355.001-145). Groundwater was encountered in two borings at depths of 4.5 and 9.5 feet below the existing ground surface at the northwest and northeast corners of the site, respectively. Pertinent data from the previous investigations were considered in preparation of this report.

INVESTIGATION

We investigated subsurface conditions by drilling and sampling twelve exploratory borings on December 4, 7, and 8, 2020 at the approximate locations shown on Fig. 1. Boring locations were determined using plans provided and elevations were obtained with a Leica GS18 GPS unit referencing the North American Vertical Datum of 1988 (NAVD 88). The borings were drilled to depths of 20 to 30 feet using 4-inch diameter, continuous-flight, solid-stem auger and a truck-mounted CME-45 drill rig. We obtained samples at 5-feet intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven by blows of an automatic 140-pound hammer falling 30 inches. Our field representative was present to observe drilling operations, log the strata encountered and obtain samples for laboratory testing. Slotted PVC well pipes with locking covers were installed to allow delayed groundwater measurements. Graphical logs of the borings are presented in Appendix A.

Samples were returned to our laboratory where they were examined. Laboratory tests included moisture content, dry density, percent silt and clay-sized particles (passing No. 200 sieve), Atterberg limits, soil suction, swell-consolidation and water-soluble sulfate concentration. Swell-consolidation tests were performed by wetting the samples under approximate overburden pressure considering proposed grades (the weight of the overlying soils after site grading). Load-back analysis was performed on select samples to estimate swelling pressure. Results of laboratory tests are presented in Appendix B and summarized in Table B-I.

SUBSURFACE CONDITIONS

Strata encountered in our exploratory borings consisted of 6.5 to 13 feet of sandy clay, clayey sand, and interlayered clay/sand underlain by weathered to comparatively unweathered claystone, sandstone, and interlayered claystone/sandstone bedrock to the maximum depth explored of 30 feet. Groundwater was measured at depths of 2 to 15 feet after drilling. Pertinent engineering characteristics of the subsoils are described in the following paragraphs.

Sand and Clay

About 6.5 to 13 feet of sandy clay, clayey sand, and/or interlayered clayey/sand were encountered in all twelve borings. The clay was stiff to very stiff, the sand was dense, and the interlayered clay/sand was stiff to very stiff or medium dense. Six samples of clay compressed 0.1 to 1.1 percent, six samples swelled 0.3 to 2.0 percent, and one sample swelled 2.9 percent when wetted. Three clay samples exhibited load-back swelling pressures of 3,900 to 4,300 psf. Two interlayered clay/sand samples compressed 0.2 and 1.6 percent and two samples swelled 0.3 and 1.6 percent. Three clay samples contained 58 to 71 percent silt and clay-sized particles and two samples exhibited moderate to high plasticity. Three interlayered clay/sand samples contained 40 to 69 percent fines and one sample exhibited moderate plasticity. One sand sample contained 24 percent fines. Four clay samples had soil suction values of 3.03 to 4.60 pF. The sandy clay is considered to be non-expansive or low swelling.

Bedrock

Claystone, sandstone, and/or interbedded claystone/sandstone bedrock was encountered in all borings at depths of 6.5 to 13 feet, at approximate elevations 5494 to 5512.5. The upper 3 to 7 feet of claystone were weathered in seven of the borings. The claystone was weathered to hard, the sandstone was hard to very hard, and the interbedded claystone/sandstone was medium hard to very hard. One claystone sample compressed 0.2 percent, twelve samples swelled 0.1 to 2.0 percent, and three samples swelled 2.7 to 3.4 percent when wetted. Seven claystone samples exhibited load-back swelling pressures of 3,000 to 20,000 psf. Three interbedded claystone/sandstone samples compressed 0.2 to 0.4 percent and five samples swelled 0.2 to 2.0 percent when wetted. Ten claystone samples had soil suction values of 3.65 to 4.08 pF. Two interbedded claystone/sandstone samples had soil suction values of 3.76 and 3.82 pF. Two claystone samples contained 79 and 82 percent fines. Four interbedded claystone/sandstone samples contained 39 to 54 percent fines and one sample exhibited moderate plasticity. The claystone is low to moderately expansive. The sandstone is judged to be non-expansive.

Groundwater

Groundwater was encountered during drilling in four borings at depths of 2 to 12 feet. When the holes were checked several days later, water was measured in all twelve borings at depths of about 2 to 15 feet, at approximate elevations 5486.5 to 5513.5. The measurements indicate groundwater flows south from the ditch and sporting fields north of the site. Water levels may fluctuate seasonally and rise in response to precipitation, landscape irrigation, and flow in nearby drainages, ditches and ponds.

GEOLOGIC HAZARDS

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 react to changes in moisture conditions. Some of the soils and bedrock swell as they increase in moisture and are referred to as expansive soils. Other soils can compress significantly upon wetting and are identified as compressible 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 compressible behavior 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 due to heave or settlement is inevitable. It is critical that all recommendations in this report are followed to increase the chances that the foundations and slabs-on-grade will perform satisfactorily. After construction, home owners, the homeowner’s association, and/or property managers must assume responsibility for maintaining the structures and use appropriate practices regarding drainage and landscaping.

Expansive Soil and Bedrock

Based on our investigation, non-expansive or low swelling soils are typically present at depths likely to influence foundation and slab performance at this site. Low to moderately expansive claystone is present at the southeast part of the site, and swell test results indicate relatively more expansion potential on Lots 21 to 24. 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 this 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 movement of the subsoils. Maintenance will be required to control risk. We recommend the builder provide a booklet to home buyers and property managers 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.

Shallow Groundwater

Shallow groundwater is present at most lots and is considered a geologic hazard. Shallow groundwater (less than about 12 feet deep below main floor or 3 to 5 feet below basement) can affect basement and utility construction. We generally recommend limiting excavations to at least 3 feet above groundwater, which would likely preclude basements unless measures discussed below are implemented. We understand that you are not planning to install an interceptor drain up-gradient of the homes. Based on planned finished floor elevations, basements will require permanent dewatering systems. Dewatering systems should be designed with a sump and pump backup although normal operation should be for gravity outfall to an underdrain or a well-drained area. Groundwater and soft, wet soil will be encountered in most excavations for basements and deep utilities. Water levels may fluctuate seasonally and rise in response to precipitation, landscape irrigation, and flow in the ditch to the north of the site.

For duplexes where the groundwater level is within 3 to 5 feet of basement floor, excavations will encounter soft, moist to wet soil. Considering the variable groundwater levels measured, we believe it is prudent to provide the details discussed in this paragraph and Fig. 3 for all buildings where basements are planned. We recommend excavations be done with low impact equipment such as long-reach backhoes to limit rutting due to wheel traffic and to provide room for a woven or grid geotextile (Mirafi RS380i or approved substitute) and at least 10 inches of drain rock below foundations and floor slabs. The foundation drain pipes can be installed on the geotextile prior to placing the

[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.

rock, for later completion of the sump and outfall. A slight excavation slope toward the sump is recommended to promote drainage at the base of the gravel layer.

Utility excavations near and below groundwater will be wet and likely require temporary dewatering. The contractor should be prepared to deal with shallow water.

SITE PREPARATION

Excavations and Utility Construction

Excavations made at this site, including those for foundations and utilities, may be governed by local, state, or federal guidelines or regulations. Subcontractors should be familiar with these regulations and take whatever precautions they deem necessary to comply with the requirements and thereby protect the safety of their employees and the public.

We believe the soils penetrated in our exploratory borings can be excavated with conventional, heavy-duty excavation equipment. We recommend the owner and the contractor become 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 clay and claystone will classify as Type B soil, and the sand, interlayered clay/sand, sandstone, and interbedded claystone/sandstone as Type C. Type B soil requires a maximum side slope inclination of 1:1 (horizontal:vertical) for temporary excavations in dry conditions and Type C requires 1½:1. Excavation side slopes specified by OSHA are dependent upon soil types and groundwater or seepage conditions encountered. The contractor's "competent person" is required to 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.

Permanent un-retained slopes should be designed no steeper than about 3H:1V and should be re-vegetated as soon as practical to control erosion; use of 4H:1V maximum slopes are preferable. A professional engineer should design excavations deeper than 20 feet.

Utilities may be constructed beneath exterior flatwork. Compaction of utility trench backfill can have a significant effect on the life and serviceability of floor slabs and exterior flatwork. We recommend utility trench backfill be placed in thin, loose lifts, and moisture conditioned and compacted according to the specifications presented below. The placement and compaction of fill, backfill and utility trench backfill should be observed and tested by a representative of our firm during construction.

Fill and Backfill

On-site soils are generally suitable for reuse as new fill, provided they are substantially free of debris, vegetation/organics, and other deleterious materials. Soil particles larger than about 3 inches should not be used for fill. Fill should be placed in thin (8 inches or less) loose lifts, moistened to within 2 percent optimum moisture content for sand and between optimum and 3 percent above optimum for clay. The fill should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698). Placement and compaction of fill should be observed and tested by a representative of our firm during construction.

If loose or soft soils are encountered in foundation excavations, they should be removed and replaced with compacted fill as recommended above or stabilized. Stabilization can likely be accomplished by crowding 1.5 to 3-inch nominal size crushed rock into the soft subsoils until the base of the excavation does not deform more than about 1 inch when compactive effort (a full-sized loader with full load) is applied.

Our experience indicates fill and backfill can settle under its own weight, even if properly compacted to the criteria provided above. We estimate potential settlement of about 1 to 2 percent of the fill thickness should be anticipated. Factors that influence the amount of settlement are depth of fill, soil type, degree of compaction, and time. The length of time for the compression to occur can be a few weeks to several years. Any improvements placed over backfill should be designed to accommodate movement.

Interceptor Drain

Shallow groundwater is present at the site. Our measurements indicate water flows south. Previously, we recommended an interceptor drain along the north site boundary to help control groundwater for easier basement construction and to provide redundancy to foundation drains. We understand you are not planning to install an interceptor drain along the north property line due to space limitations. If basements are desired, groundwater will have to be controlled with individual drain systems at each building, as discussed elsewhere in this report. The underdrain discussed below can be used to discharge foundation drains.

Underdrain

Our firm generally advocates an underdrain system below sanitary sewer mains and services to control groundwater that may accumulate in response to development. The underdrain also helps to control shallow water and could allow gravity flow from basement foundation drain systems.

It may not be practical to install underdrains at this site if a gravity discharge is not available. It is possible a pumped system could be used, which would require more long-term maintenance. If an underdrain system is not installed, individual house foundation drains would discharge into sumps for primary discharge using pumps. Sump discharge can result in ponding and recycling if slopes between lots are not adequately graded and well-drained. Problems with chronic ice or algae formation on sidewalks have also developed from sump discharge.

If used, the underdrain should consist of ¾ to 1½-inch clean, free-draining gravel surrounding a perforated PVC pipe (Fig. 8). Given the shallow groundwater at this site, we recommend perforated pipe. The pipe should be sized for anticipated flow. The line should consist of smooth, perforated or slotted, rigid PVC pipe placed at a grade of at least 0.5 percent. A concrete cutoff should be constructed around the sewer pipe and underdrain pipe immediately downstream of the point where the underdrain pipe exits the sewer trench and transitions from perforated to solid (Fig. 9). Solid pipe should be used down gradient of this cutoff wall. The underdrains should be designed to discharge to a gravity outfall or pumped system.

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. 10). 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 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.

Stabilization

Soft, very moist soils will likely be encountered in most excavations and should be removed or stabilized. Soft excavation bottoms can be stabilized by crowding at least 10 inches of crushed rock into the soils until firm. Acceptable rock materials include, but are not limited to, No. 2 and No. 57 or 67 rock. Crushed rock on a layer of woven geosynthetic fabric (Mirafi RS380i or approved substitute) is recommended, which should reduce the amount of aggregate needed to stabilize the subgrade. The stabilization rock and drain rock discussed above are the same material.

FOUNDATIONS

Based on data from our drilling and laboratory testing, and anticipated foundation excavation elevations, the soils below excavations will consist of low swelling or non-expansive soils. Expansive claystone was found to be relatively shallow on Lots 21-24. Swell tests on samples from all lots except Lots 21/22 and 23/24 indicate low potential movement if the claystone is wetted further. We believe footing foundations are appropriate for ten of the twelve duplex buildings, as shown on Fig. 2. Drilled pier foundations should be used on Lots 21/22 and 23/24. Where basements are used, most or all foundations will be constructed on a gravel layer. Design criteria for foundations are presented below. These criteria were developed from analysis of field and laboratory data and our experience. The builder and structural engineer should also consider design and construction details established by the structural warrantor (if any) that may impose additional design and installation requirements

<u>Footings</u>

1. Footings at the first floor or garage level should be constructed on moisture-conditioned, compacted fill or natural soils. Footings at the basement level should be constructed on at least 10 inches of consolidated gravel meeting ASTM C33 #57 or #67 rock. Woven geofabric (Mirafi RS380i or approved substitute) should be placed below the gravel layer across the entire width of the basement excavation (Fig. 3). A representative from our firm should observe the excavations to evaluate whether the materials that are exposed are as anticipated.

2. Soils loosened during foundation excavation or in the footing forming process, or any loose or soft soils encountered at the footing level, should be stabilized or removed and compacted to the criteria presented in <u>Fill and Backfill</u> prior to placing concrete.

3. Footings should be designed for a maximum allowable soil pressure of 2,500 psf and a minimum deadload pressure of 800 psf. Foundations can be designed using dead plus half live load. We anticipate footings designed using this soil pressure could experience less than 1 inch of differential movement.

4. Footings should have a minimum width of 16 inches. Foundations for isolated columns should have minimum dimensions of 18 inches by 18 inches. Larger sizes may be required depending upon the loads and structural system used.

5. Foundation walls should be well-reinforced, top and bottom. We recommend reinforcement sufficient to span an unsupported distance of at least 10 feet or the distance between pads, whichever is greater. Reinforcement should be designed by the structural engineer considering the effects of large openings and lateral loads on wall performance.

6. Exterior footings must be protected from frost action. Normally, 3 feet of frost cover is assumed in the area.

7. The completed foundation excavations should be observed by a representative of our firm to confirm subsurface conditions are as anticipated from our borings.

8. Excessive wetting of foundation soils during and after construction can cause heave or softening and settlement of foundation soils and result in footing and slab movements. Proper surface drainage around and between buildings is critical to control wetting. The foundation drain and utility service trenches should be braced or adequately sloped away from footings to reduce the risk of undermining the footings. Sump pit and sewer line trench construction should avoid undermining the footings. Backfill of sewer line trenches should be compacted. Voids around the sump pit excavation should be backfilled with on-site soils, squeegee, or “flowable fill” to reduce settlement.

<u>Drilled Piers Bottomed in Bedrock</u>

1. Piers should be designed for a maximum allowable end pressure of 20,000 psf and allowable skin friction of 2,000 psf for the portion of pier in bedrock. Skin friction should be neglected for the upper 3 feet of pier.

2. Piers should be designed for a minimum deadload pressure of 20,000 psf based on pier cross-sectional area. If this deadload cannot be achieved through the weight of the structure, the pier length and bedrock penetration should be increased beyond the minimum value specified in the next item. Axial tension loads can be resisted using the skin friction value provided above.

3. Piers should have a minimum total length of at least 16 feet in basement areas and 20 feet in non-basement areas, with a minimum of 10 feet penetration into bedrock. Longer piers may be necessary to achieve proper bedrock penetration.

4. Pier holes should be cleaned prior to placement of concrete. Concrete should be on-site and placed in the pier holes immediately after the holes are drilled, cleaned and inspected using drill and pour construction procedure. Concrete should not be placed in pier holes containing more than about 3 inches of water unless tremie procedures are used.

5. Piers should be designed to resist an ultimate uplift force calculated as (85 kips x pier diameter in feet) less applied deadload to resist tension in the event of swelling. Piers should be reinforced their full length and the reinforcement should extend an adequate distance into grade beams and foundation walls. Grade 60 (or better) steel is recommended. More reinforcement may be required for structural considerations.

6. There should be a 6-inch (or thicker) continuous void beneath all grade beams and foundation walls, between piers, to concentrate the deadload of the structures onto the piers.

7. Foundation walls and grade beams should be well reinforced. The reinforcement should be designed by the structural engineer considering lateral earth pressures and the effects of large openings within basement walls.

8. Concrete should have sufficient slump to fill the pier holes and not hang on the reinforcement. We recommend a slump of 6 inches ±1 inch. Formation of “mushrooms” or enlargements at the tops of piers should be avoided during pier drilling and subsequent construction operations.

9. Installation of drilled piers should be observed by a representative of our firm to identify the proper bearing strata and to observe the contractor’s installation procedures.

BASEMENT SLAB PERFORMANCE RISK

We conducted swell tests to provide a basis to calculate potential heave of the soil and bedrock for each duplex building. Based on the test results and our experience, we estimated potential heave of less than 0.5-inch to 4.1 inches at the ground surface and less than 0.5-inch to 2.9 inches at the basement level. If Lots 21/22 and 23/24 are omitted, we estimated potential heave of less than 0.5-inch to 2.1 inches at the ground surface and less than 0.5-inch to 2.0 inches at the basement level. Estimates of potential heave at each boring location are presented in the table below. We judge slab movements of 2 inches or less are probable. Slabs may settle if loose or soft soils are present and/or excessive wetting and softening of subsoils occurs.

ESTIMATED POTENTIAL GROUND HEAVE AT
PLANNED GROUND FLOOR ELEVATION AND ESTIMATED BASEMENT LEVEL
BASED ON 24 FEET DEPTH OF WETTING

Lot	Estimated Potential Heave at Planned Final Grade (inches)	Estimated Potential Heave at Estimated Basement Level (inches)	Risk Due to Expansive Soil and Bedrock
1/2	1.7	1.1	LOW
3/4	0.6	0.6	LOW
5/6	<0.5	<0.5	LOW
7/8	2.1	2.0	LOW
9/10	1.5	1.1	LOW
11/12	1.2	1.0	LOW
13/14	2.1	1.8	LOW
15/16	0.8	0.5	LOW
17/18	1.2	0.9	LOW
19/20	0.5	<0.5	LOW
21/22	4.1	2.9	MODERATE
23/24	3.9	2.5	MODERATE

The results of the laboratory testing, subsoil profiles, heave estimates, and our experience with residential construction and performance were used to provide an 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 risk of poor slab-on-grade performance. We judge there is moderate risk of poor basement floor slab performance for Lots 21/22 and 23/24, and low risk for all other lots. Actual heave will likely be less than our calculations imply. A more detailed discussion of this evaluation is provided in Exhibit A.

FLOOR SYSTEMS

Slabs-On-Grade

Full-depth basements could be used. Based on results of our investigation, we judge there is moderate risk of poor slab performance on Lots 21/22 and 23/24, and low risk for the other ten duplexes. Our experience indicates slab-on-grade floor performance has generally been satisfactory on low risk sites. Slab movement of 1 to 2 inches is considered "normal" for these sites. Slab-on-grade floors may be used for basements on all lots, provided the estimated slab movements and associated damages are acceptable. If movement of slab-on-grade basement floors is not tolerable, structurally supported basement floors (a.k.a. structural floors) can be used. Where slabs-on-grade are provided, we recommend the precautions for slab-on-grade construction that are included in Exhibit A.

Structurally Supported Floors

A structural floor is supported by the foundation system. Structural floors should be used in non-basement, finished living areas, such as the main or first level. Design and construction issues associated with structural floors include ventilation and lateral loads. Where structurally supported floors are installed over a crawl space, the required air space depends on the materials used to construct the floor and the potential expansion of the underlying soils. Building codes require a clear space of 18 inches between exposed earth and untreated wood floor components. For non-organic floor systems, we recommend a minimum clear space of 10 inches. This minimum clear space should be maintained between any point on the underside of the floor system (including beams and floor drain traps) and the soils. Structural slab-on-void floors may be used and should have at least 6 inches of void.

Where structurally supported floors are used, utility connections including water, gas, air duct, and exhaust stack connections to floor supported appliances should allow some deflection of the floor. Plumbing that passes through the floor should ideally be hung from the underside of the structural floor and not lain on the bottom of the excavation. It is prudent to maintain the minimum clear space below all plumbing lines. This configuration may not be achievable for some parts of the installation. If trenching below the lines is necessary, we recommend sloping these trenches so they discharge to the foundation drain.

Control of humidity in crawl spaces is important for indoor air quality and performance of wood floor systems. We believe the best current practices to control humidity involve the use of a vapor retarder or vapor barrier (10 mil minimum) placed on the soils below accessible subfloor areas. The vapor retarder/barrier should be sealed at joints and attached to concrete foundation elements. The Moisture Management Task Force of Metro Denver[2] has compiled additional discussion and recommendations regarding best practices for the control of humidity in below-grade, under-floor spaces.

Porches, Decks and Patios

Porches and decks with roofs that are integral with a building should be constructed with the same foundation type as the building when porch or deck foundation movement would damage the structure. Deck foundations should be designed by a structural engineer. For simple decks that are not integral with a building and can tolerate some movement, the use of short pier or footing foundations bottomed at least 3 feet below grade can be considered, provided the foundations are located outside foundation wall backfill. The deck foundations should bottom below foundation wall backfill to reduce risk of settlement; longer (8 to 10 feet or more) deck piers may be necessary to provide adequate support. The inner edge of a deck may be supported on joist hangers nailed to the rim joist, or haunches or steel angles bolted to the foundation walls and detailed such that movement of the deck foundation will not cause distress to the structure. We suggest use of adjustable bracket-type connections or other details between foundations and deck posts so the posts can be adjusted if movement occurs.

Porches, patio slabs, and other exterior flatwork should be isolated from the structures. Porch slabs can be constructed to reduce the likelihood that settlement or heave will affect the slabs. One approach (for smaller porches located over basement backfill zones) is to place loose backfill under a structurally supported slab. A lower risk approach is to construct a structural porch slab over void-forming materials. Conditions should allow the void-forming materials to soften quickly after construction to reduce the

[2]"Guidelines for Design and Construction of New Homes with Below-Grade Under-Floor Spaces," Moisture Management Task Force, October 30, 2003.

risk of transmitting ground heave to the porch slab. Plastic-coated void boxes should not be used unless provisions are made to allow water vapor to penetrate and degrade them.

Garage Floors and Exterior Flatwork

Garage floors, driveways and sidewalks are normally constructed as slab-on-grade. Performance of conventional slabs on expansive and compressible soils is erratic. Various properties of the soils and environmental conditions influence magnitude of movement and other performance. Increases in the moisture content in these soils may cause heaving or settlement and may result in cracking of slabs-on-grade. Backfill below slabs should be moisture-conditioned and compacted to reduce settlement, as discussed in **BACKFILL COMPACTION**. Driveways and exterior slabs constructed on the backfill may settle and crack if the backfill is not properly moisture-treated and compacted. Where slabs-on-grade are used, we recommend the precautions for slab-on-grade construction that are included in Exhibit A.

We recommend exterior flatwork and sidewalks be isolated from foundations to reduce the risk of transferring heave, settlement or freeze-thaw movement to the structures. One alternative would be to construct the inner edges of the flatwork on haunches or steel angles bolted to the grade beams and detailing the connections such that movement will cause less distress to the building, rather than tying the slabs directly into the building foundation. Construction on haunches or steel angles and reinforcing the sidewalks and other exterior flatwork will reduce the potential for differential settlement and better allow them to span across wall backfill. Frequent control joints should be provided to reduce problems associated with shrinkage. Panels that are approximately square perform better than rectangular ones.

BELOW-GRADE WALLS

Basement and/or foundation walls and grade beams that extend below grade should be designed to resist lateral earth pressures where backfill is not present to about the same extent on both sides of the wall. Several factors affect the lateral earth pressure including, but not limited to the type, compaction, slope and drainage of the backfill, and the rigidity of the wall against rotation and deflection. For a very rigid wall where negligible or very little deflection will occur, an “at-rest” lateral earth pressure should be used in design. For walls that can deflect or rotate 0.5 to 1 percent of the wall height (depending upon the backfill types), lower “active” lateral earth pressures are appropriate. Our experience indicates walls can deflect or rotate slightly under normal design loads, and that this deflection typically does not affect the structural integrity of the walls. Thus, the earth pressure on the walls will likely be between the “active” and “at-rest” conditions.

If on-site soils are used as backfill and the backfill is not saturated, we recommend design of basement walls and grade beams using an equivalent fluid density of at least 60 pounds per cubic foot (pcf). The value assumes deflection; some minor cracking of walls may occur. If very little wall deflection is desired, a higher design value is appropriate. The structural engineer should also consider site-specific grade restrictions and the effects of large openings on the behavior of the walls.

BACKFILL COMPACTION

Settlement of foundation wall and utility trench backfill can cause damage to concrete flatwork and/or result in poor drainage conditions. Compaction of backfill can reduce settlement. Attempts to compact backfill near foundations to a high degree can cause damage to foundation walls and window wells and may increase lateral pressures on the foundation walls. The potential for cracking of a foundation wall can vary widely based on many factors including the degree of compaction achieved, the weight and type of compaction equipment utilized, the structural design of the wall, the strength of the concrete at the time of backfill compaction, and the presence of temporary or permanent bracing.

Proper moisture conditioning of backfill is as important as compaction because settlement commonly occurs in response to wetting. The addition of water complicates the backfill process, especially during cold weather. Frozen soils are not considered suitable for use as backfill because excessive settlement can result when the frozen materials thaw. Exhibit C describes four alternative methods to place, moisture condition, and compact backfill along with a range of possible settlement, and advantages and disadvantages of each approach, based upon our experience. These are just a few of the possible techniques, and represent a range for your evaluation. We recommend Alternative C or D if you wish to control settlement.

Precautions should be taken when backfilling against a foundation wall. Temporary bracing of comparatively long, straight sections of foundation walls should be used to limit damage to walls during the compaction process. Waiting at least seven days after the walls are placed to allow the concrete to gain strength can also reduce the risk of damage. Compaction of fill placed beneath and next to counterforts (if any) and grade beams may be difficult to achieve without damaging these building elements. Proper moisture conditioning of the fill prior to placement in these areas will help reduce potential settlement.

Ideally, drainage swales should not be located over the backfill zone (including excavation ramps), as this can increase the amount of water infiltration into the backfill and cause excessive settlement. Swales should be a minimum of 5 feet from the foundation to help reduce water infiltration. Irrigated vegetation, sump pump discharge pipes, sprinkler valve boxes, and roof downspout terminations should also be at least 5 feet from the foundation.

SUBSURFACE DRAINS AND SURFACE DRAINAGE

Water from irrigation and precipitation can penetrate backfill and accumulate in below grade areas along foundation walls and in crawl spaces creating wet or moist below grade conditions after construction. To reduce the likelihood of accumulation of water in below grade areas, we recommend provision of an interior or exterior drain around the perimeter of basement walls. The provision of a drain will not eliminate slab movement or prevent moist conditions. The drain should consist of a 4-inch diameter, perforated or slotted pipe encased in free-draining gravel. The drain should lead to a positive gravity outlet, such as a sump where water can be removed by pumping. Sump pumps must be maintained by property owners. Typical foundation drain details for basements are presented on Figs. 3 through 5.

We have observed occasional incidents of water in basement window wells after construction. We recommend a drain pipe to connect the bottom of window wells to the basement foundation drain in accordance with Section R310.2.2 of the 2012 IRC. Typical window well drain details are provided on Figs. 6 and 7. If the foundation drain is also used as part of a radon ventilation system, special details may be required to connect the window well drain to the foundation drain. For interior basement foundation drains and footing foundations, “tunneling” under the footing or installation of short segments of void form in the footings and below window wells is recommended to provide a flow path for water from the outside of the basement walls to the interior foundation drain (Figs. 4 through 7). The structural engineer should consider the impact of this detail on footing foundation design.

Our experience indicates moist conditions can develop in non-basement crawl space areas, resulting in isolated instances of damp soils, musty smells and, in rare cases, standing water. These crawl space areas should be well ventilated, depending on the use of a vapor retarder/barrier and the floor material selected. Some builders install drain systems around non-basement crawl space areas as a precaution; we regard these installations as optional.

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.

CONCRETE

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentrations of less than 0.01 to 0.18 in three samples from this site. For this level of sulfate concentration, ACI 332-08 *Code Requirements for Residential Concrete* indicates concrete shall be made with ASTM C150 Type II cement, or an ASTM C595 or C1157 hydraulic cement meeting moderate sulfate-resistant hydraulic cement (MS) designation.

In our experience, superficial damage may occur to the exposed surfaces of highly permeable concrete. 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 shallow groundwater. Concrete should have a total air content of 6 percent ± 1.5 percent. We advocate damp-proofing of all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams).

CONSTRUCTION OBSERVATIONS

This report has been prepared for the exclusive use of Sunrise Village, LLC and your team during design and construction for the proposed project. The information, conclusions, and recommendations presented herein are based upon consideration of many factors including, but not limited to, the type of structures proposed, the geologic setting, and the subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice evolve in geotechnical engineering. The recommendations provided are appropriate for about three years. If the proposed residences are not constructed within about three years, we should be contacted to determine if we should update this report.

We recommend that CTL | Thompson, Inc. provide construction observation services to allow us the opportunity to verify whether soil conditions encountered in the excavations are consistent with those found during this investigation. Our representative should also test the compaction of fill below footings and foundation wall backfill. If others perform these observations, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

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. The homeowners, homeowner's association, or property managers must assume responsibility for maintaining the structures and use appropriate practices regarding drainage and landscaping. Improvements performed after construction should be completed in accordance with recommendations provided in this report and may require additional soil investigation and consultation.

LIMITATIONS

Our borings were located to obtain a reasonably accurate picture of subsurface conditions below the planned construction. The borings are representative of conditions encountered only at the boring locations. Subsurface variations not indicated by our borings are possible.

The recommendations presented in this report are based on the proposed construction as currently planned. Revisions in the planned construction could affect our recommendations. We should be contacted if construction will differ from descriptions in this report to review and revise our recommendations, if necessary.

We believe this investigation was conducted in a manner consistent with that level of skill and care 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 in the analysis of the influence of subsurface conditions on the design of the improvements or any other aspect of the proposed construction, please call.

CTL | THOMPSON, INC.

Adam Cauble, P.E.
Project Manager

Reviewed by:

David A. Glater, P.E.
Senior Principal Engineer

David Allen Glater
Jan 21 2021 12:50 PM

AC:DAG/nn

Via e-mail: ssundberg@creeksidecommunities.com
dcerniglia@creeksidecommunities.com

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[3] (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. CTL Thompson also performs potential heave calculations to aid in our judgment. 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.

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 3 inches is considered normal and we believe in the majority of instances, movements of this magnitude constitute reasonable slab performance; more heave can occur. 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 basement and garage floors and exterior flatwork.

[4]"Guideline for Slab Performance Risk Evaluation and Residential Basement Floor System Recommendations", Colorado Association of Geotechnical Engineers, December 1996.

The home buyers should be advised the garage floor slab 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 the house 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 houses 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 R506) 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 floor 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 3.2.3 of the 2006 American Concrete Institute (ACI) Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)".

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 to avoid transfer of movement.

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 must maintain these connections.

5. Use of slab bearing partitions should be minimized. Where such partitions are necessary, a slip joint (or float) allowing at least 2 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 home buyer should monitor partition voids and other connections and re-establish the voids before they close to less than ½-inch.

6. Plumbing and utilities that penetrate slabs should be isolated from the slabs. Heating and air conditioning systems constructed on slabs should be provided with flexible connections capable of at least 2 inches of vertical movement so slab movement is not transmitted to the ductwork. These connections must be maintained by the home buyer.

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.

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. <u>The home owners, homeowner's association and/or property managers should maintain surface drainage and, if an irrigation system is installed, it should substantially conform to these recommendations.</u>

1. Wetting or drying of the open foundation, utility and earthwork excavations should be avoided.

2. The ground surface surrounding the exterior of each building should be sloped to drain away from the building in all directions. We recommend a minimum constructed slope of at least 12 inches in the first 10 feet (10 percent) in landscaped areas around buildings with basements, where practical, and a minimum slope of 5 percent around buildings with no basements.

   We do not view the recommendation to provide a 10 percent slope away from the foundations as an absolute. It is desirable to create this slope where practical, because we know that backfill will likely settle to some degree. By starting with sufficient slope, positive drainage can be maintained for most settlement conditions. There are many situations around a building where a 10 percent slope cannot be achieved practically, such as around patios, at inside foundation corners, and between a structure and nearby sidewalk. In these areas, we believe it is desirable to establish as much slope as practical and to avoid irrigation. We believe it is acceptable to use a slope on the order of 5 percent perpendicular to the foundation in these limited areas. Between buildings that are separated by a distance of less than 20 feet, the constructed slope should generally be at least 10 percent to the swale used to convey water out of this area.

3. 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.

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

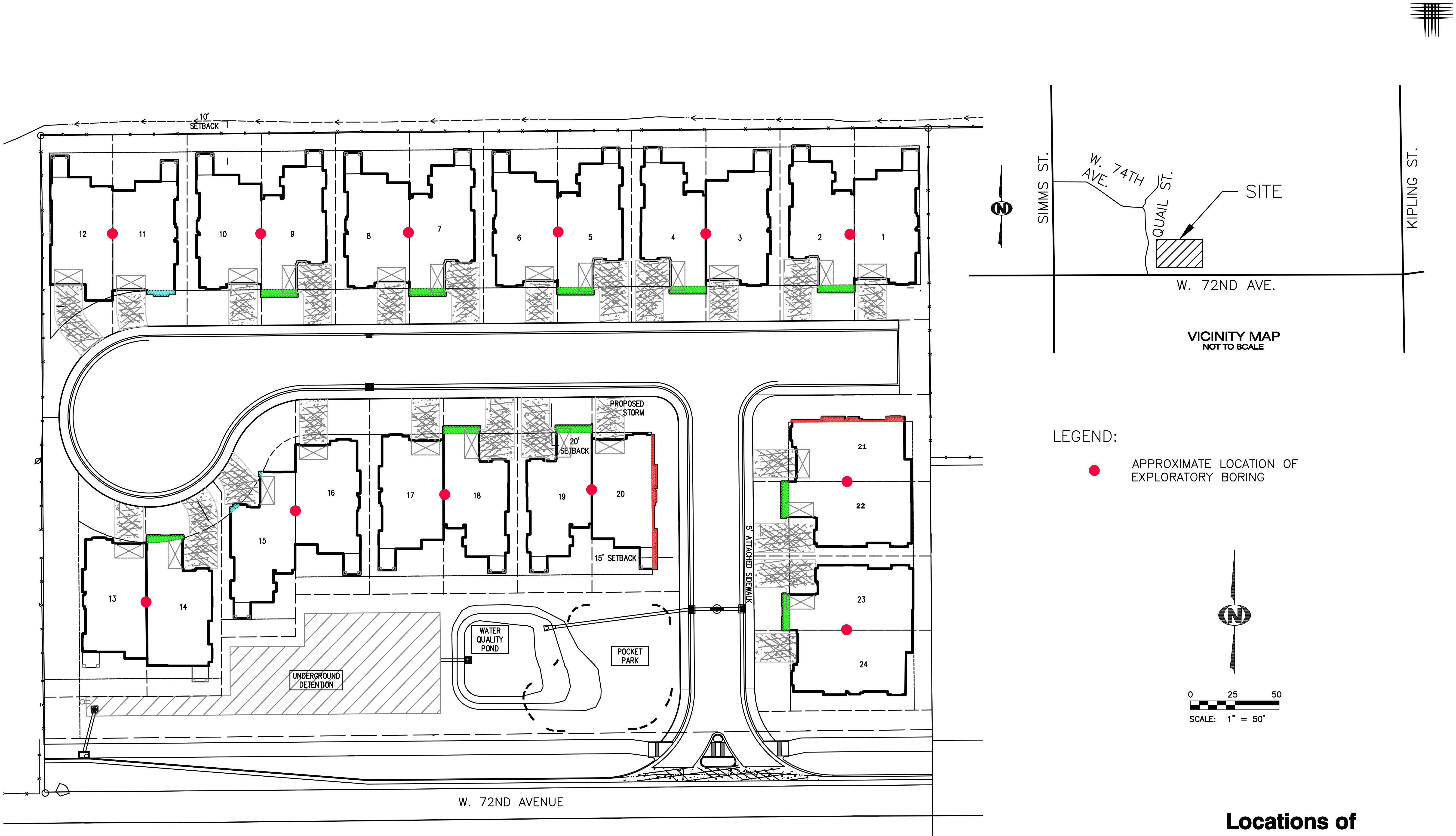
5. Roof downspouts and drains should discharge well beyond the limits of all backfill. Splash blocks and/or extensions should be provided at all downspouts so water discharges onto the ground beyond the backfill. We generally recommend against burial of downspout discharge. Where it is necessary to bury 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.

6. The importance of proper 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 grass should not be located within 5 feet of the foundations. Lawn sprinklers should not discharge within 5 feet of foundations. Plastic sheeting should not be placed beneath landscaped areas adjacent to foundation walls or grade beams. Geotextile fabric can inhibit weed growth and allow evaporation.

7. 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.

EXHIBIT C
EXAMPLE BACKFILL COMPACTION ALTERNATIVES

Alt.	Description	Possible Settlement	Pros (+) / Cons (-)
A	Place in 18 to 24-inch lifts, without moisture conditioning. Compact lift surface to about 85 percent of maximum standard Proctor (ASTM D698) dry density.	5 to 15% of depth (for 8 feet of backfill, 5 to 15 inches)	+ Fast + Water not required - Excessive Settlement - Highest water penetration - Highest probability of warranty repair
B	Moisture condition within 2% of optimum, place in 12 to 18-inch lifts. Compact lift surface to about 85 to 90 percent.	5 to 10 percent of depth	+ Relatively Fast - Moderate water penetration - Excessive settlement - Need for water during fill compaction - Warranty repairs probable
C	Moisture condition to within 2 percent of optimum and place in 8 to 12-inch lifts. Compact lift surface to 90 to 95 percent.	2 to 5 percent of Depth	+ Reduced warranty + Reduced water infiltration + Reduced settlement - Possible higher lateral pressure - Slower - Need for water during fill compaction - Potential damage to walls
D	Moisture condition and place as in C. Compact lift surface to at least 95 percent.	1 to 2 percent of Depth	+ Reduced warranty + Reduced water infiltration + Lowest comparative settlement - Possible higher lateral pressure - Slower - Need for water during fill compaction - Potential damage to walls



SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1

Locations of Exploratory Borings

Fig. 1

LEGEND:

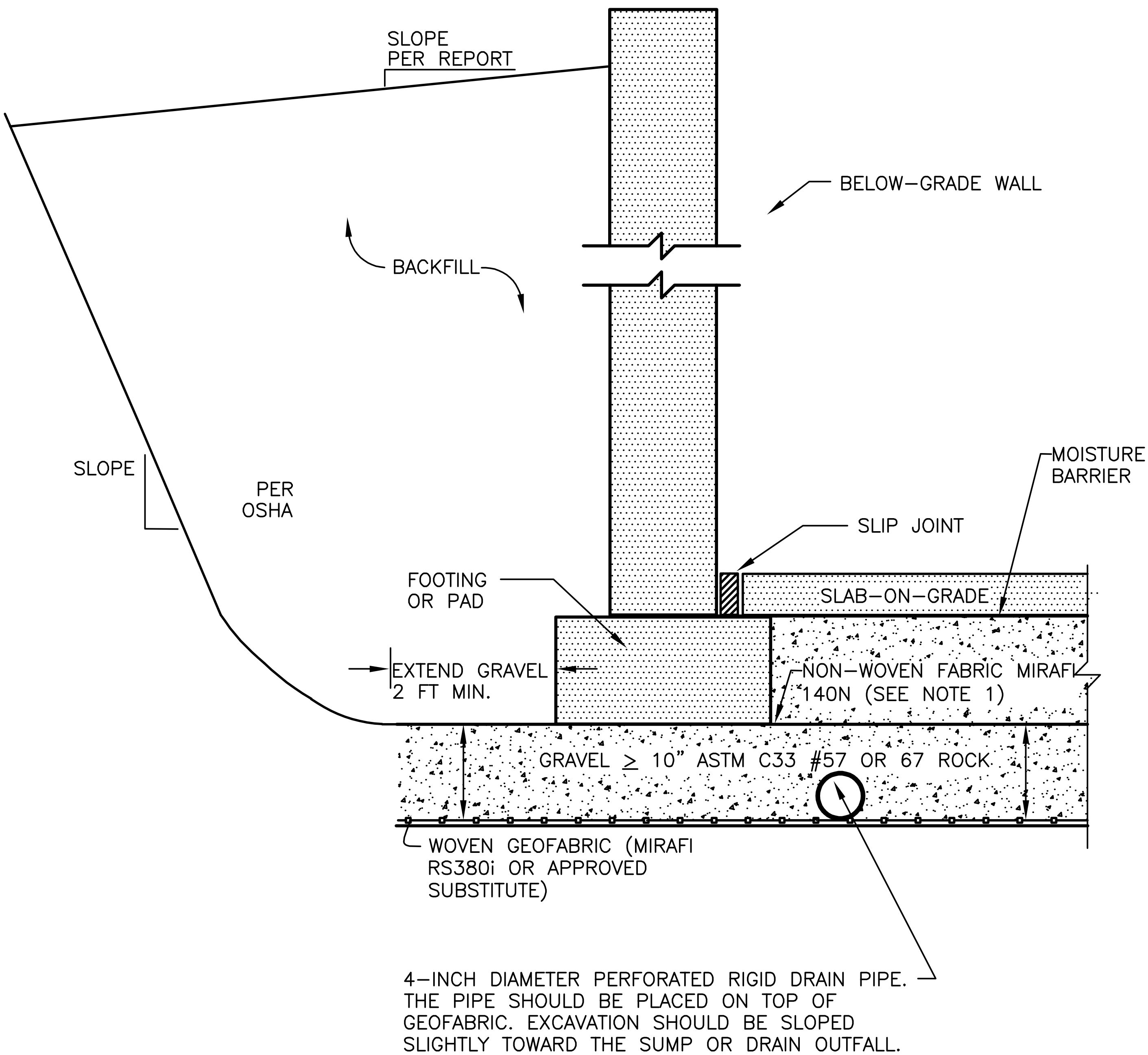
- APPROXIMATE LOCATION OF EXPLORATORY BORING
- FOOTINGS WITH MINIMUM DEADLOAD
- DRILLED PIERS BOTTOMED IN BEDROCK

0 25 50
SCALE: 1" = 50'

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1

Recommended Foundation Systems

Fig. 2



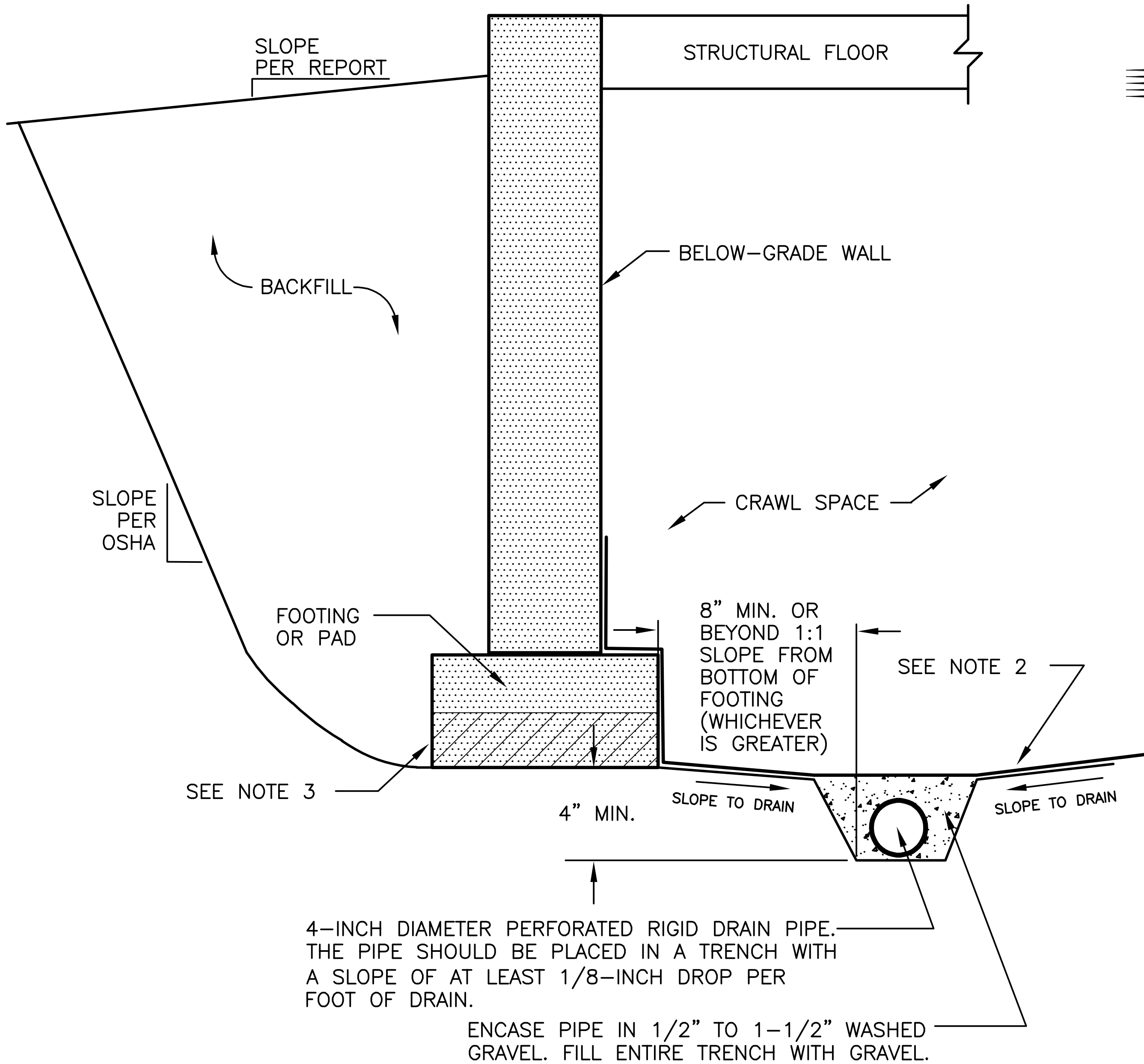
NOTE:

1) IF USING #57–67 ROCK UP TO SLAB, NON–WOVEN FABRIC CAN BE OMITTED. OTHERWISE, USE PEA GRAVEL (IE SQUEEGEE) AND FABRIC

Excavation Stabilization and Drainage Layer

Fig. 3

00-FTG-INT-STF-01



NOTES:

1) THE BOTTOM OF THE DRAIN SHOULD BE AT LEAST 4 INCHES BELOW BOTTOM OF FOOTING AT THE HIGHEST POINT AND SLOPE DOWNWARD TO A POSITIVE GRAVITY OUTLET OR TO A SUMP WHERE WATER CAN BE REMOVED BY PUMPING.

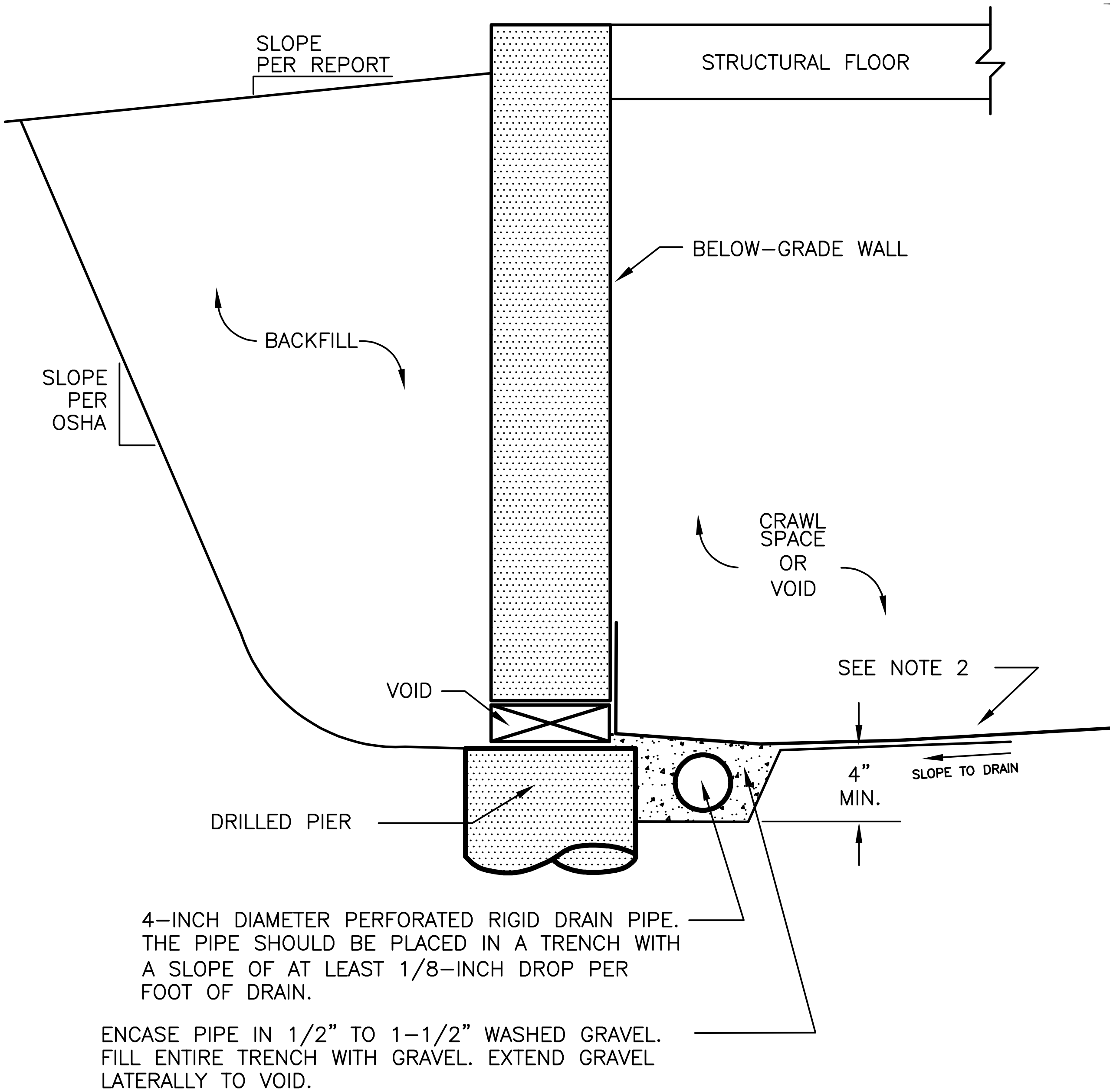
2) TO HELP CONTROL THE HUMIDITY IN THE CRAWL SPACE, A MINIMUM 6-MIL POLYETHYLENE VAPOR RETARDER SHOULD BE PLACED OVER THE CRAWL SPACE SOILS. THE RETARDER SHOULD BE ATTACHED TO CONCRETE FOUNDATION ELEMENTS AND EXTEND UP FOUNDATION WALLS AT LEAST 8 INCHES ABOVE TOP OF FOOTING. OVERLAP JOINTS 3 FEET AND SEAL.

3) FOR FOOTINGS IN BASEMENT AREAS, WE RECOMMEND PLACING AN 8-INCH THICK, 8-INCH WIDE SECTION OF VOID FORM PERPENDICULAR TO FOOTING ABOUT EVERY 10 TO 15 FEET AND AT WINDOW WELLS, TO ALLOW WATER IN WALL BACKFILL TO PASS BENEATH THE FOOTING INTO THE INTERIOR DRAIN. THIS CAN ALSO BE ACCOMPLISHED BY "TUNNELING" UNDER FOOTINGS AT THE TIME OF DRAIN INSTALLATION. THIS DETAIL SHOULD BE REVIEWED BY THE STRUCTURAL ENGINEER DURING FOUNDATION DESIGN AND INCORPORATED INTO THE FOUNDATION PLAN. ALTERNATIVELY, AN EXTERIOR FOUNDATION DRAIN CAN BE USED.

Non-Basement Interior Foundation Wall Drain (Crawl Space or Slab-on- Void)

Fig. 4

00-PIER-INT-STF-01



NOTES:

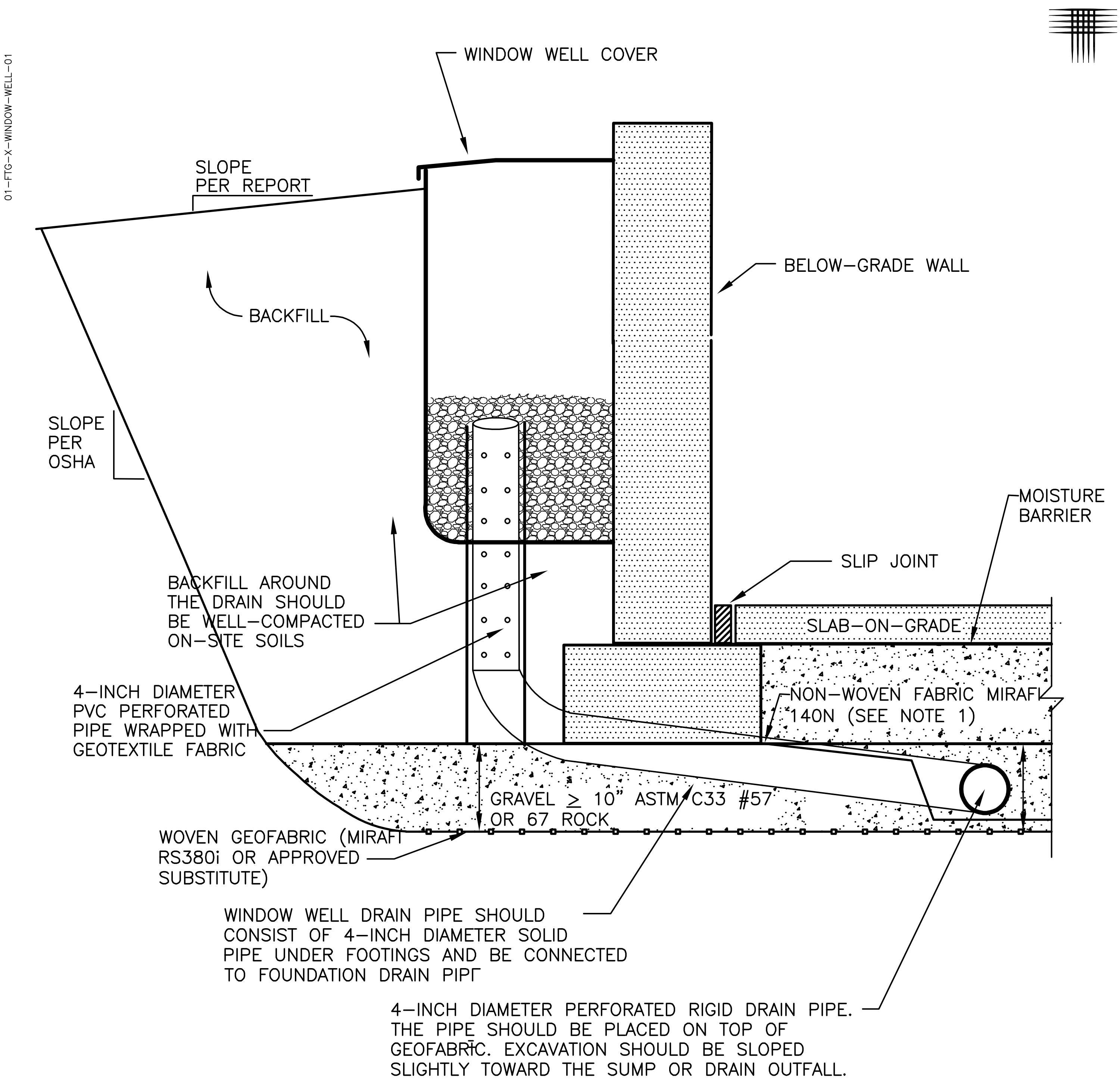
1) THE BOTTOM OF THE DRAIN SHOULD BE AT LEAST 4 INCHES BELOW BOTTOM OF VOID AT THE HIGHEST POINT AND SLOPE DOWNWARD TO A POSITIVE GRAVITY OUTLET OR TO A SUMP WHERE WATER CAN BE REMOVED BY PUMPING.

2) TO HELP CONTROL THE HUMIDITY IN THE CRAWL SPACE, A MINIMUM 6-MIL POLYETHYLENE VAPOR RETARDER SHOULD BE PLACED OVER THE CRAWL SPACE SOILS. THE RETARDER SHOULD BE ATTACHED TO CONCRETE FOUNDATION ELEMENTS AND EXTEND UP FOUNDATION WALLS AT LEAST 8 INCHES ABOVE TOP OF VOID. OVERLAP JOINTS 3 FEET AND SEAL.

Non-Basement Interior Foundation Wall Drain (Crawl Space or Slab-on-Void)

Fig. 5

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1



NOTE:

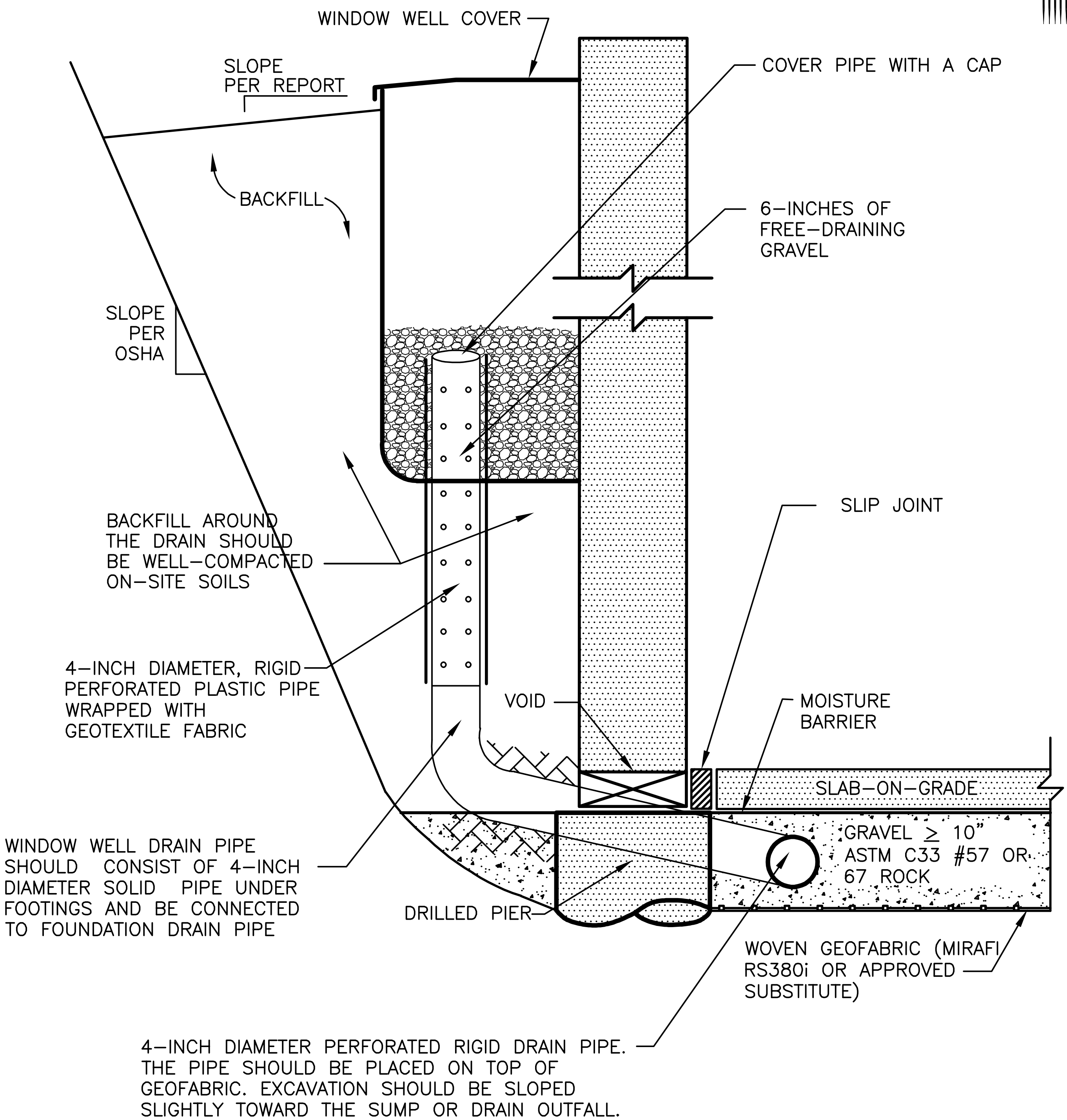
1) IF USING #57-67 ROCK UP TO SLAB, NON-WOVEN FABRIC CAN BE OMITTED. OTHERWISE, USE PEA GRAVEL (IE SQUEEGEE) AND FABRIC

2) THE BOTTOM OF THE INTERIOR DRAIN SHOULD BE AT LEAST 4 INCHES BELOW BOTTOM OF FOOTING AT THE HIGHEST POINT AND SLOPE DOWNWARD TO A POSITIVE GRAVITY OUTLET OR TO A SUMP WHERE WATER CAN BE REMOVED BY PUMPING.

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1

Window Well Drain Detail

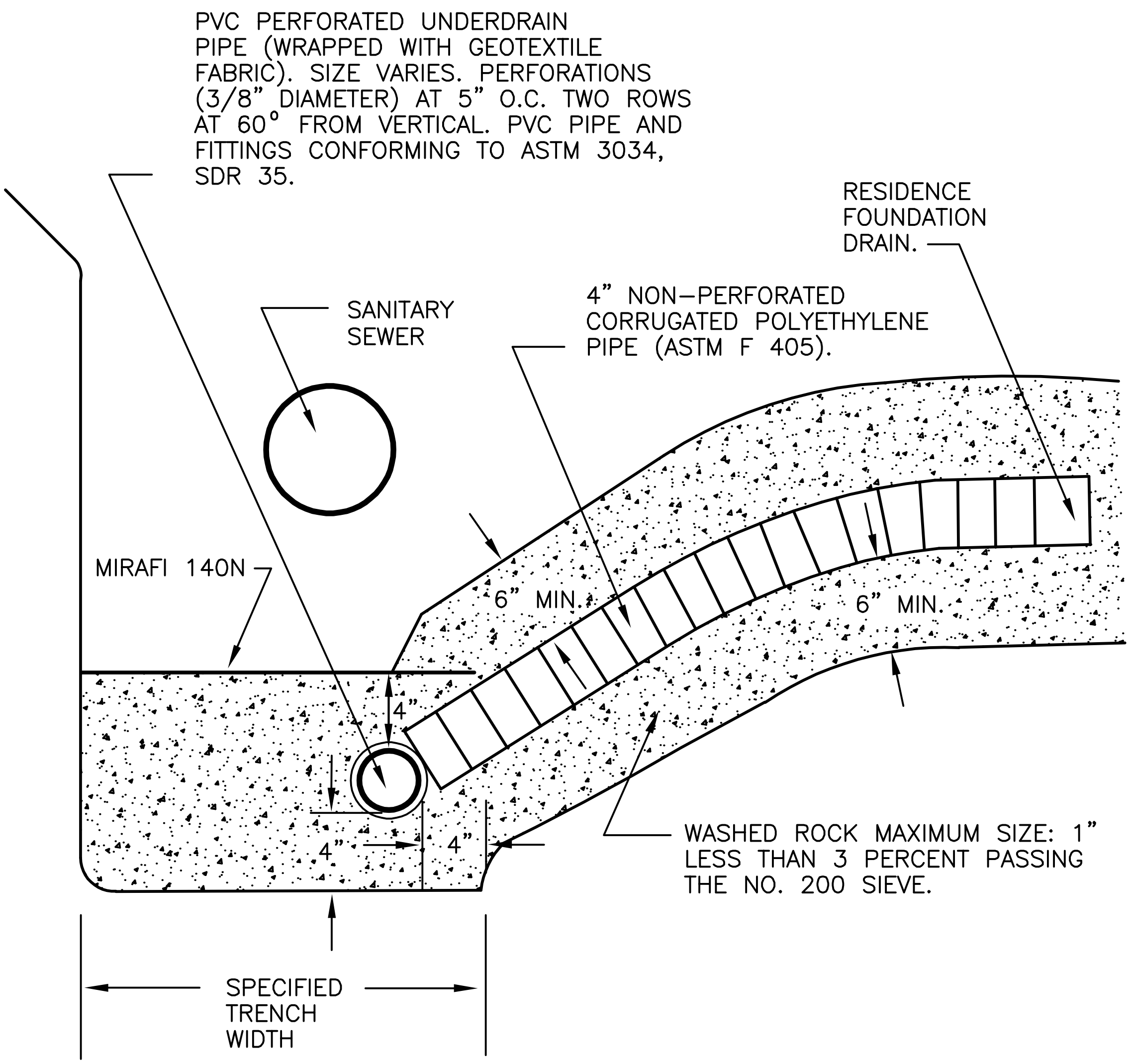
Fig. 6



01-FTG-X-WINDOW-WELL-01

NOTE: THE BOTTOM OF THE DRAIN SHOULD BE AT LEAST 4 INCHES BELOW BOTTOM OF VOID AT THE HIGHEST POINT AND SLOPE DOWNWARD TO A POSITIVE GRAVITY OUTLET OR TO A SUMP WHERE WATER CAN BE REMOVED BY PUMPING.

50-UNDERDRAIN_02

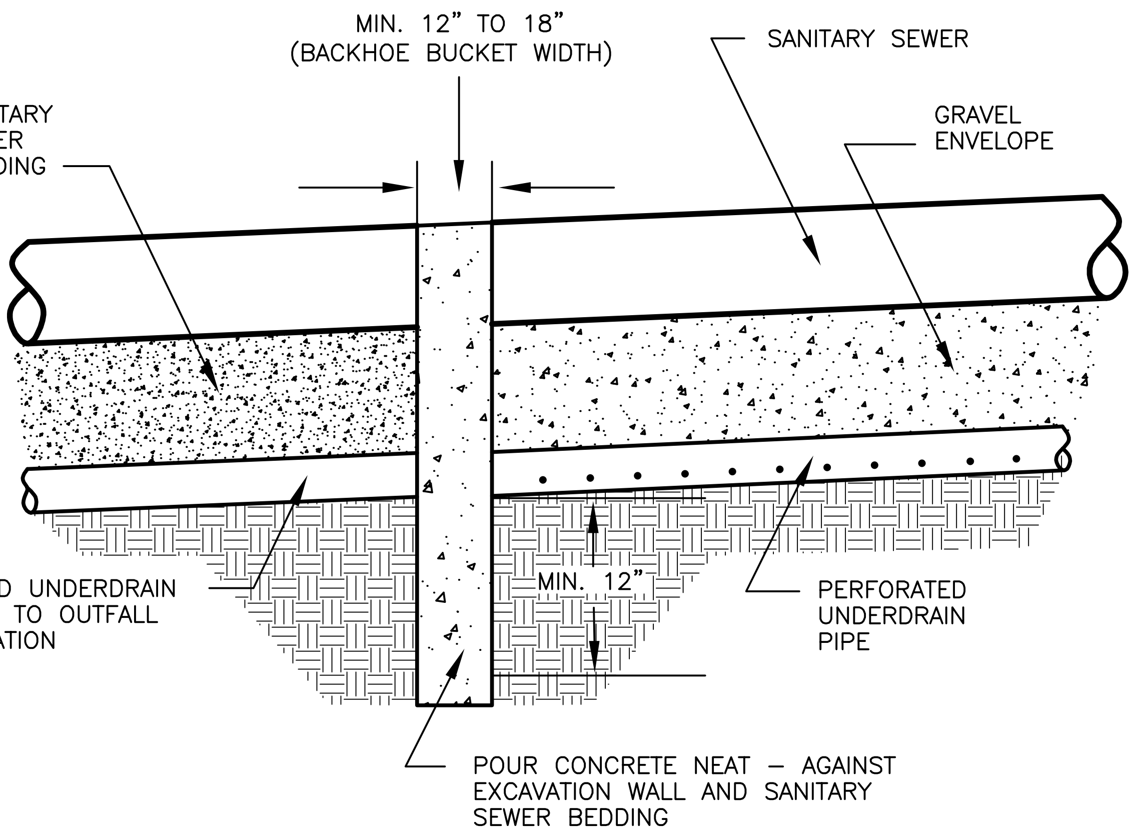


NOTE: NOT TO SCALE.

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1

Sewer Underdrain Detail

Fig. 8

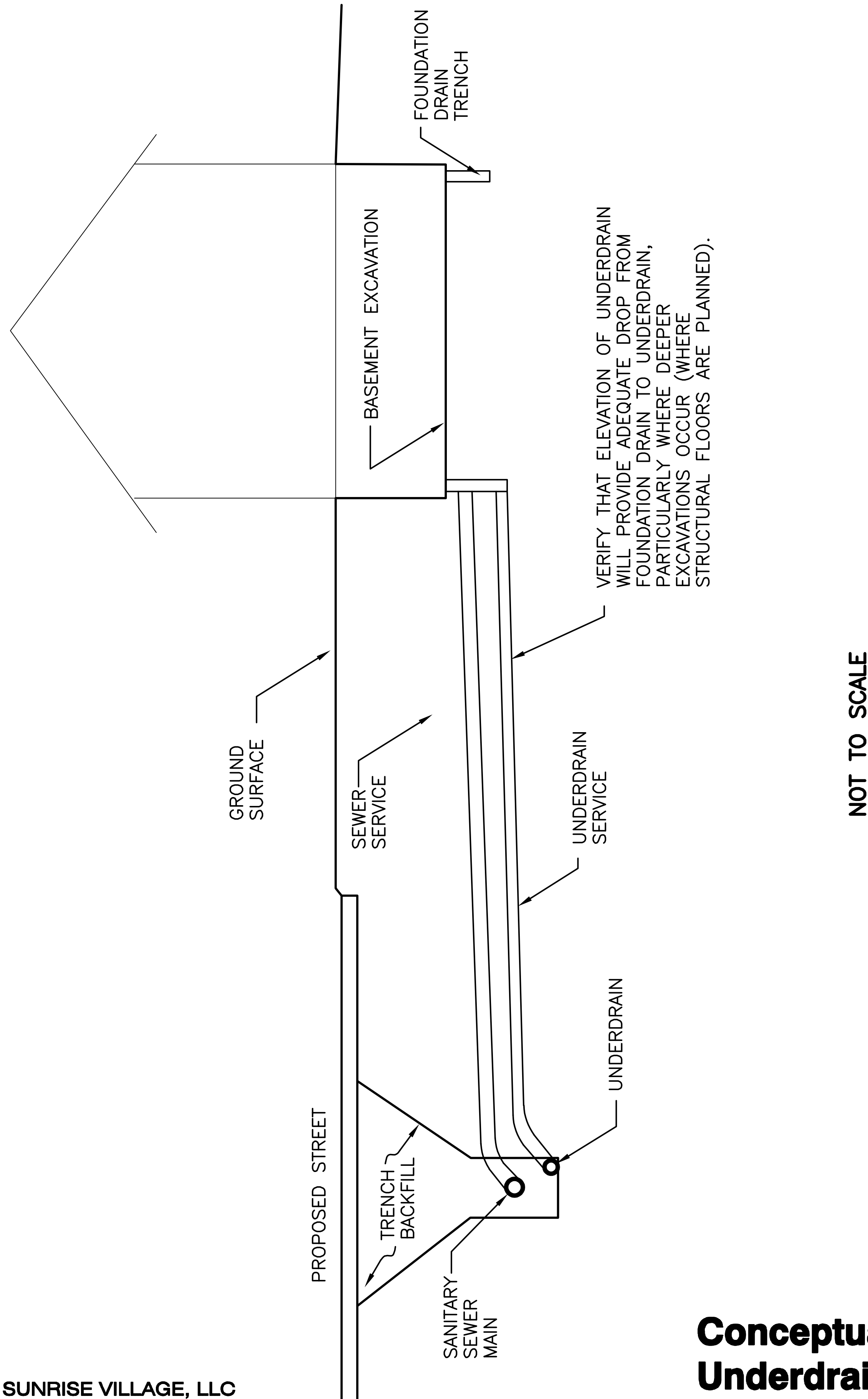


NOTE:
THE CONCRETE CUTOFF WALL SHOULD EXTEND INTO THE UNDISTURBED SOILS OUTSIDE THE UNDERDRAIN AND SANITARY SEWER TRENCH A MINIMUM DISTANCE OF 12 INCHES.

Underdrain Cutoff Wall Detail

Fig. 9

50-UNDERDRAIN_06



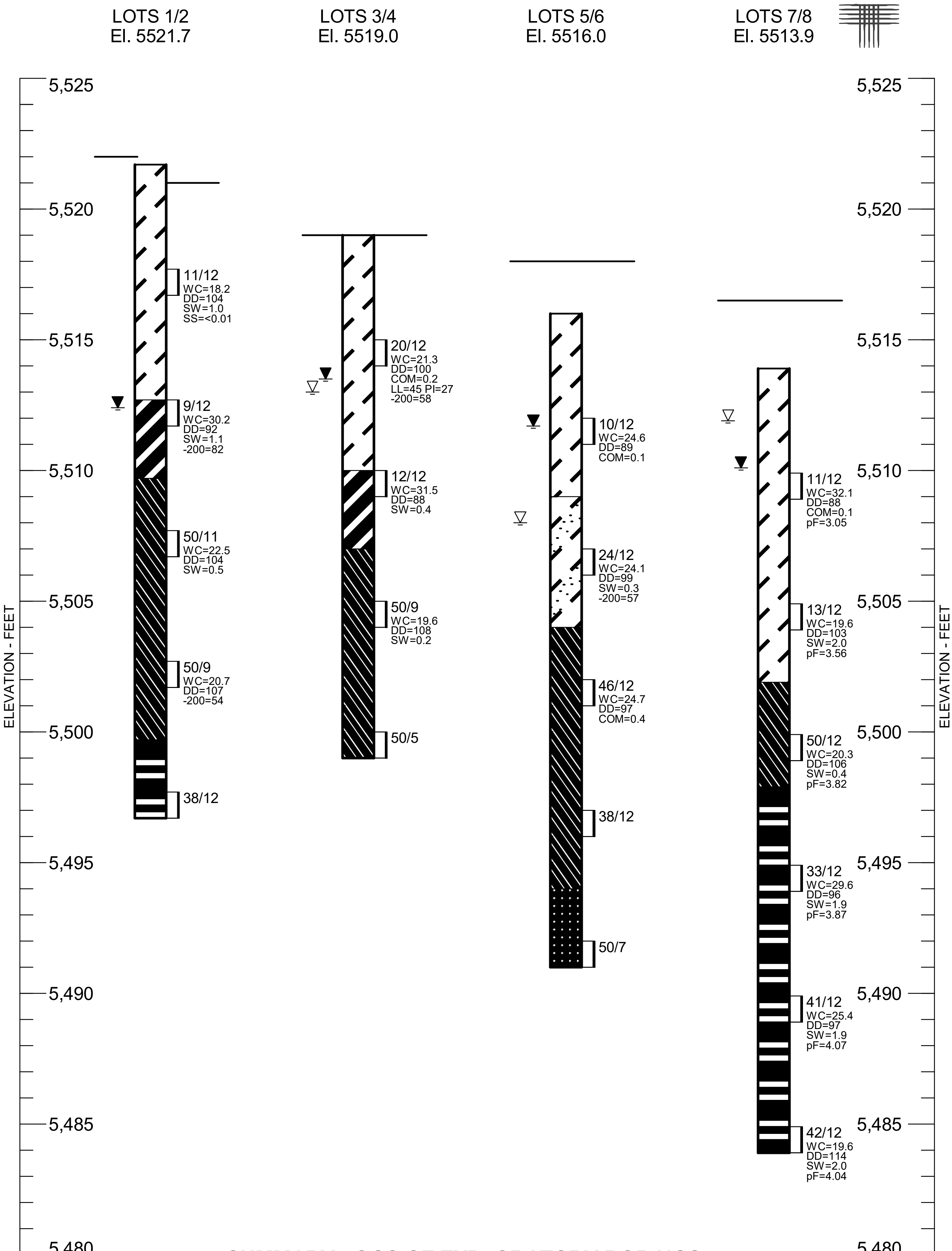
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T Project No. DN49,355.001-120-R1

Conceptual Underdrain Service Profile

Fig. 10

APPENDIX A

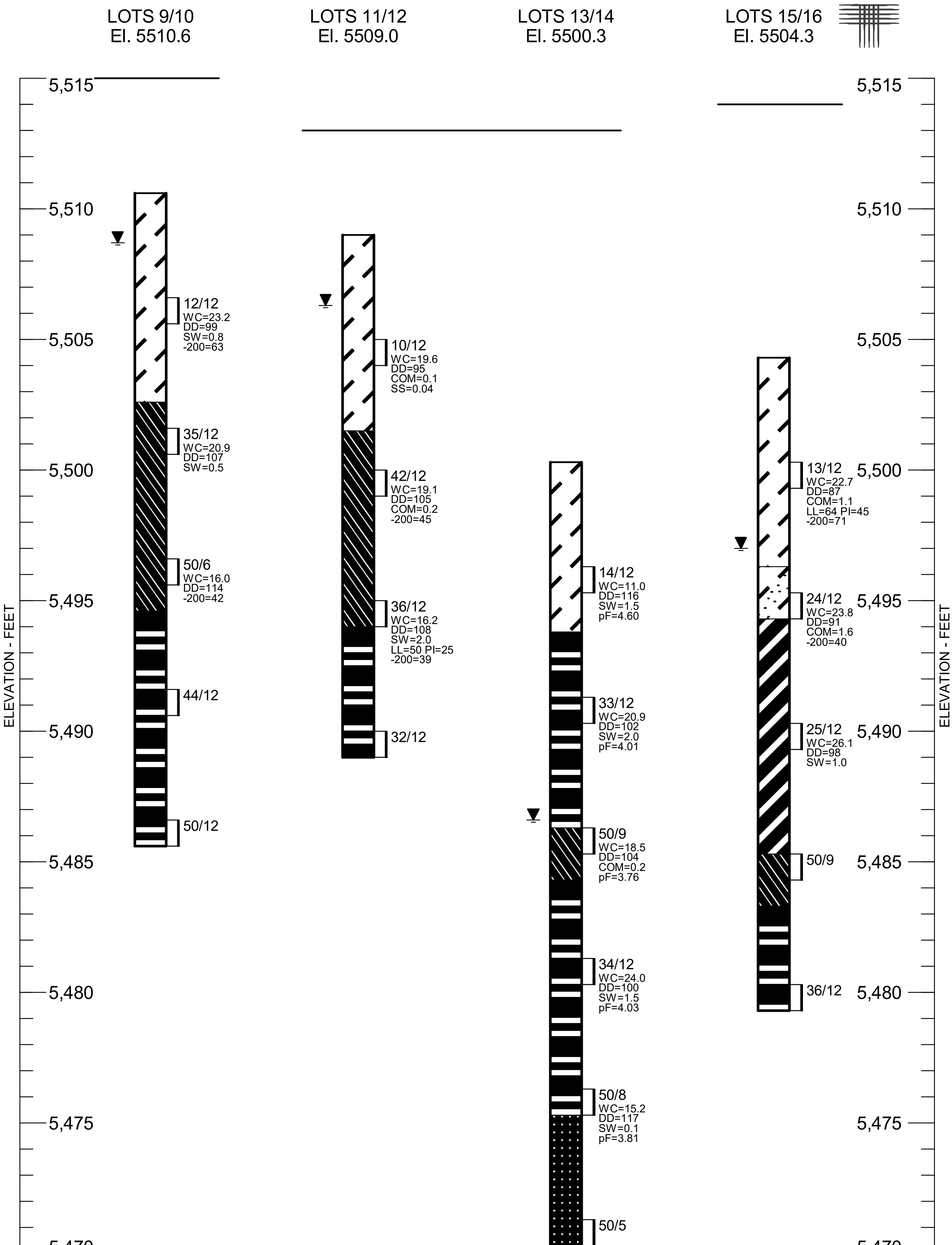
LABORATORY TEST RESULTS
TABLE A-I – SUMMARY OF LABORATORY TEST RESULTS



SUMMARY LOGS OF EXPLORATORY BORINGS

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

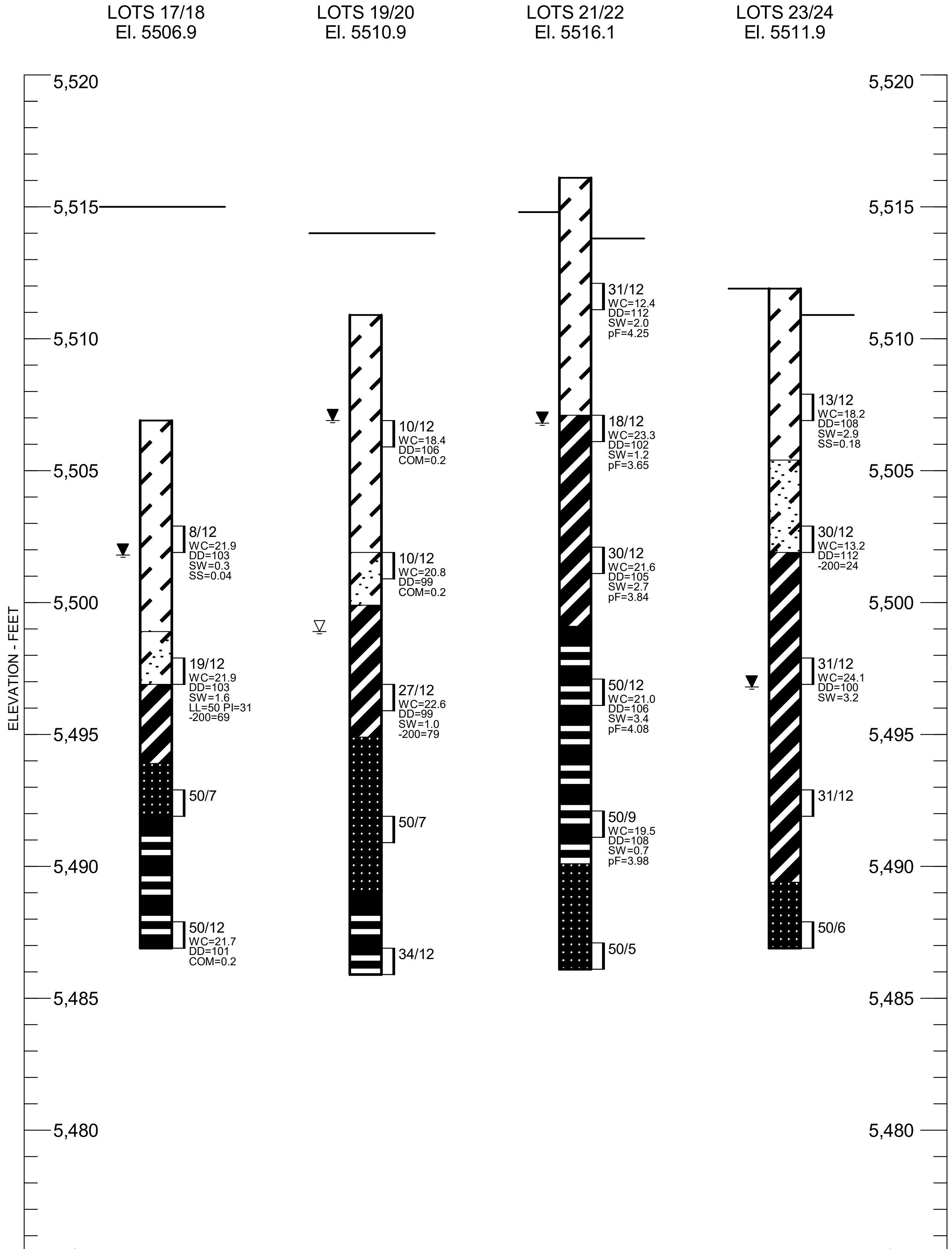
FIG. A- 1



SUMMARY LOGS OF EXPLORATORY BORINGS

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

FIG. A- 2



SUMMARY LOGS OF EXPLORATORY BORINGS

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

LEGEND:

- CLAY, SANDY, STIFF TO VERY STIFF, MOIST, BROWN, RUST, TAN (CL).
- SAND, CLAYEY, DENSE, MOIST, GRAY, TAN (SC).
- INNTERLAYERED CLAY AND SANDY, CLAYEY TO SANDY, STIFF TO VERY STIFF OR MEDIUM DENSE, MOIST, BROWN, TAN, GRAY, RUST.
- BEDROCK, WATHERED CLAYSTONE, MOIST, BROWN, RUST, GRAY, TAN.
- BEDROCK, SANDSTONE, HARD TO VERY HARD, MOIST, TAN, RUST.
- BEDROCK, CLAYSTONE, MEDIUM HARD TO HARD, MOIST, GRAY, RUST.
- BEDROCK, INTERBEDDED CLAYSTONE/SANDSTONE, CLAYEY TO SANDY, MEDIUM HARD TO VERY HARD, BROWN, GRAY, RUST.
- DRIVE SAMPLE. THE SYMBOL 11/12 INDICATES 11 BLOWS OF AN AUTOMATIC 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- WATER LEVEL MEASURED AT TIME OF DRILLING.
- WATER LEVEL MEASURED AFTER DRILLING ON DECEMBER 13, 2020.
- INDICATES FINISHED FLOOR ELEVATION.

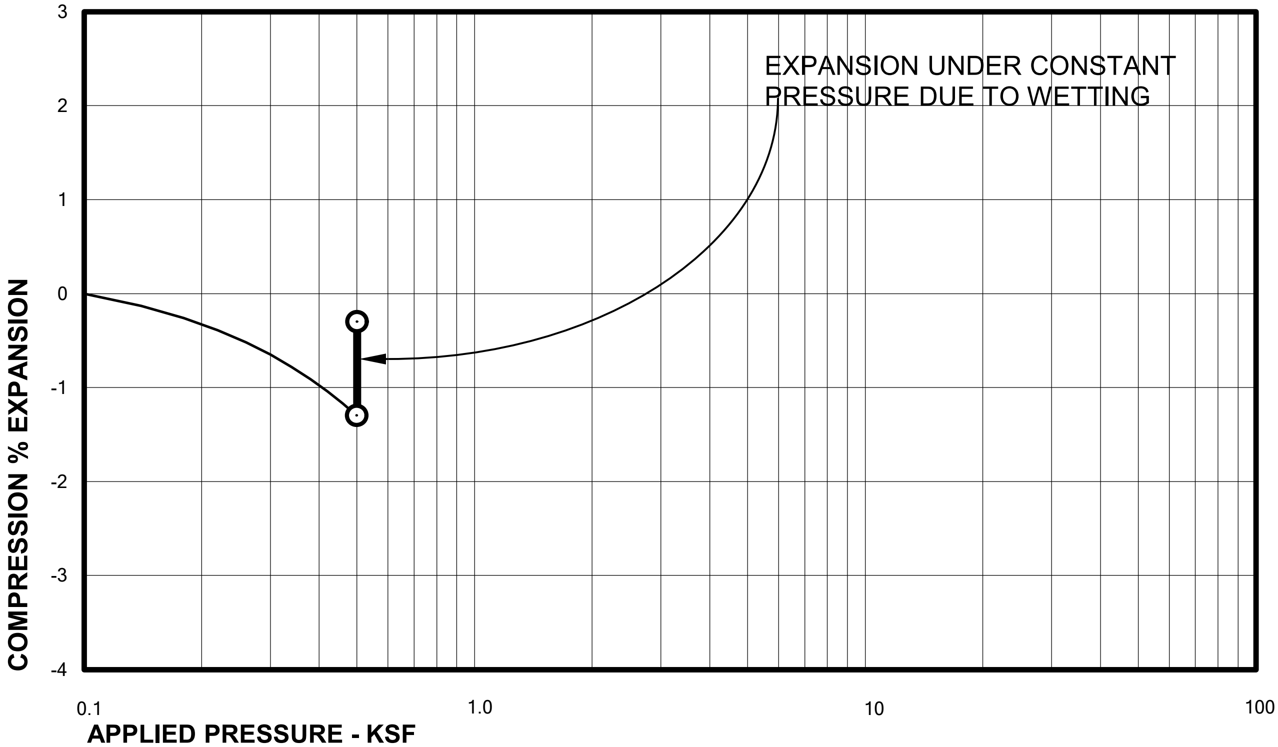
NOTES:

1. THE BORINGS WERE DRILLED ON DECEMBER 4, 7 AND 8, 2020 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT SOLID-STEM AUGER AND TRUCK-MOUNTED CME-45 DRILL RIG.
2. BORING LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM USING A LEICA GS18 GPS UNIT REFERENCING THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
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 (%).
   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.

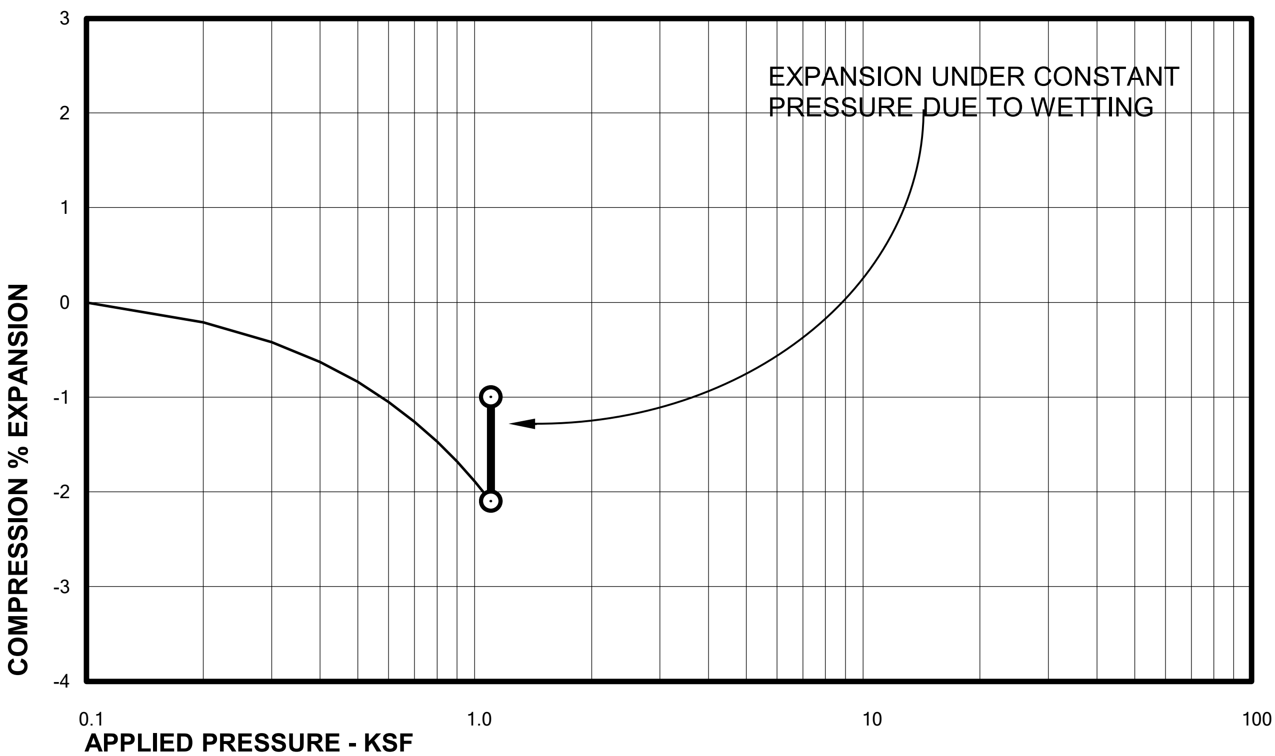
FIG. A- 3

APPENDIX B

LABORATORY TEST RESULTS AND TABLE B-I



Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	104	PCF
From	LOTS 1/2 AT 4 FEET	MOISTURE CONTENT=	18.2	%

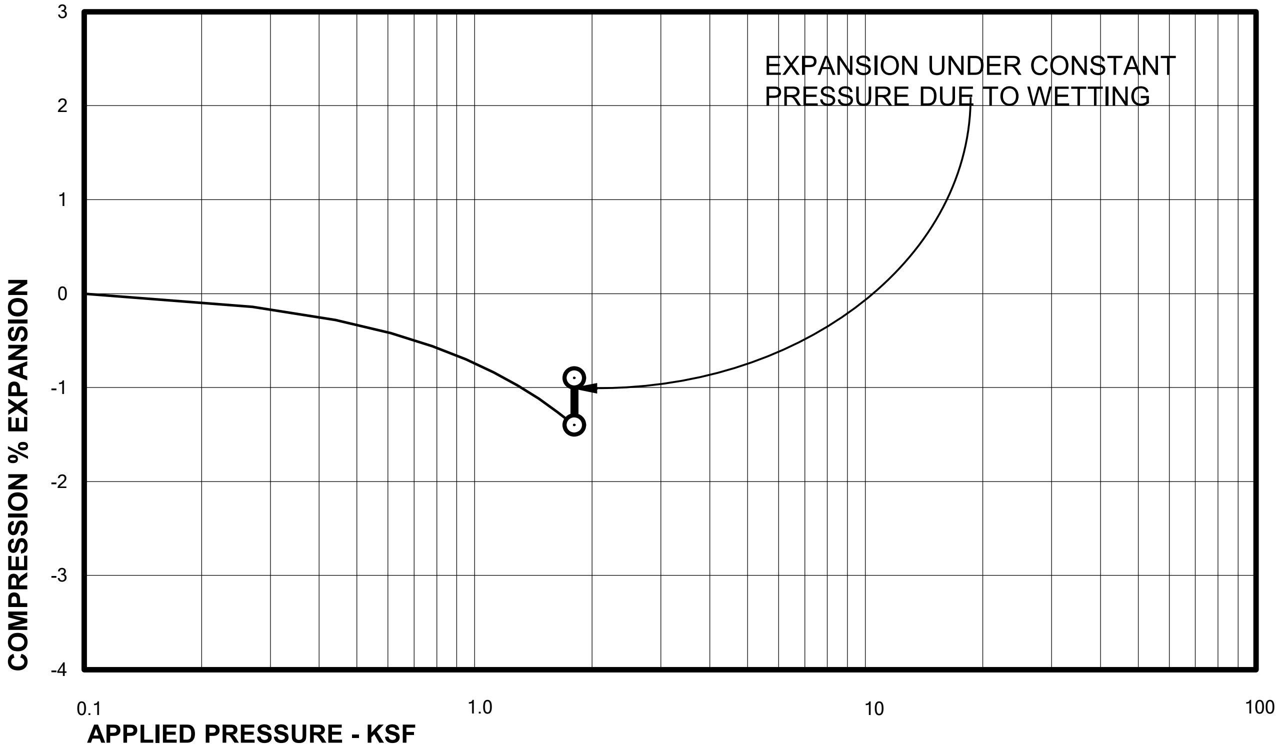


Sample of	WEATHERED CLAYSTONE	DRY UNIT WEIGHT=	92	PCF
From	LOTS 1/2 AT 9 FEET	MOISTURE CONTENT=	30.2	%

Swell Consolidation Test Results

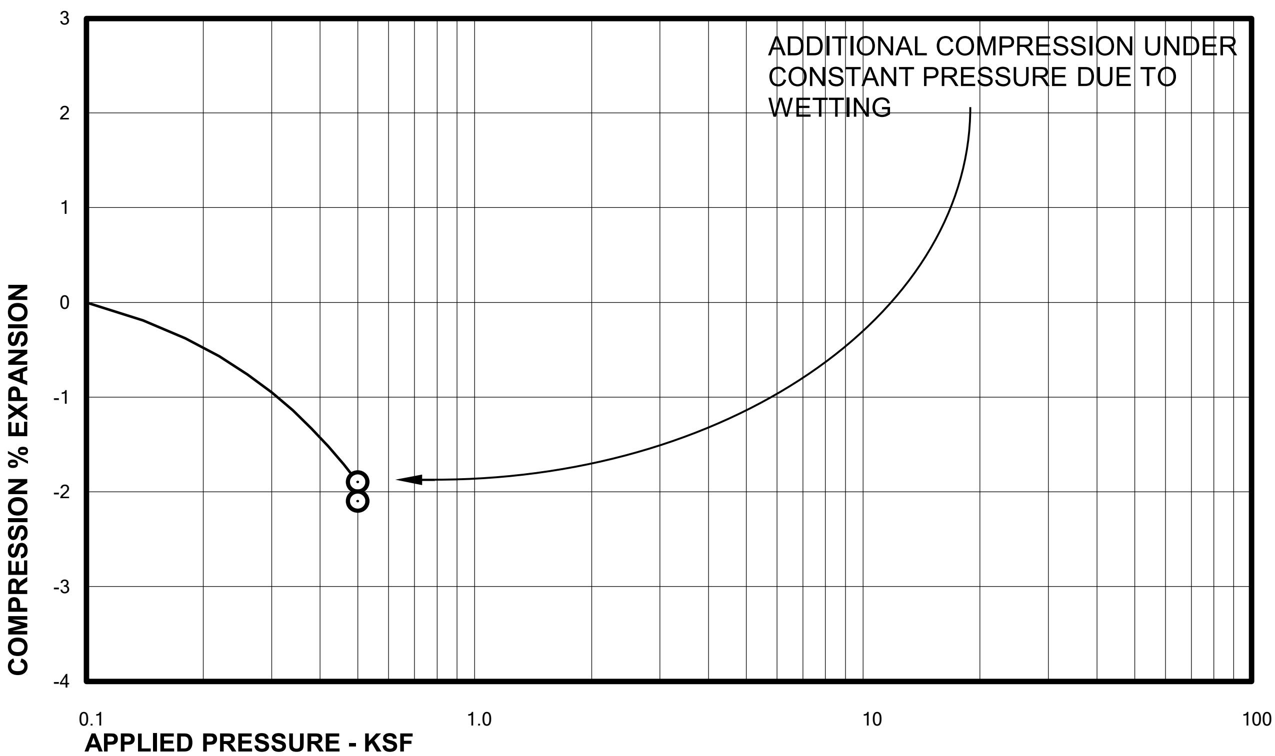
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

FIG. B-1



Sample of INTERBEDDED CLAYSTONE/SANDSTONE
From LOTS 1/2 AT 14 FEET

DRY UNIT WEIGHT= 104 PCF
MOISTURE CONTENT= 22.5 %



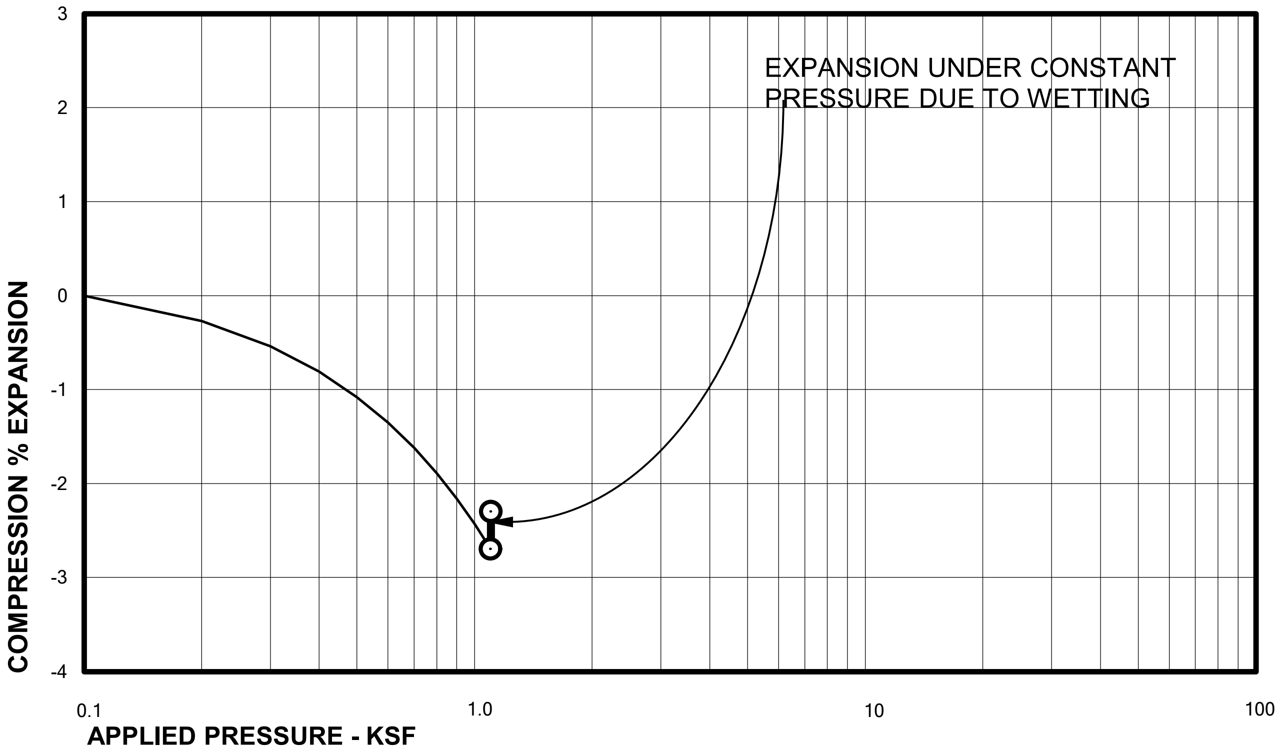
Sample of CLAY, SANDY (CL)
From LOTS 3/4 AT 4 FEET

DRY UNIT WEIGHT= 100 PCF
MOISTURE CONTENT= 21.3 %

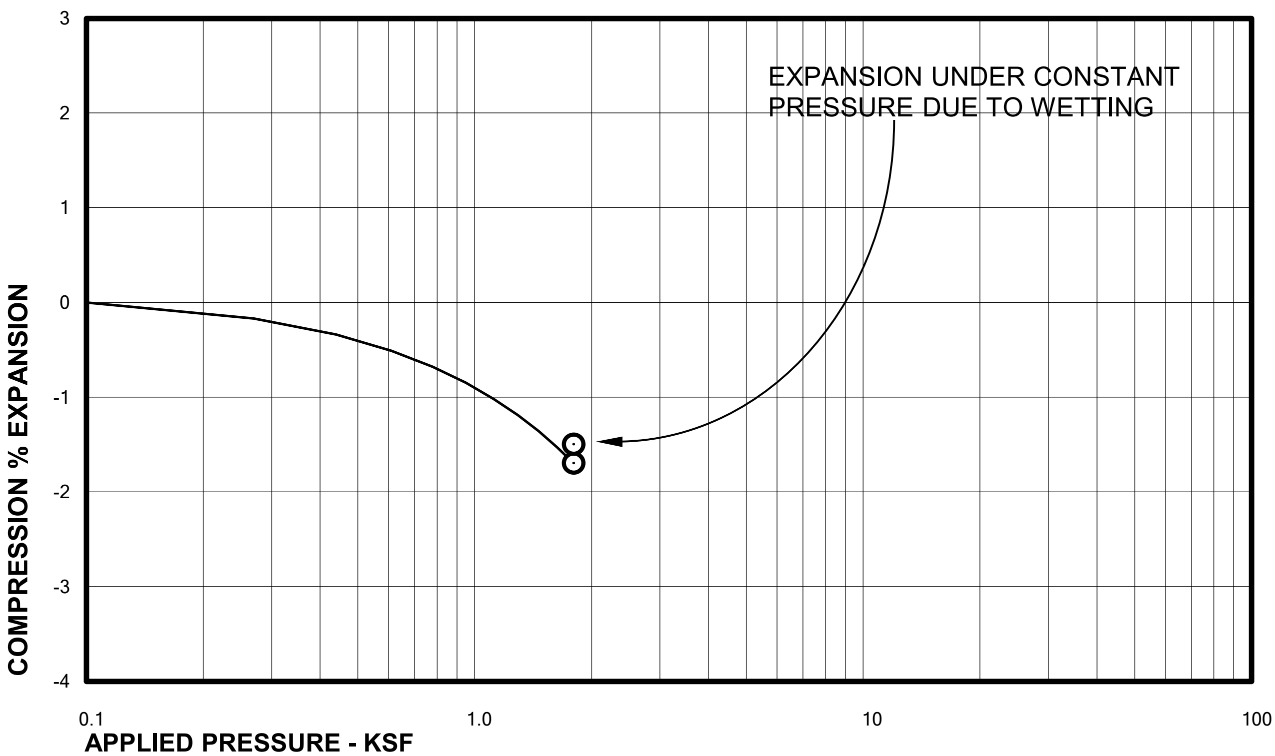
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-2



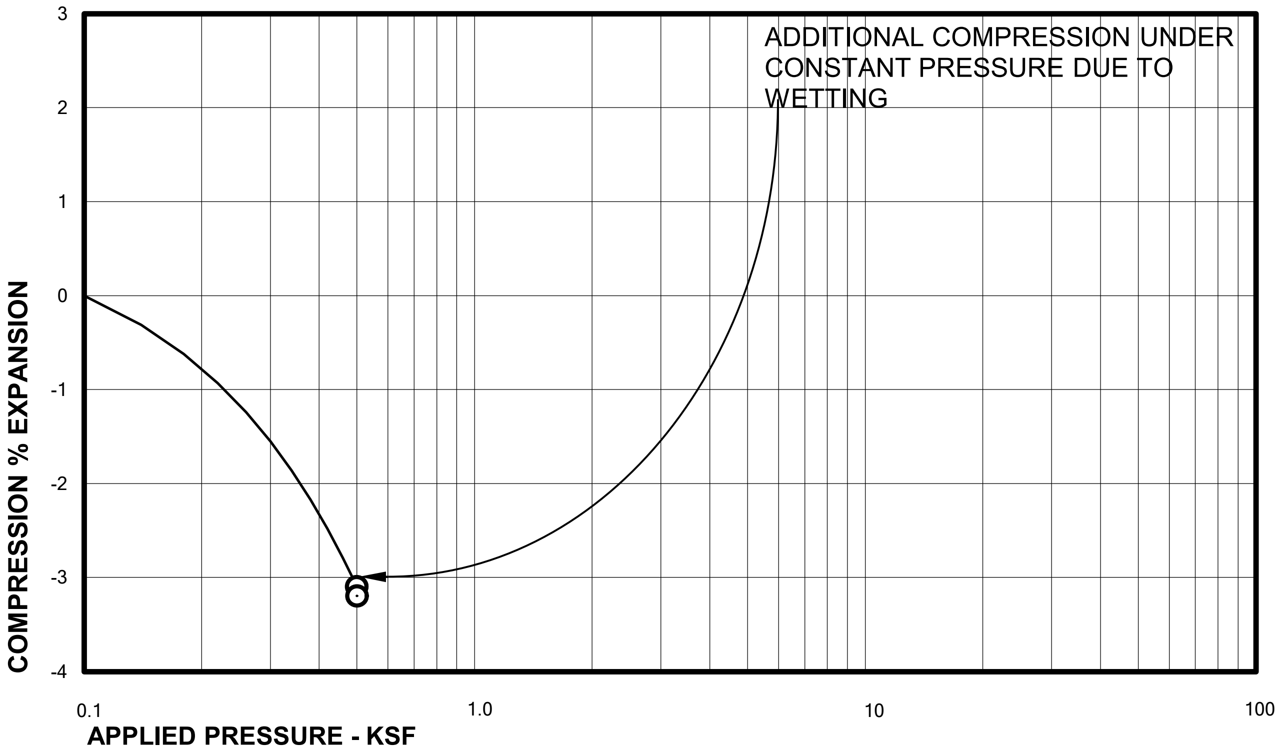
Sample of	WEATHERED CLAYSTONE	DRY UNIT WEIGHT=	88	PCF
From	LOTS 3/4 AT 9 FEET	MOISTURE CONTENT=	31.5	%



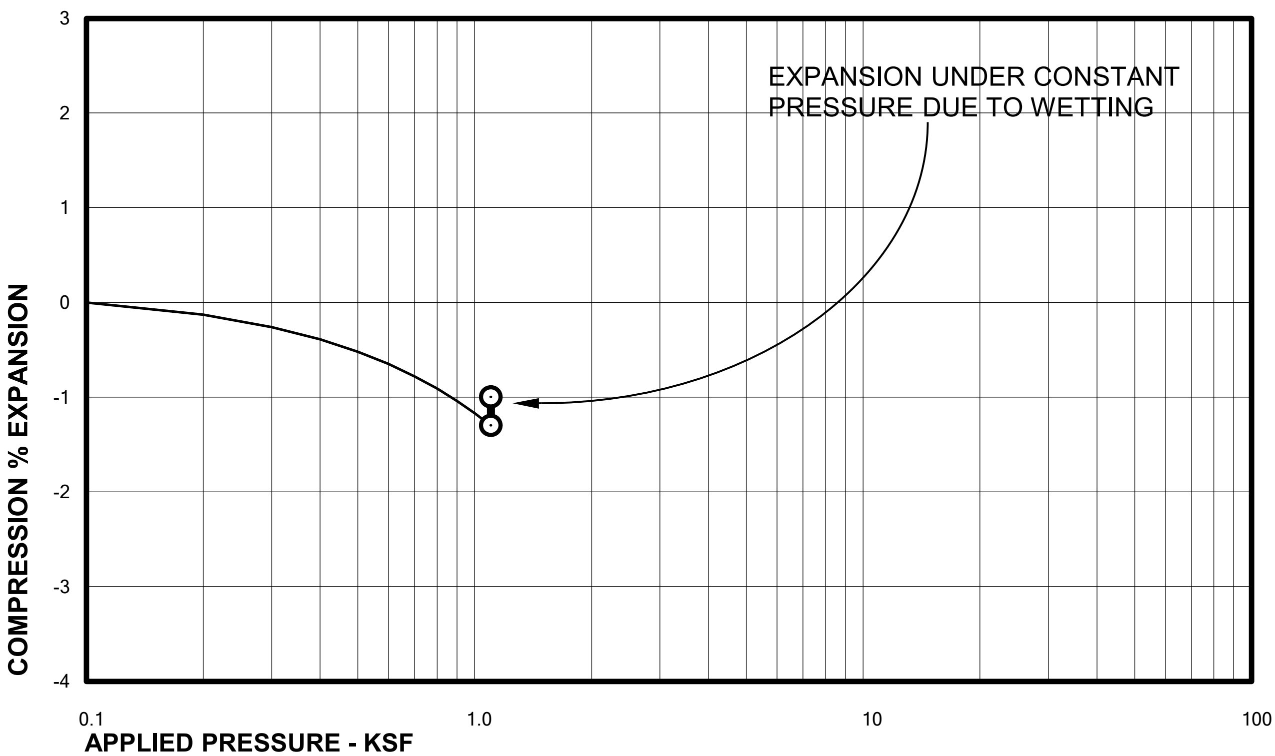
Sample of	INTERBEDDED CLAYSTONE/SANDSTONE	DRY UNIT WEIGHT=	108	PCF
From	LOTS 3/4 AT 14 FEET	MOISTURE CONTENT=	19.6	%

Swell Consolidation Test Results

FIG. B-3

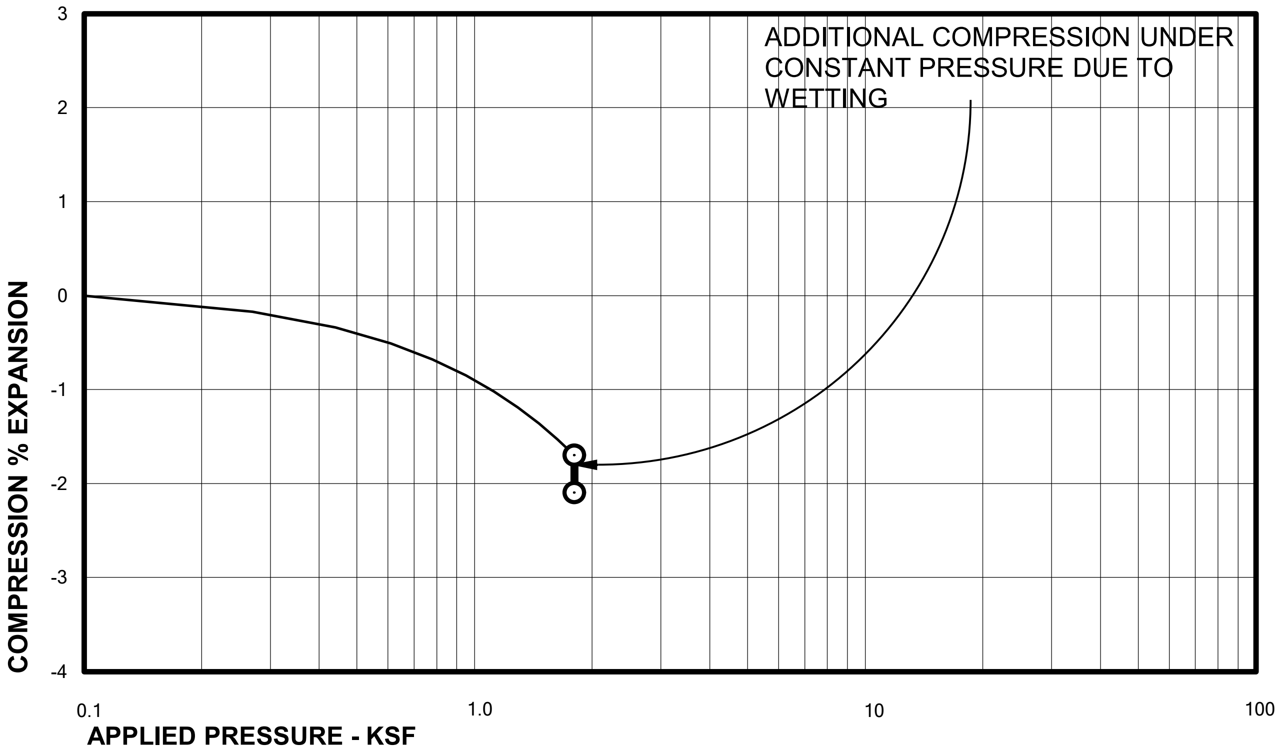


Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	89	PCF
From	LOTS 5/6 AT 4 FEET	MOISTURE CONTENT=	24.6	%



Sample of	INTERLAYERED CLAY/SAND	DRY UNIT WEIGHT=	99	PCF
From	LOTS 5/6 AT 9 FEET	MOISTURE CONTENT=	24.1	%

Swell Consolidation Test Results

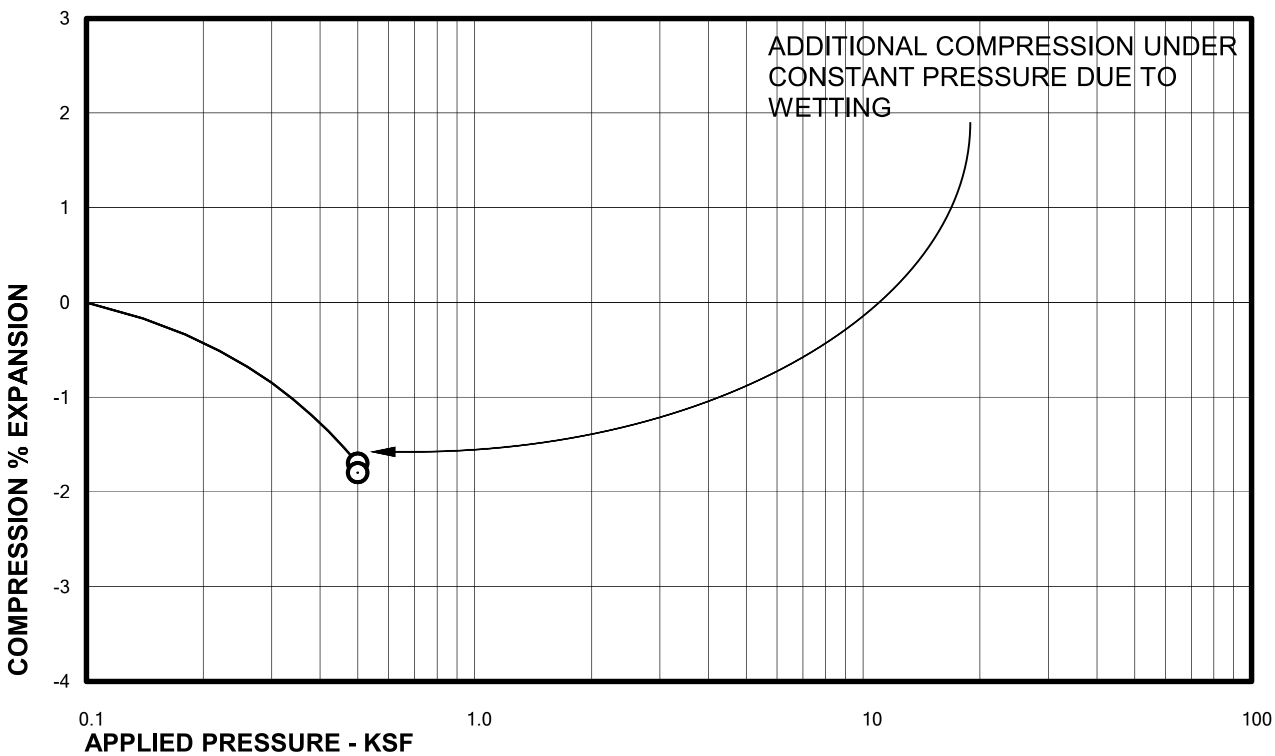


Sample of INTERBEDDED CLAYSTONE/SANDSTONE

From LOTS 5/6 AT 14 FEET

DRY UNIT WEIGHT= 97 PCF

MOISTURE CONTENT= 24.7 %



Sample of CLAY, SANDY (CL)

From LOTS 7/8 AT 4 FEET

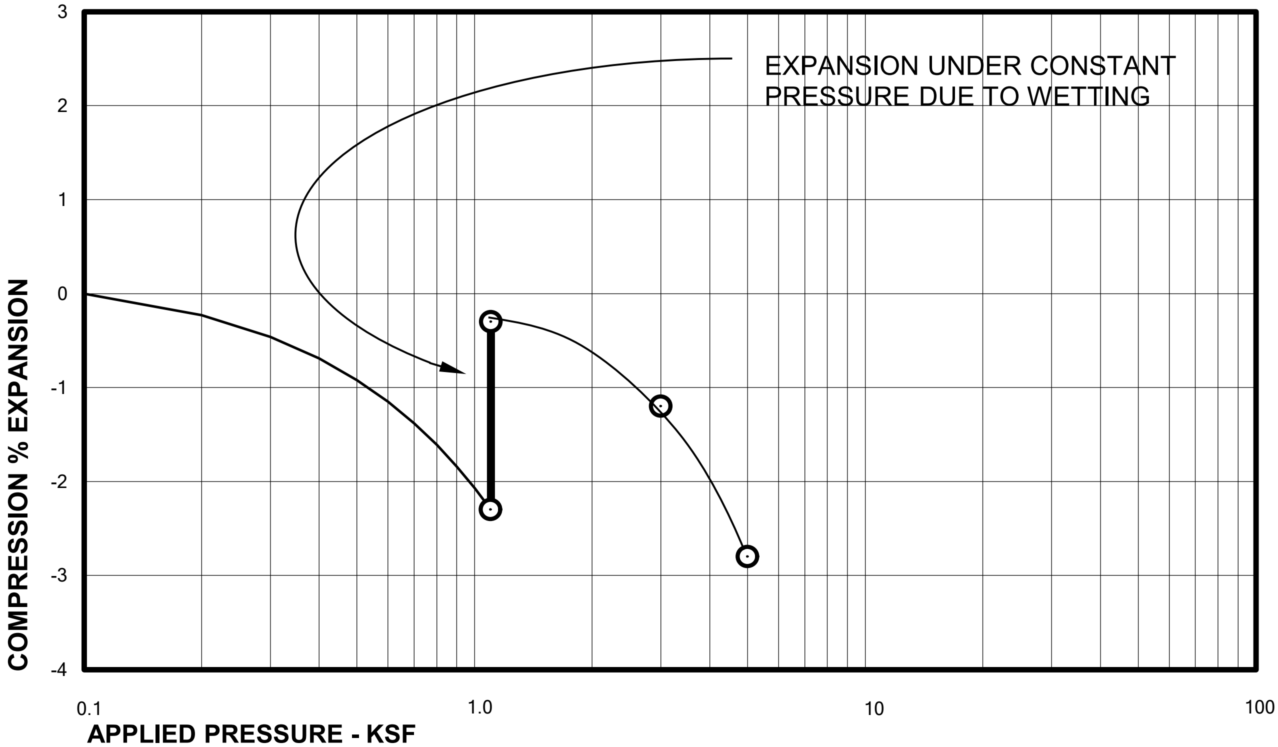
DRY UNIT WEIGHT= 88 PCF

MOISTURE CONTENT= 32.1 %

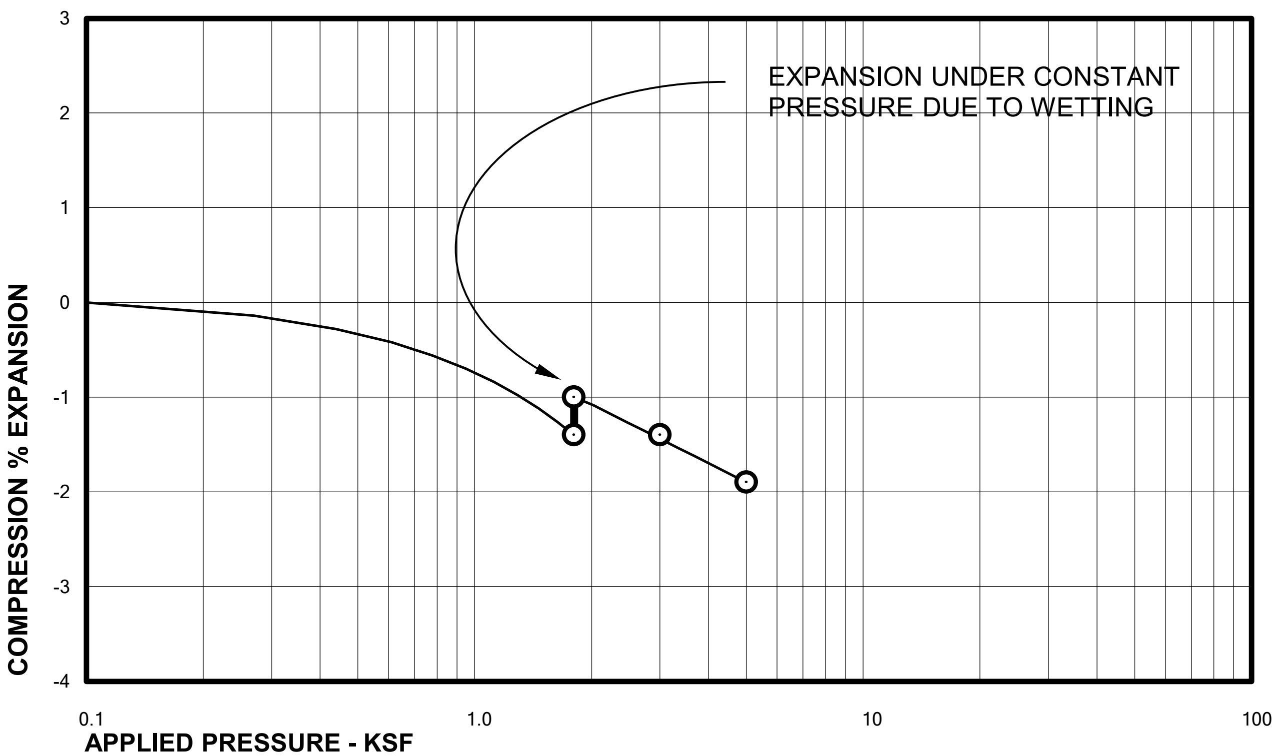
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-5



Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	103	PCF
From	LOTS 7/8 AT 9 FEET	MOISTURE CONTENT=	19.6	%

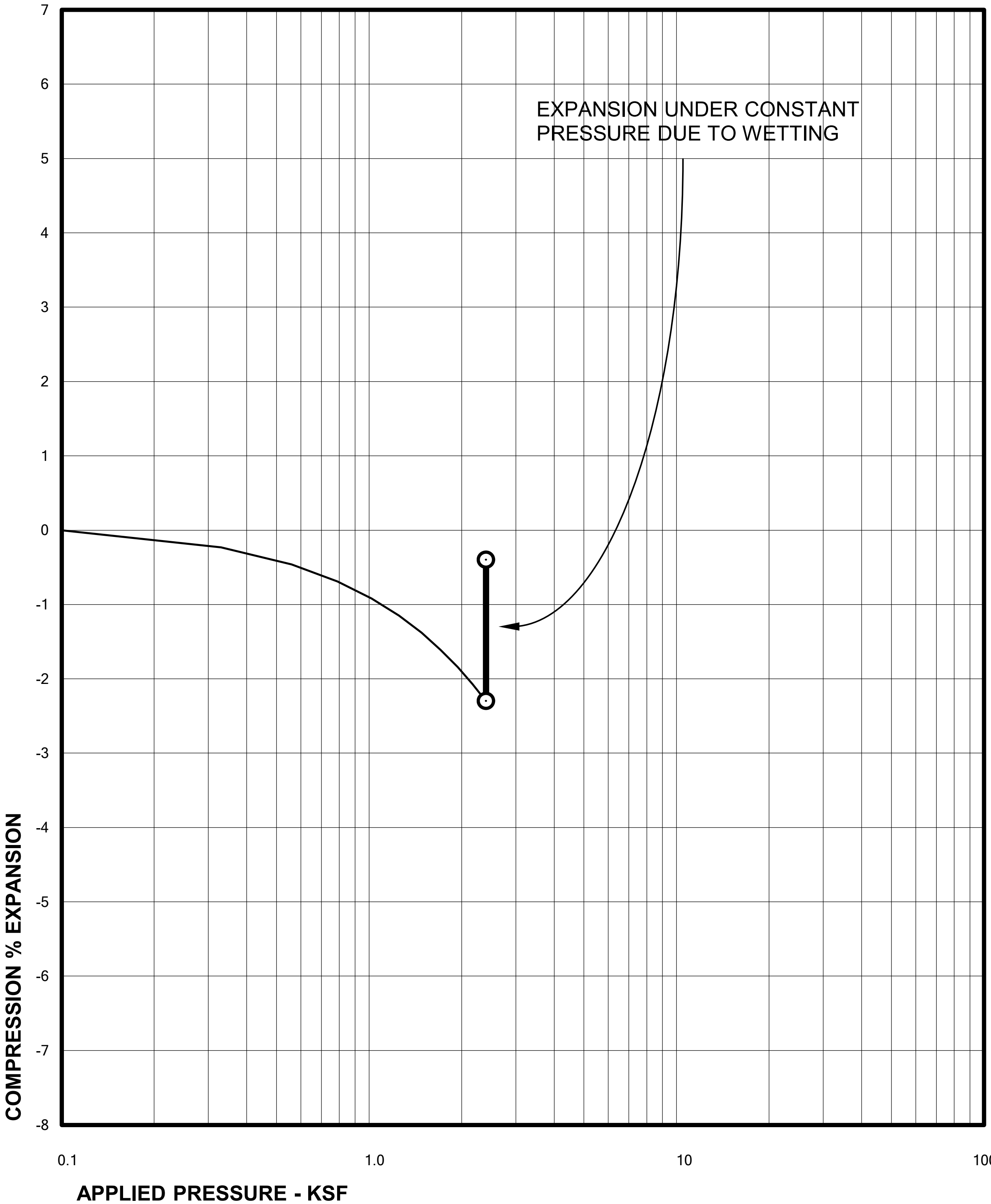


Sample of	INTERBEDDED CLAYSTONE/SANDSTONE	DRY UNIT WEIGHT=	106	PCF
From	LOTS 7/8 AT 14 FEET	MOISTURE CONTENT=	20.3	%

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-6



Sample of CLAYSTONE

From LOTS 7/8 AT 19 FEET

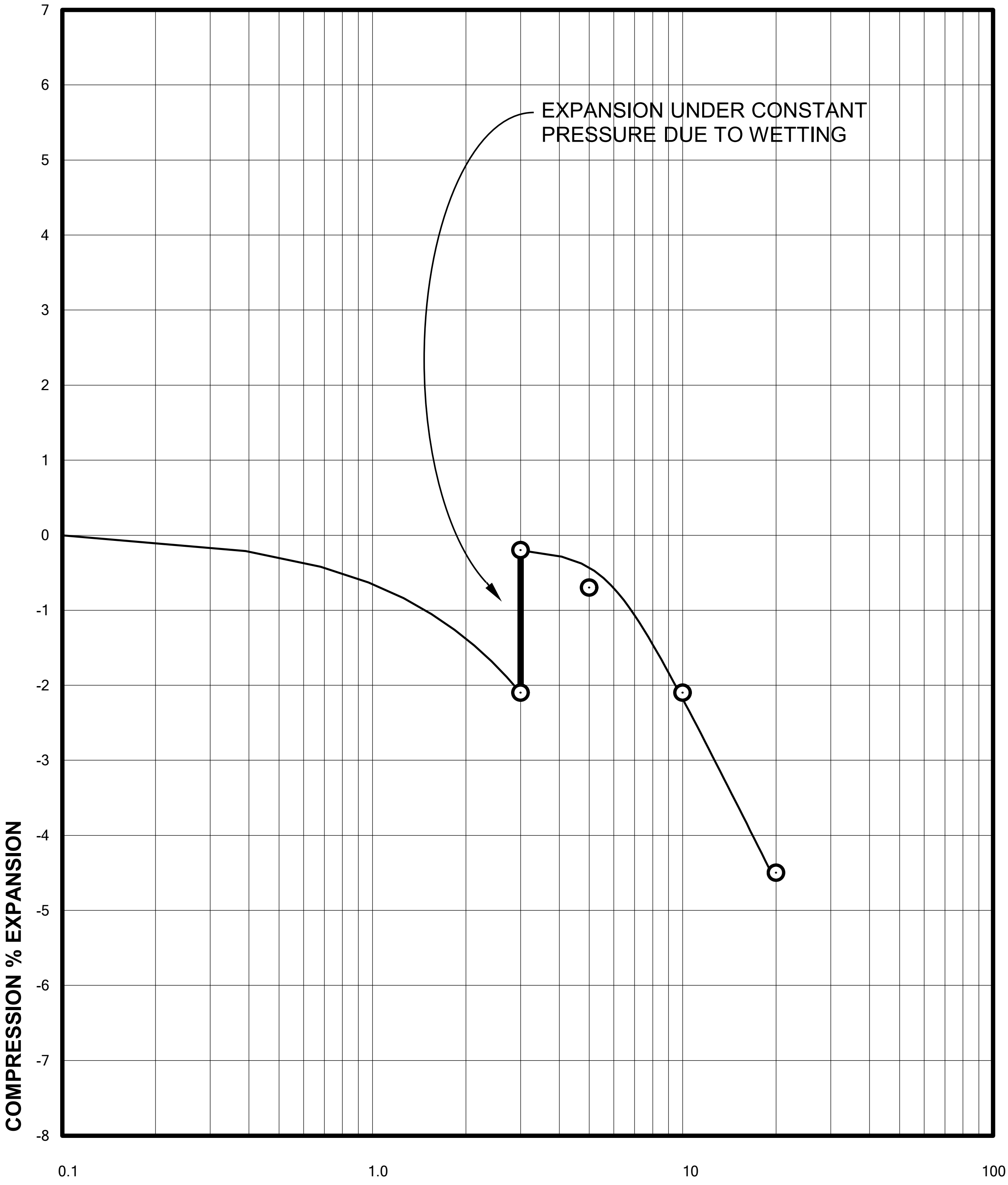
DRY UNIT WEIGHT= 96 PCF

MOISTURE CONTENT= 29.6 %

Swell Consolidation Test Results

FIG. B-7

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

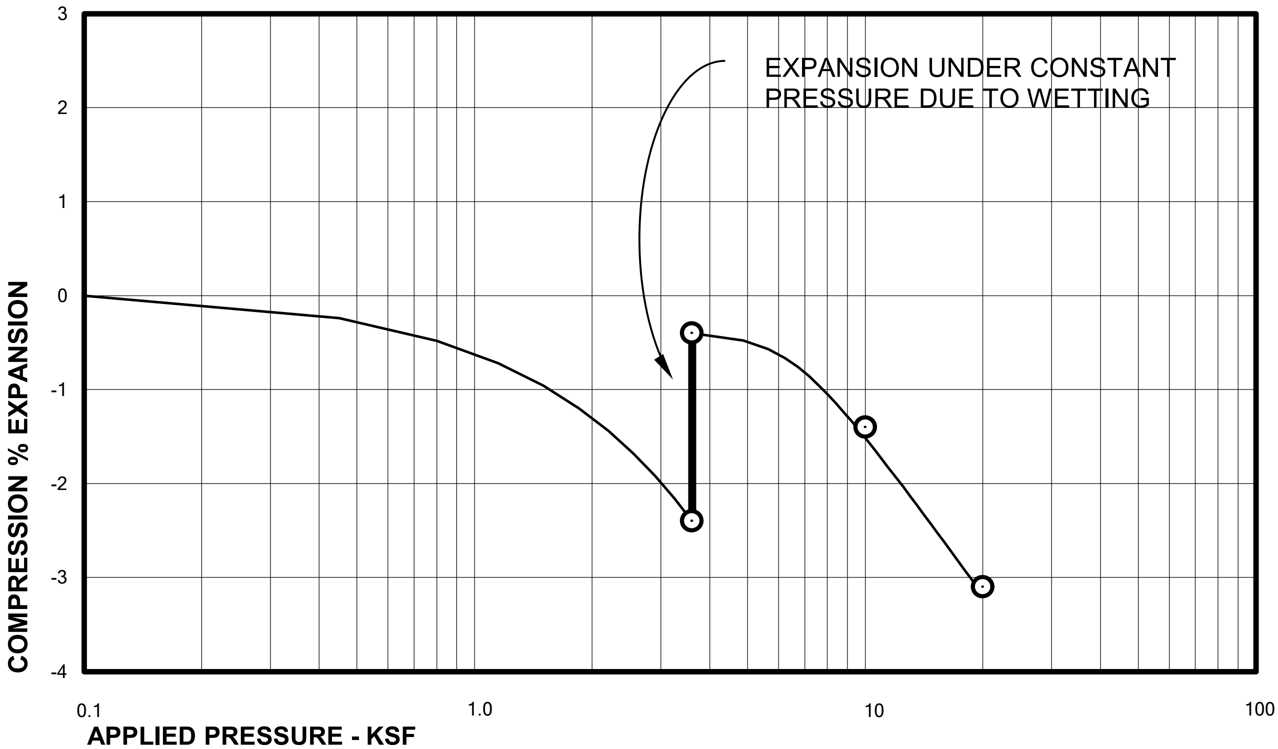


Sample of	CLAYSTONE	DRY UNIT WEIGHT=	97	PCF
From	LOTS 7/8 AT 24 FEET	MOISTURE CONTENT=	25.4	%

Swell Consolidation Test Results

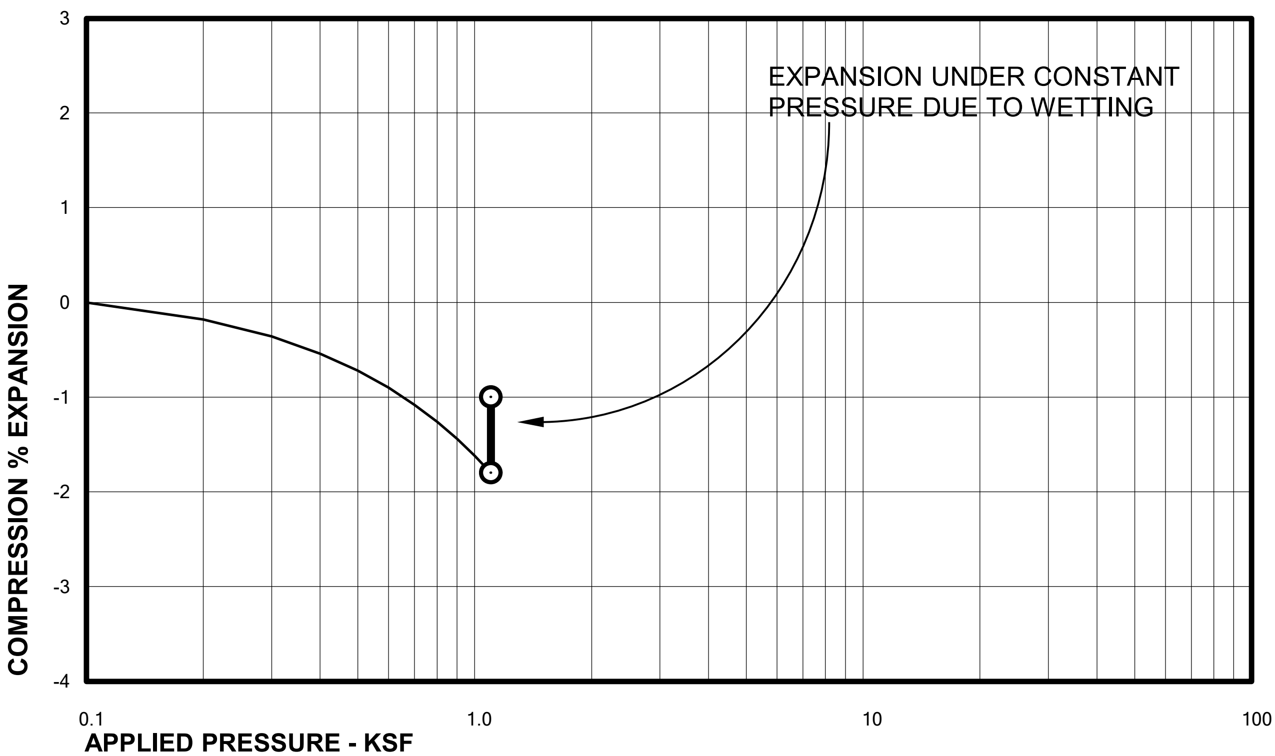
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

FIG. B-8



Sample of CLAYSTONE
From LOTS 7/8 AT 29 FEET

DRY UNIT WEIGHT= 114 PCF
MOISTURE CONTENT= 19.6 %

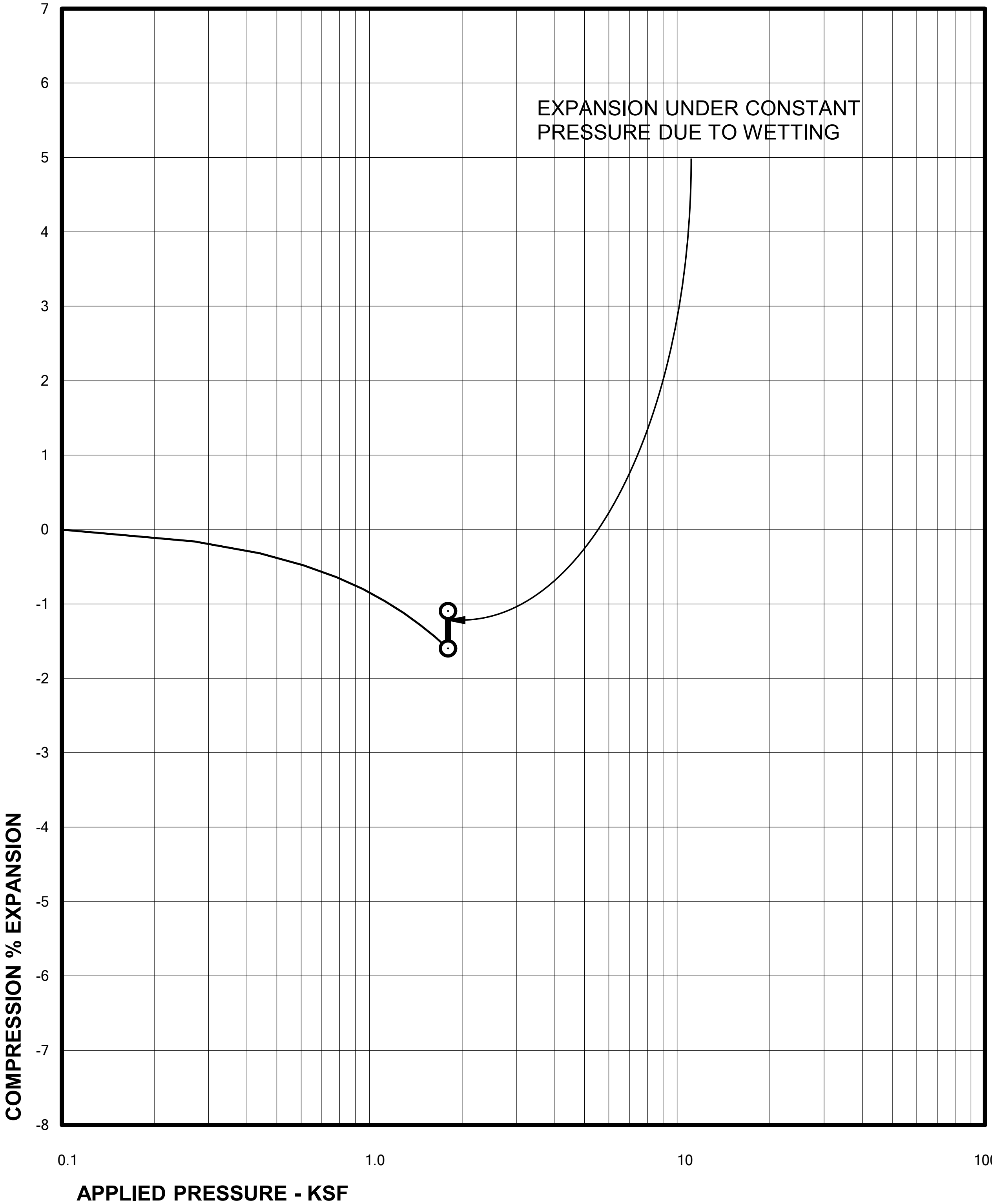


Sample of CLAY, SANDY (CL)
From LOTS 9/10 AT 4 FEET

DRY UNIT WEIGHT= 99 PCF
MOISTURE CONTENT= 23.2 %

Swell Consolidation Test Results

FIG. B-9



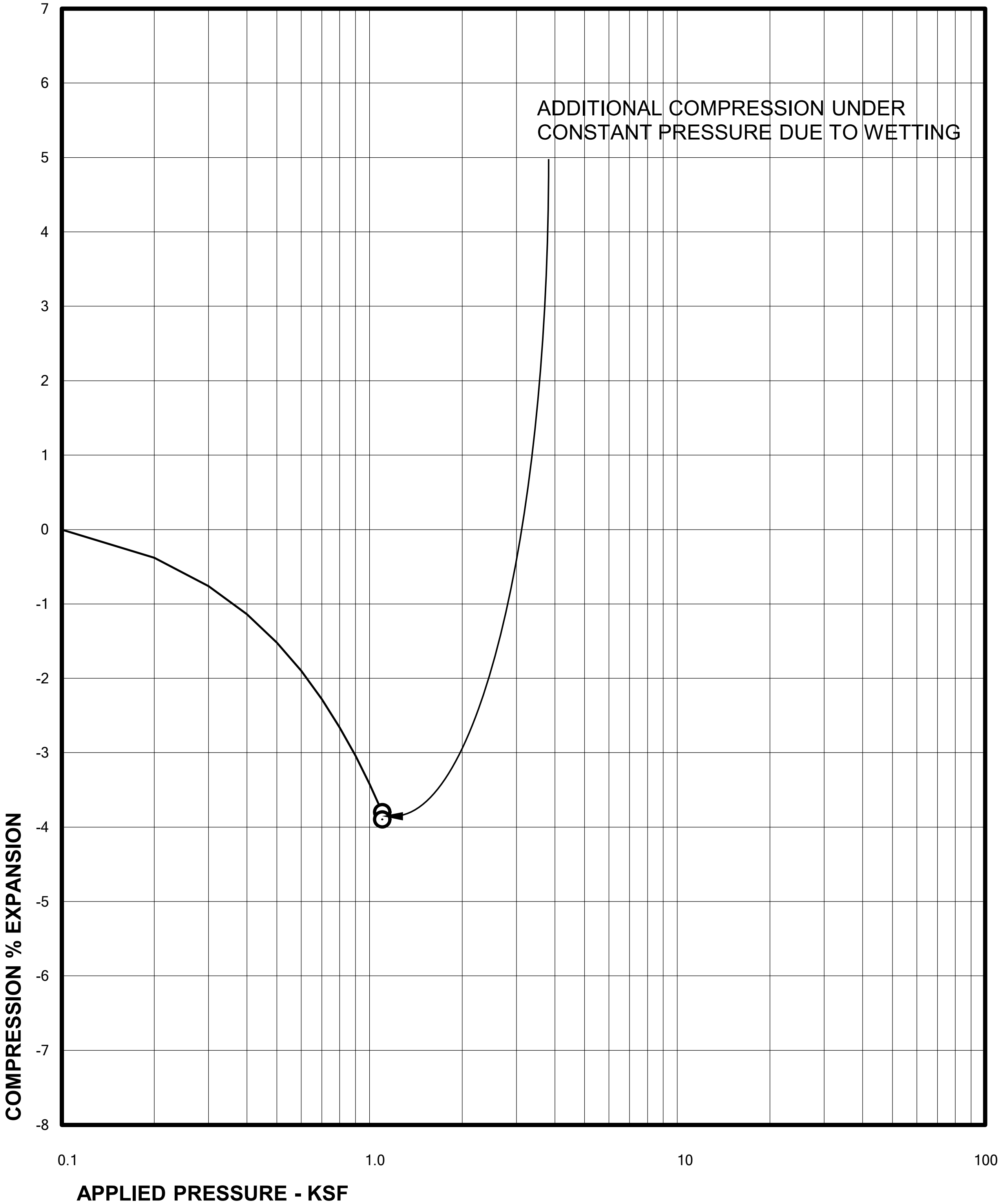
Sample of INTERBEDDED CLAYSTONE/SANDSTONE
From LOTS 9/10 AT 9 FEET

DRY UNIT WEIGHT= 107 PCF
MOISTURE CONTENT= 20.9 %

Swell Consolidation Test Results

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

FIG. B-10

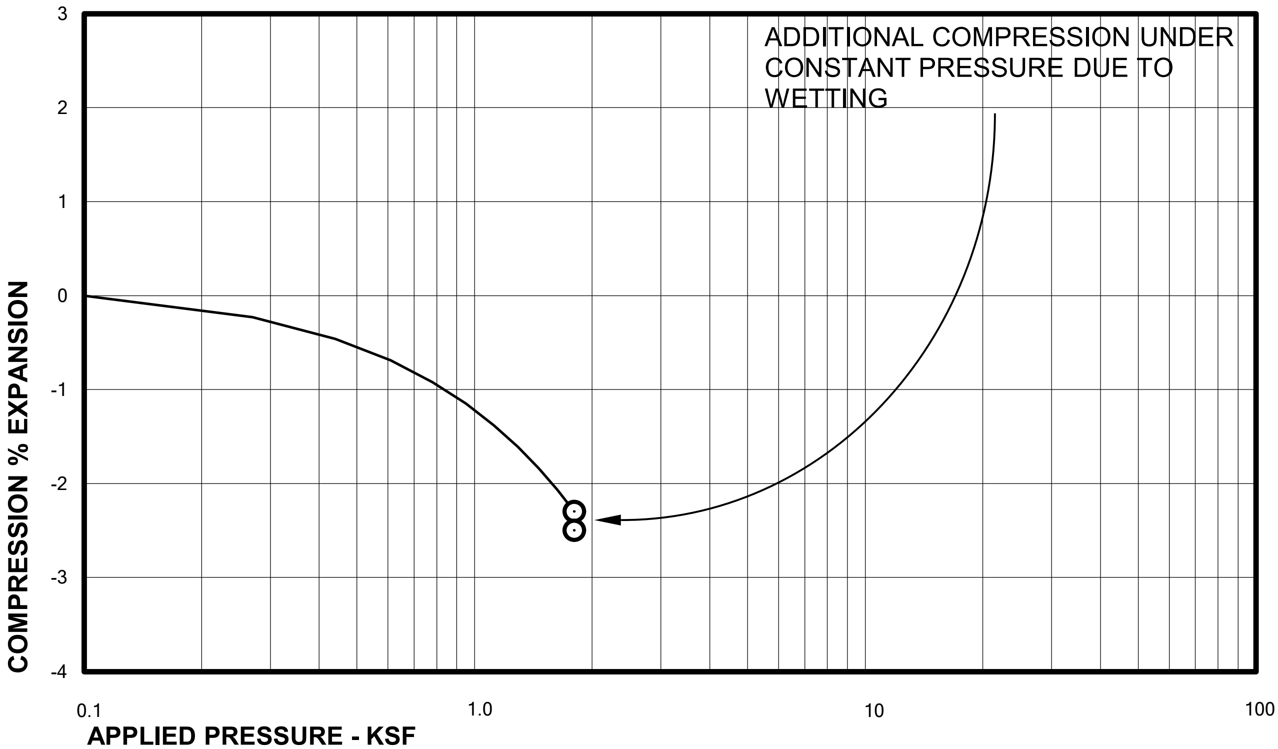


Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	95	PCF
From	LOTS 11/12 AT 4 FEET	MOISTURE CONTENT=	19.6	%

Swell Consolidation Test Results

FIG. B-11

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

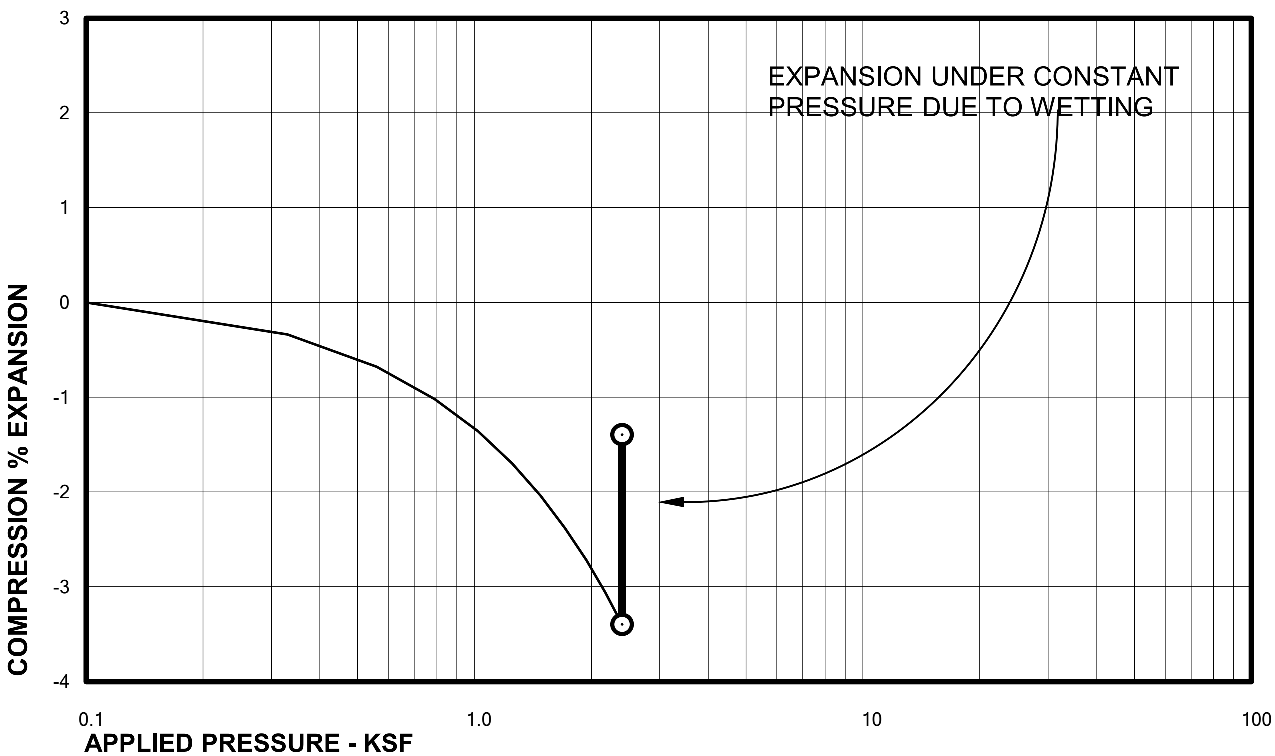


Sample of INTERBEDDED CLAYSTONE/SANDSTONE

From LOTS 11/12 AT 9 FEET

DRY UNIT WEIGHT= 105 PCF

MOISTURE CONTENT= 19.1 %



Sample of INTERBEDDED CLAYSTONE/SANDSTONE

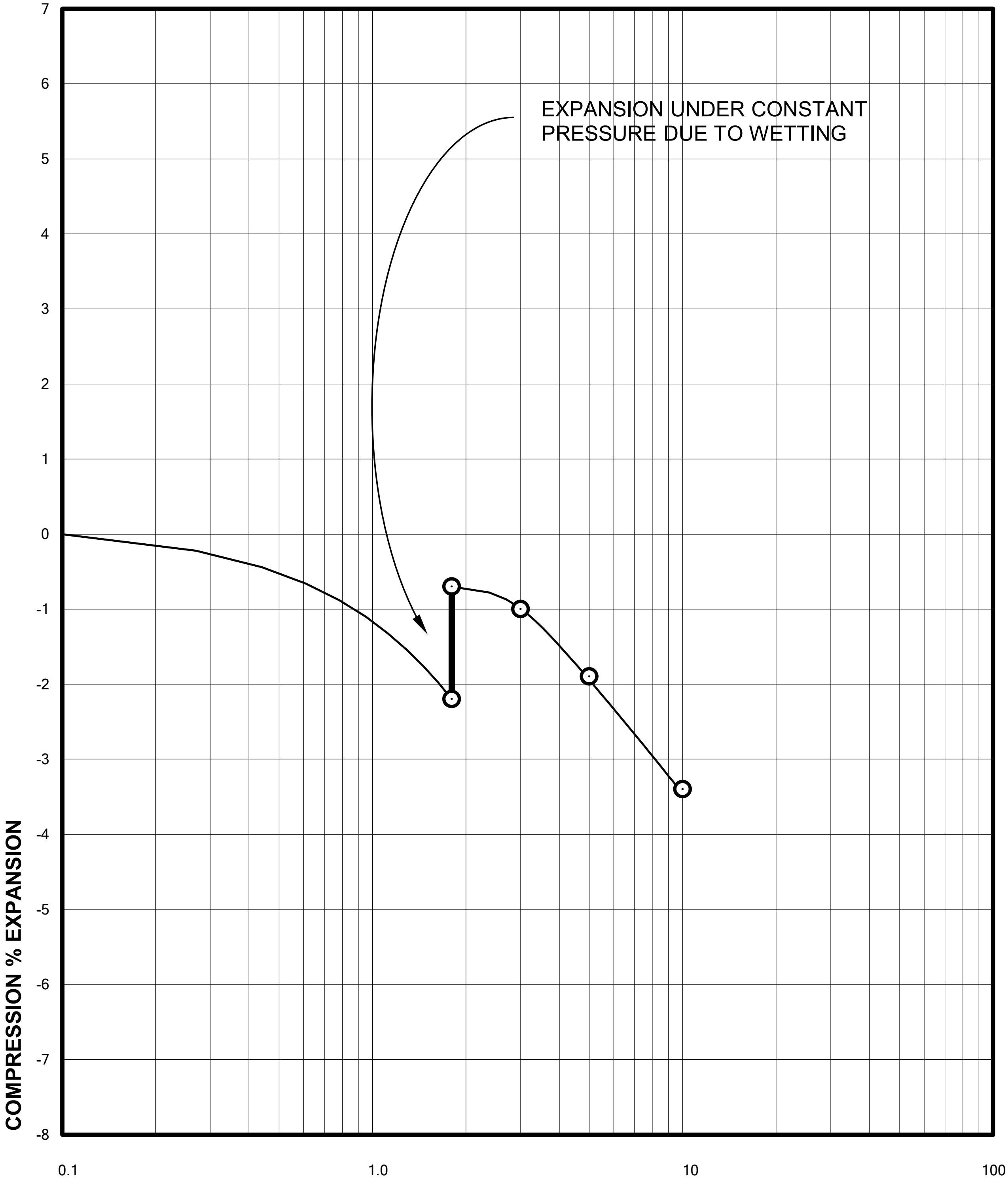
From LOTS 11/12 AT 14 FEET

DRY UNIT WEIGHT= 108 PCF

MOISTURE CONTENT= 16.2 %

Swell Consolidation Test Results

FIG. B-12

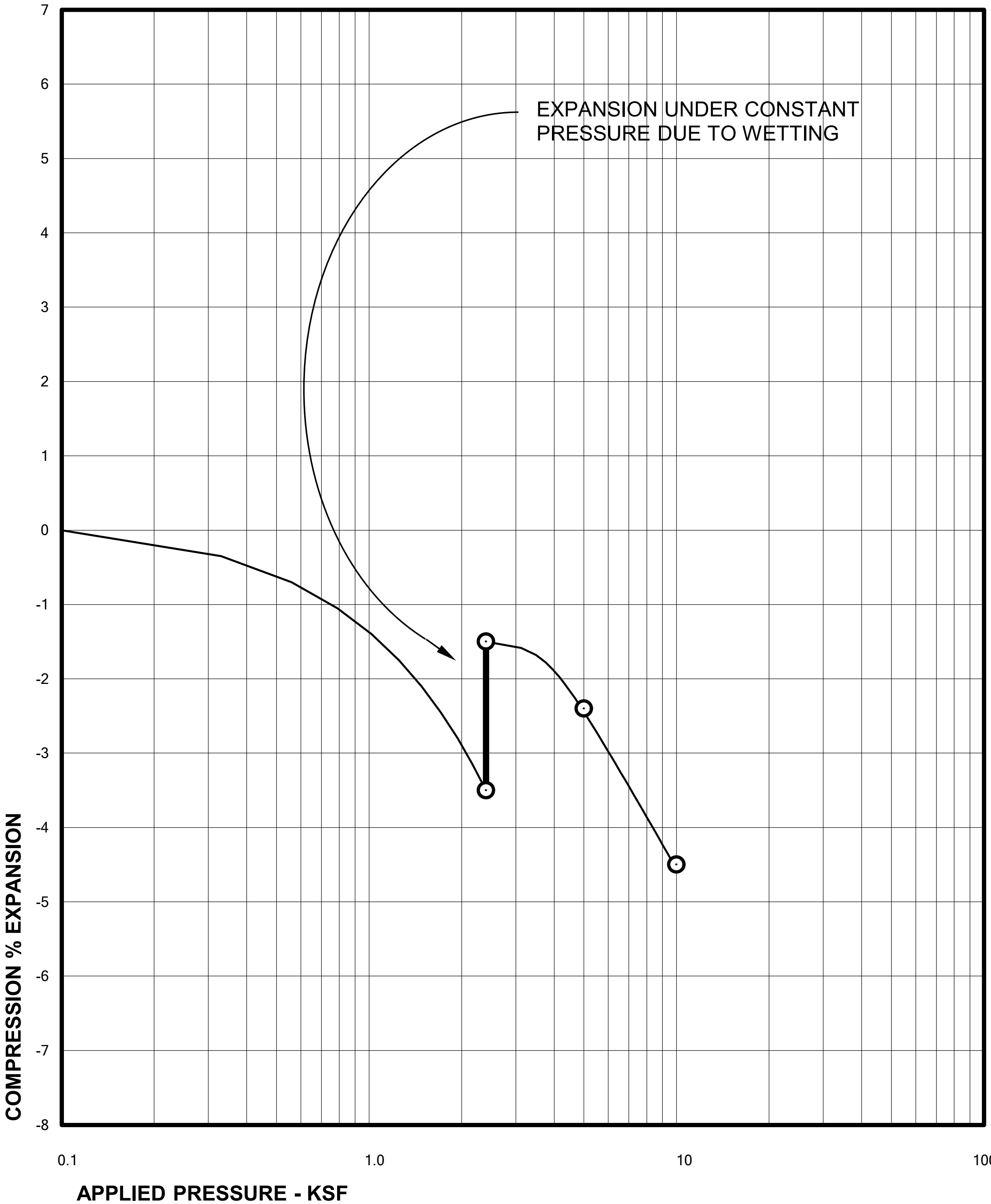


Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	116	PCF
From	LOTS 13/14 AT 4 FEET	MOISTURE CONTENT=	11.0	%

Swell Consolidation Test Results

FIG. B-13

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1



Sample of CLAYSTONE

From LOTS 13/14 AT 9 FEET

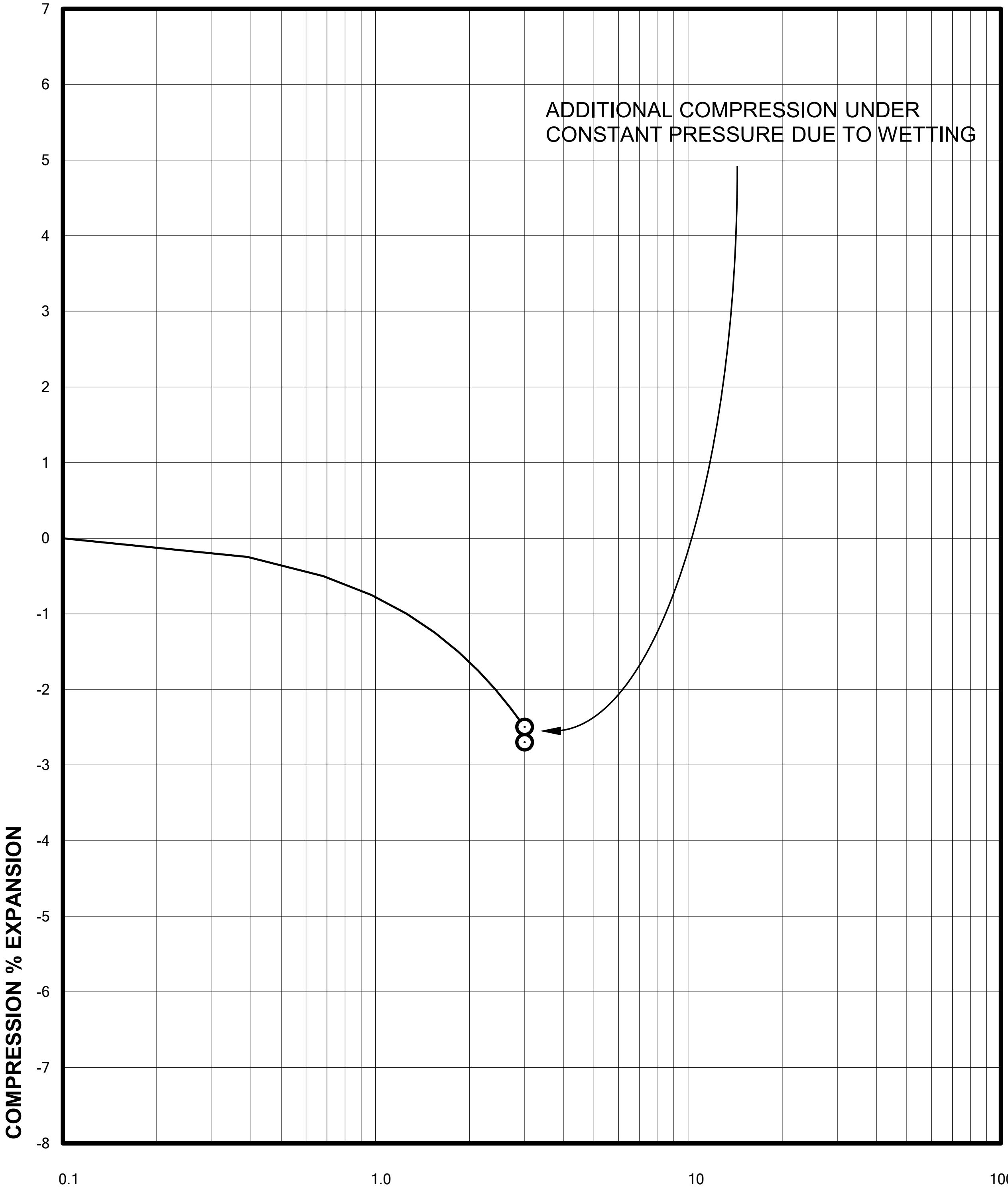
DRY UNIT WEIGHT= 102 PCF

MOISTURE CONTENT= 20.9 %

Swell Consolidation Test Results

FIG. B-14

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1



Sample of INTERBEDDED CLAYSTONE/SANDSTONE

From LOTS 13/14 AT 14 FEET

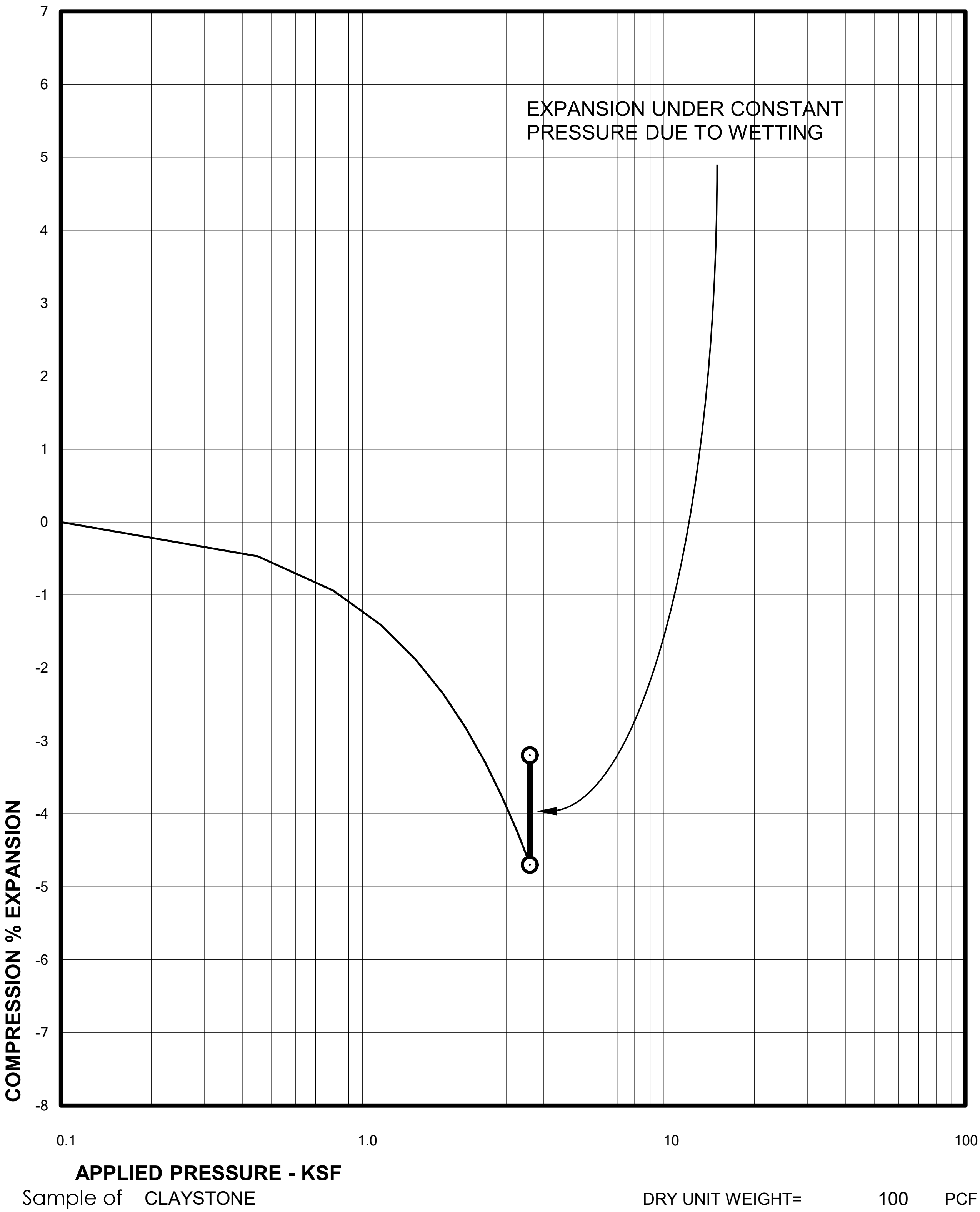
DRY UNIT WEIGHT= 104 PCF

MOISTURE CONTENT= 18.5 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-15

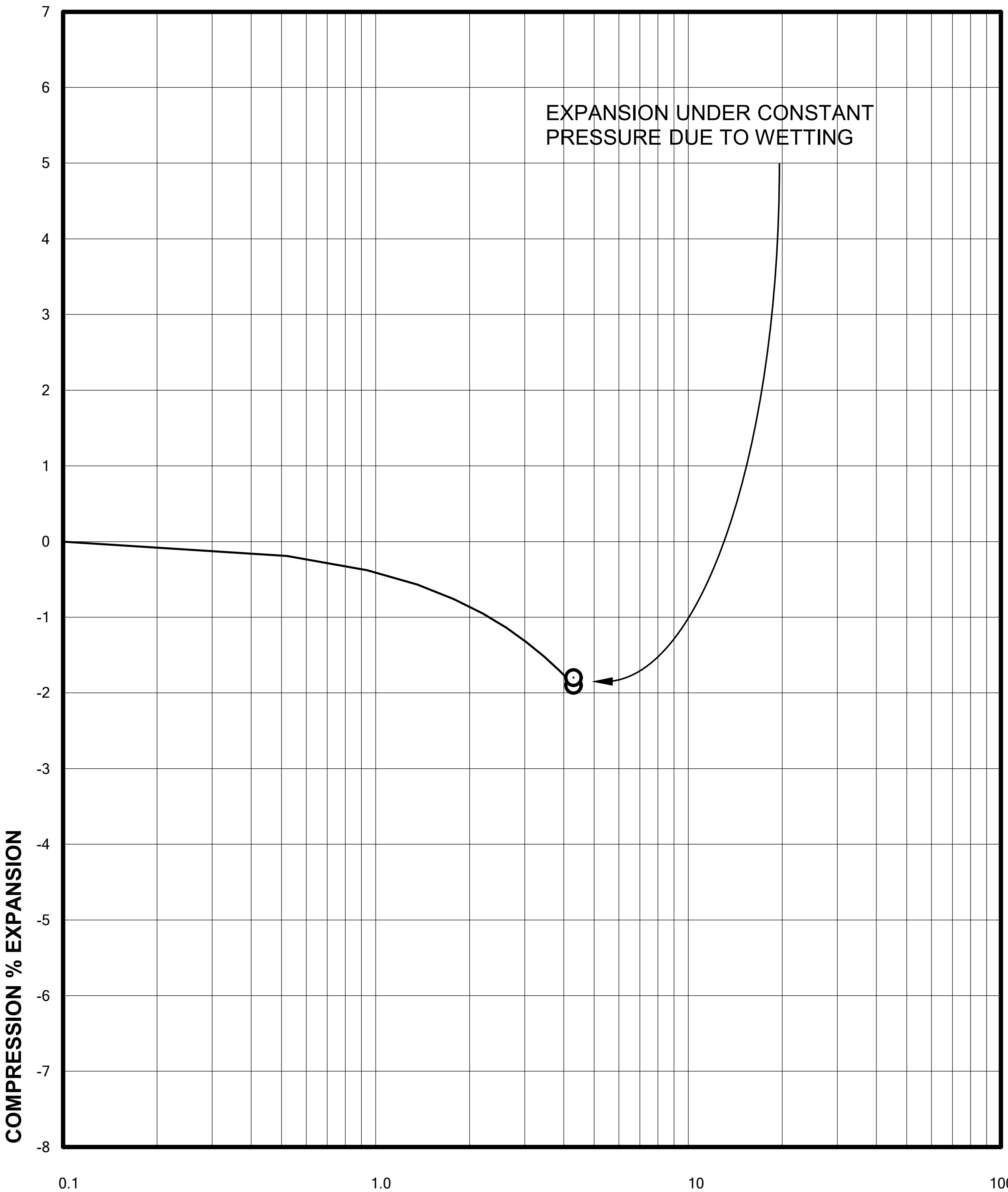


Sample of	CLAYSTONE		DRY UNIT WEIGHT=	100	PCF
From	LOTS 13/14 AT 19 FEET		MOISTURE CONTENT=	24.0	%

Swell Consolidation Test Results

FIG. B-16

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1



Sample of CLAYSTONE

From LOTS 13/14 AT 24 FEET

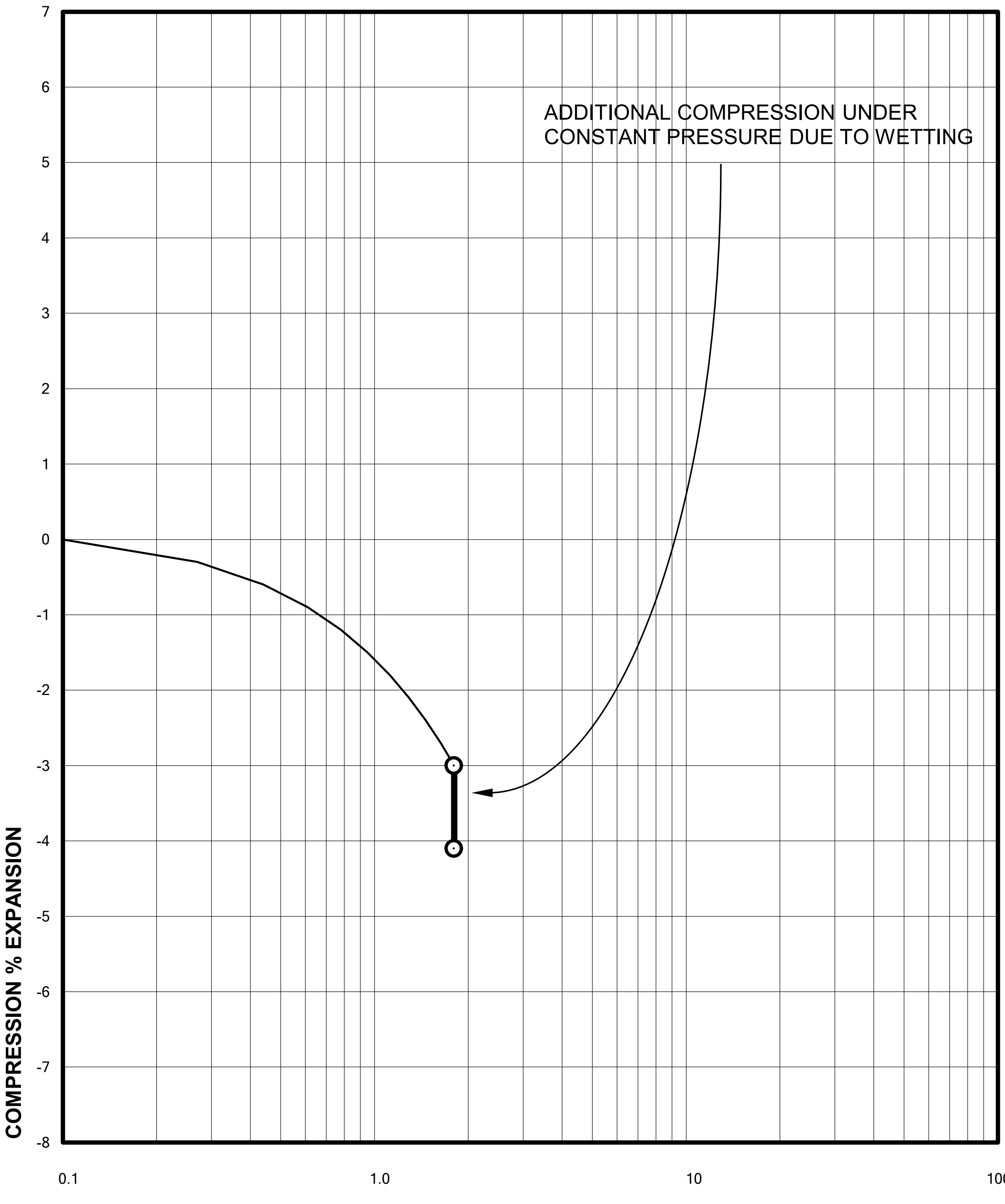
DRY UNIT WEIGHT= 117 PCF

MOISTURE CONTENT= 15.2 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-17



Sample of CLAY, SANDY (CL)

From LOTS 15/16 AT 4 FEET

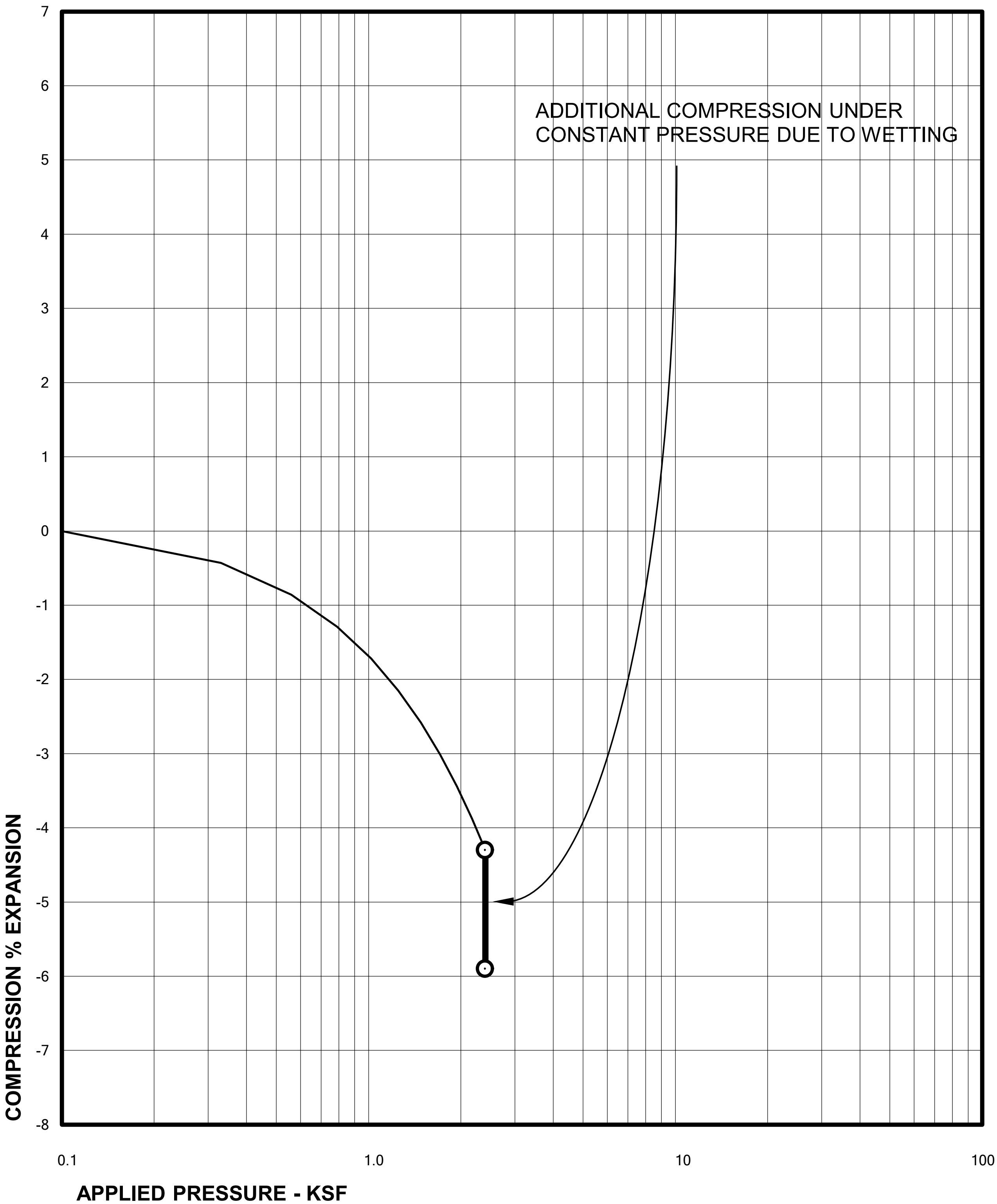
DRY UNIT WEIGHT= 87 PCF

MOISTURE CONTENT= 22.7 %

Swell Consolidation Test Results

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

FIG. B-18



Sample of INTERLAYERED CLAY/SAND

From LOTS 15/16 AT 9 FEET

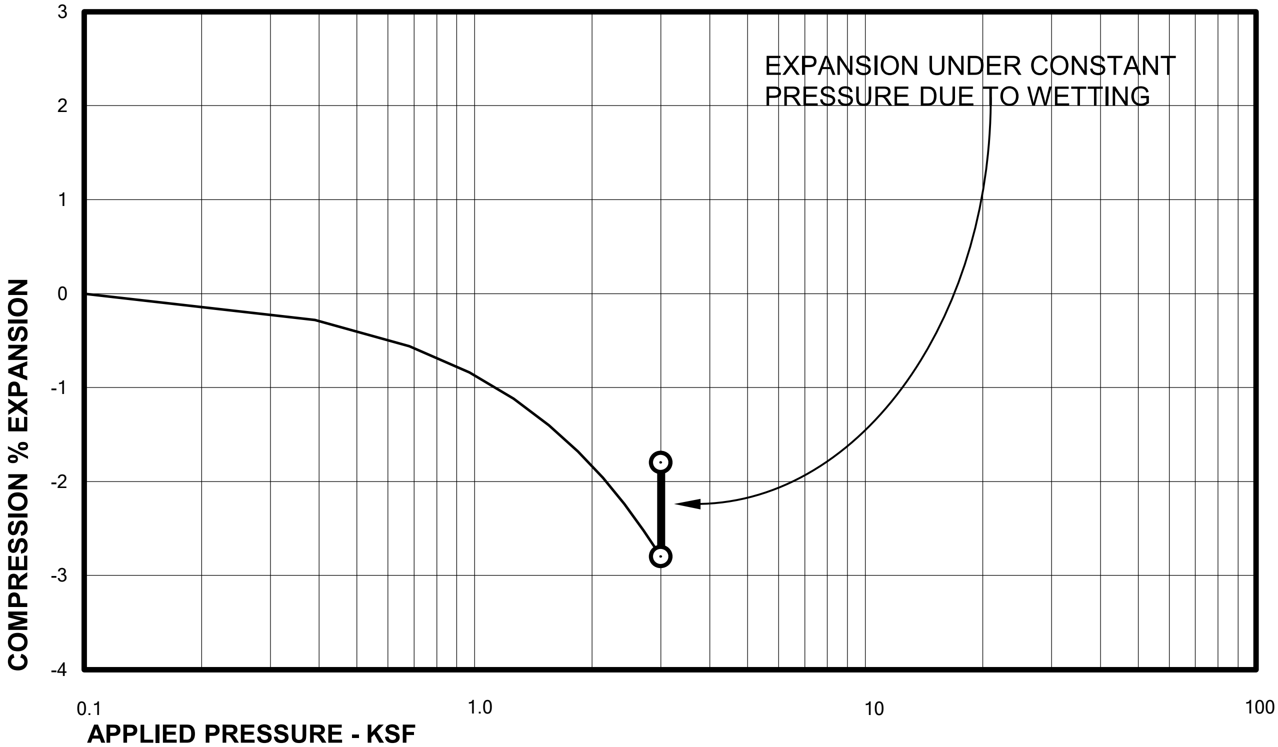
DRY UNIT WEIGHT= 91 PCF

MOISTURE CONTENT= 23.8 %

Swell Consolidation Test Results

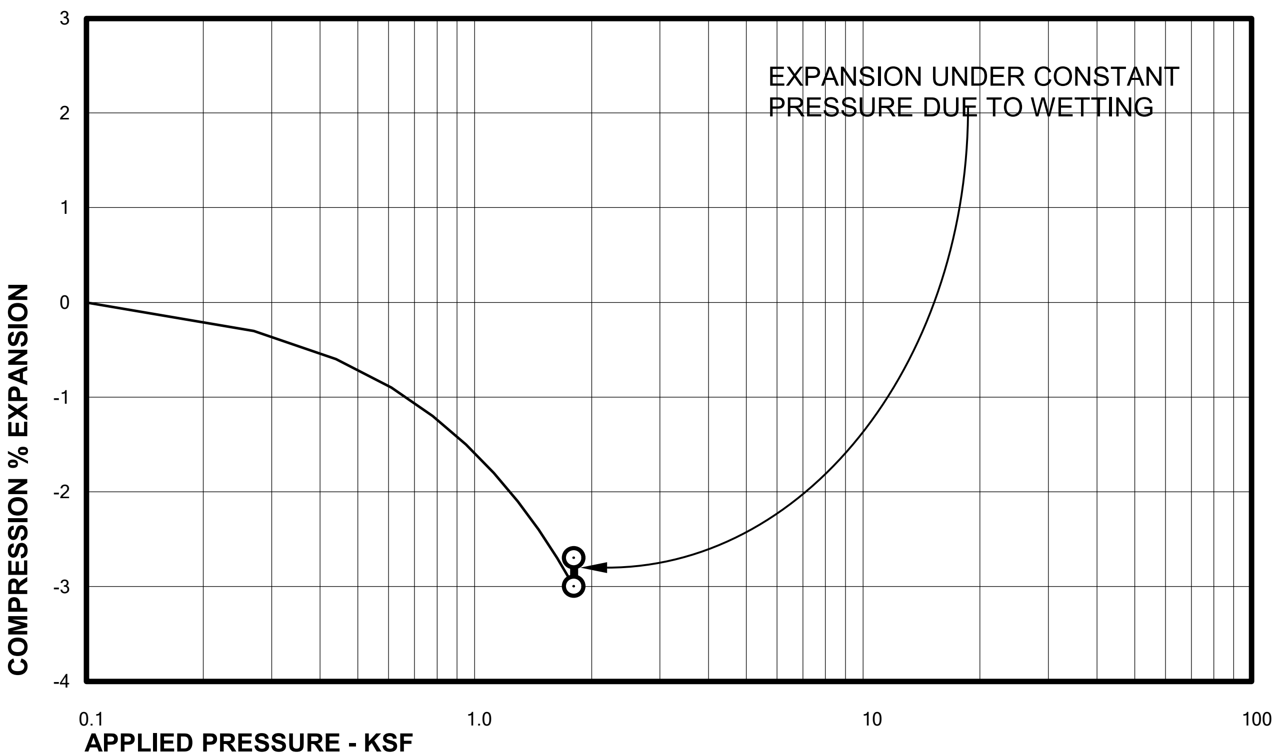
FIG. B-19

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1



Sample of WEATHERED CLAYSTONE
From LOTS 15/16 AT 14 FEET

DRY UNIT WEIGHT= 98 PCF
MOISTURE CONTENT= 26.1 %



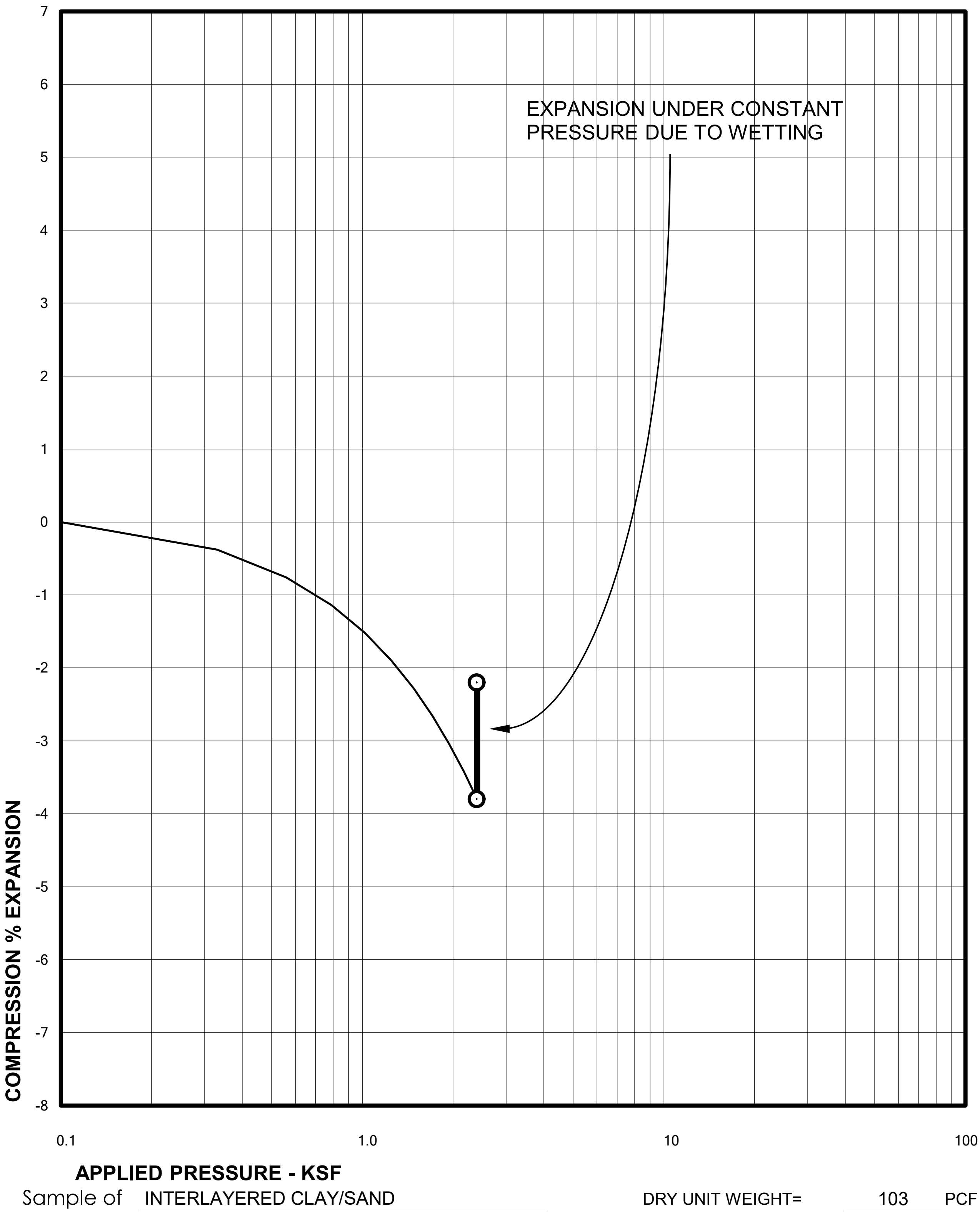
Sample of CLAY, SANDY (CL)
From LOTS 17/18 AT 4 FEET

DRY UNIT WEIGHT= 103 PCF
MOISTURE CONTENT= 21.9 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-20



Sample of INTERLAYERED CLAY/SAND

From LOTS 17/18 AT 9 FEET

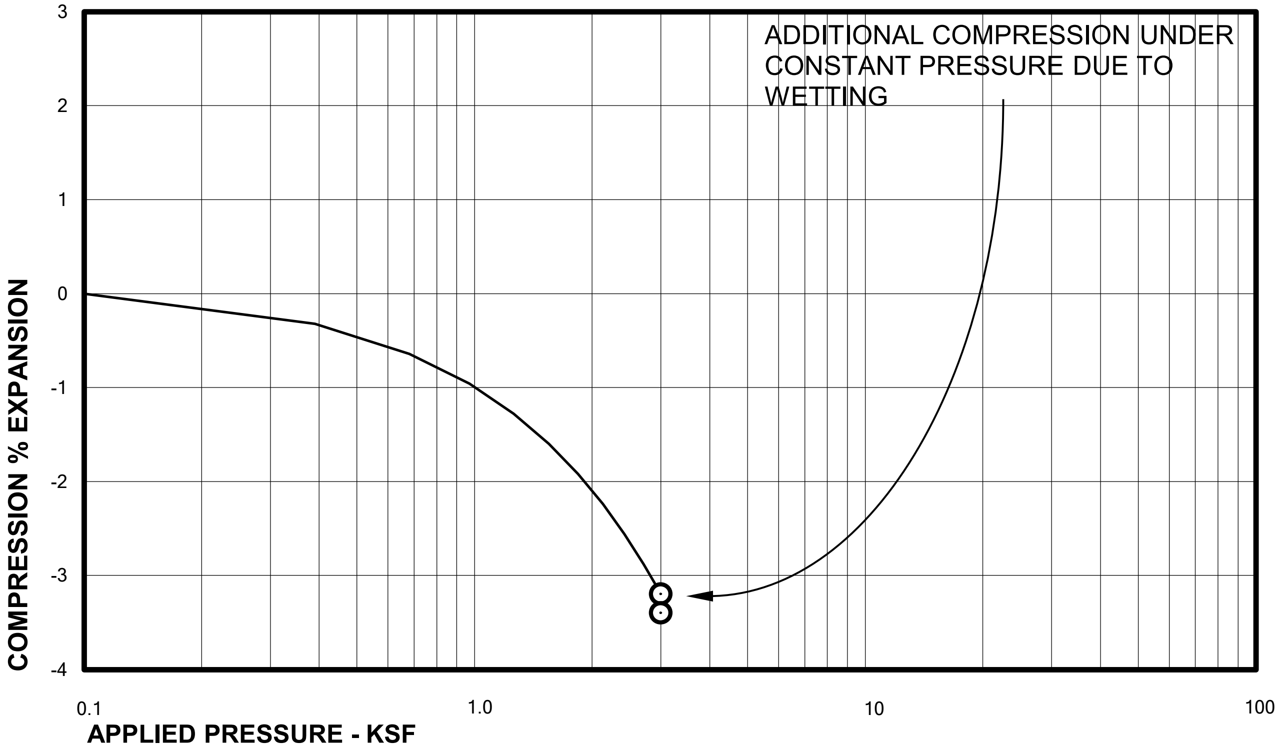
DRY UNIT WEIGHT= 103 PCF

MOISTURE CONTENT= 21.9 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-21

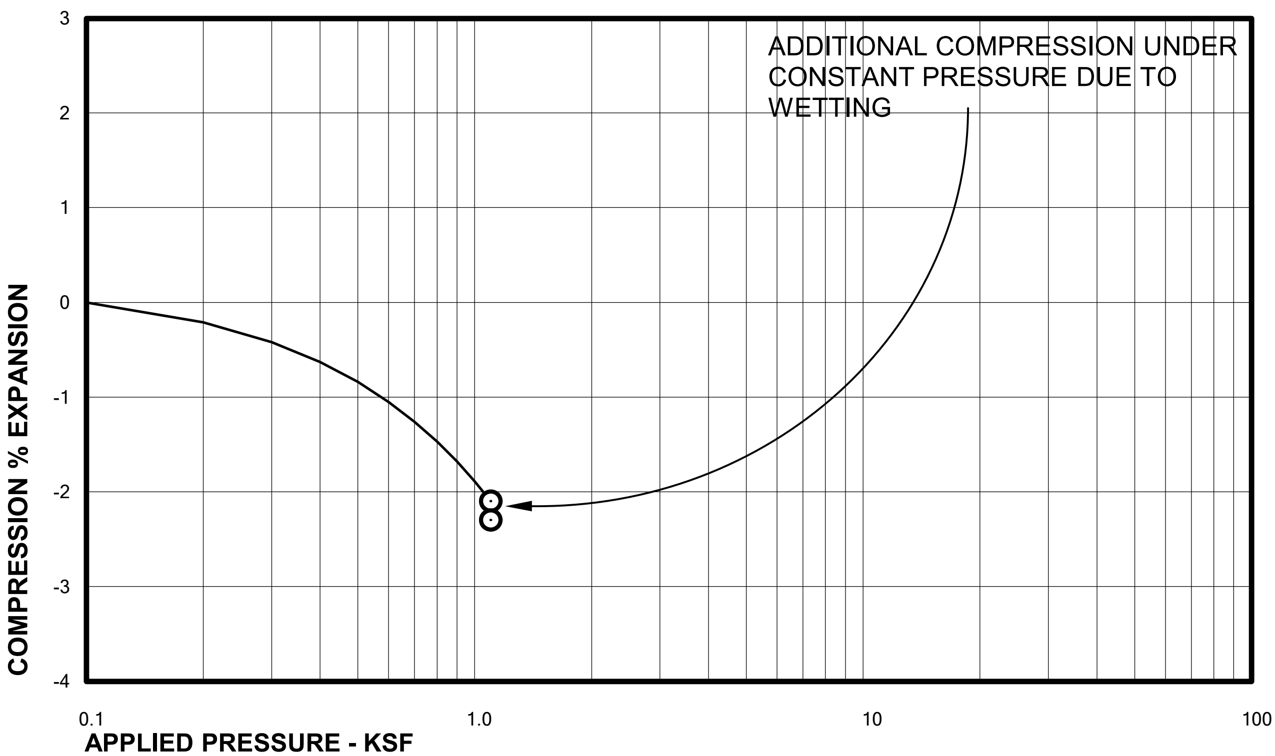


Sample of CLAYSTONE

From LOTS 17/18 AT 19 FEET

DRY UNIT WEIGHT= 101 PCF

MOISTURE CONTENT= 21.7 %



Sample of CLAY, SANDY (CL)

From LOTS 19/20 AT 4 FEET

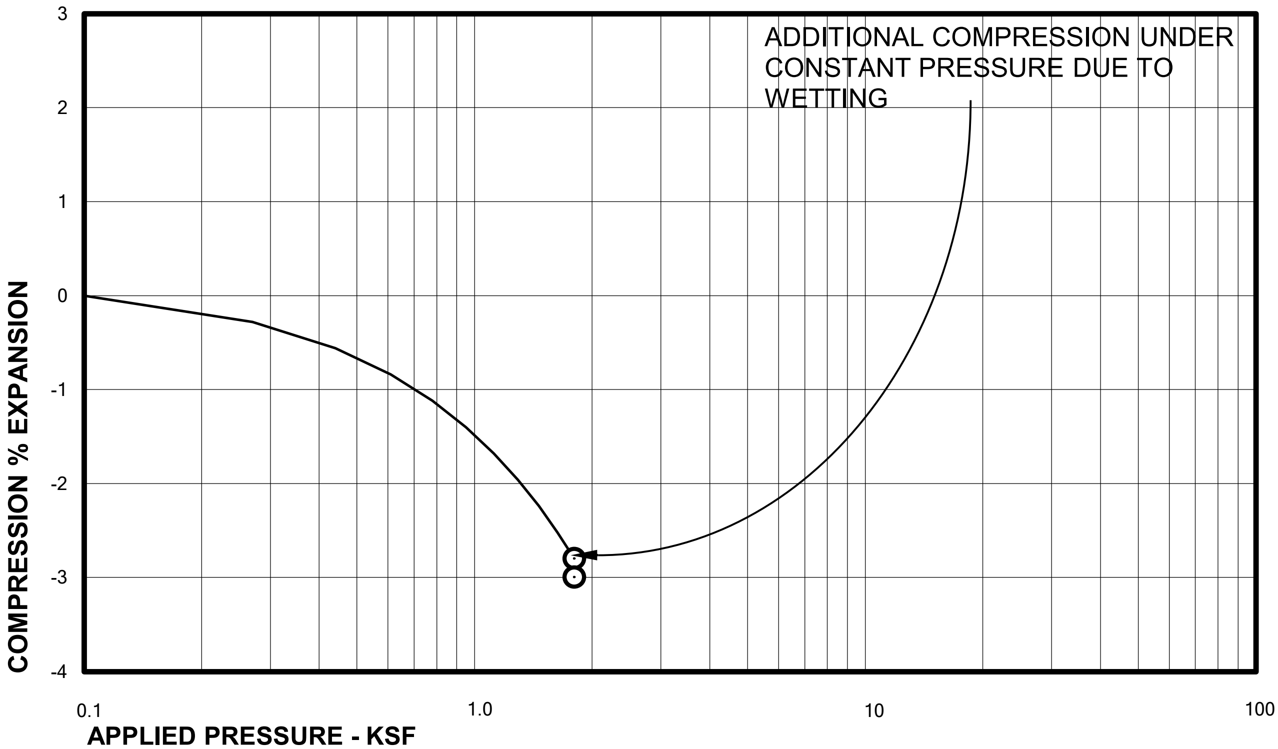
DRY UNIT WEIGHT= 106 PCF

MOISTURE CONTENT= 18.4 %

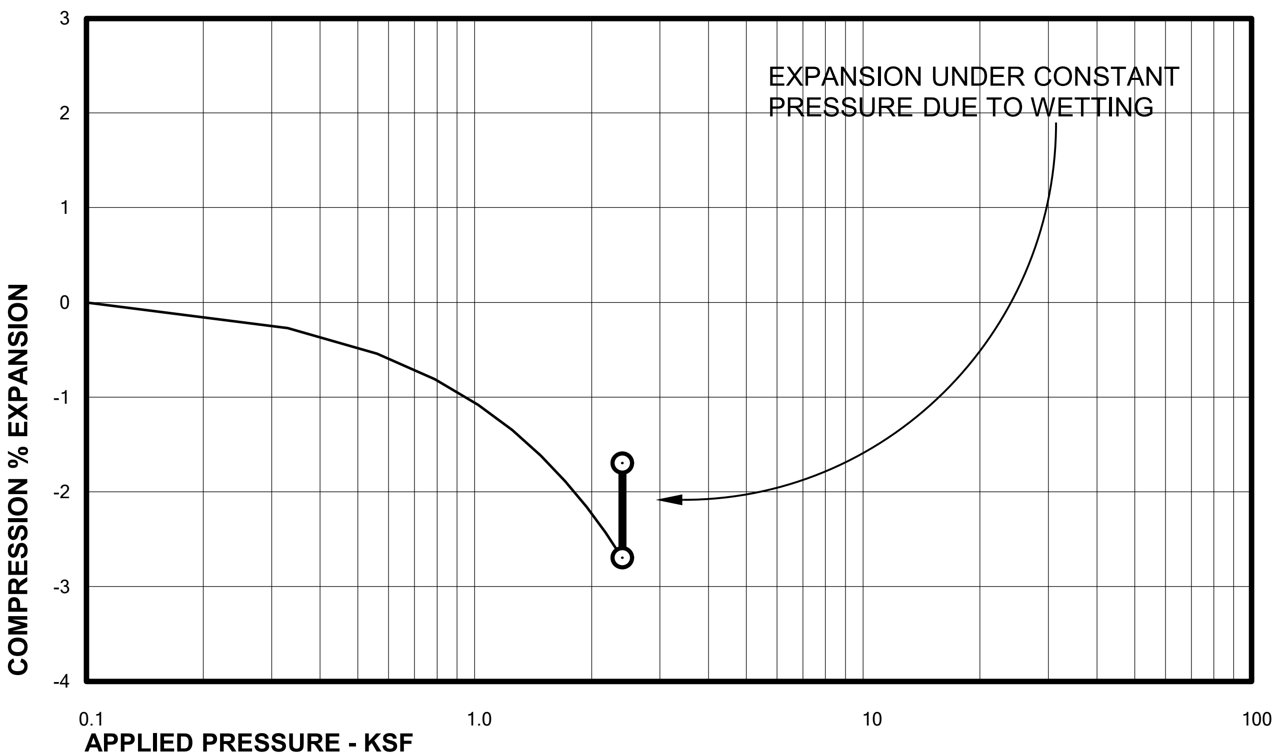
SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-22



Sample of	INTERLAYERED CLAY/SAND	DRY UNIT WEIGHT=	99	PCF
From	LOTS 19/20 AT 9 FEET	MOISTURE CONTENT=	20.8	%

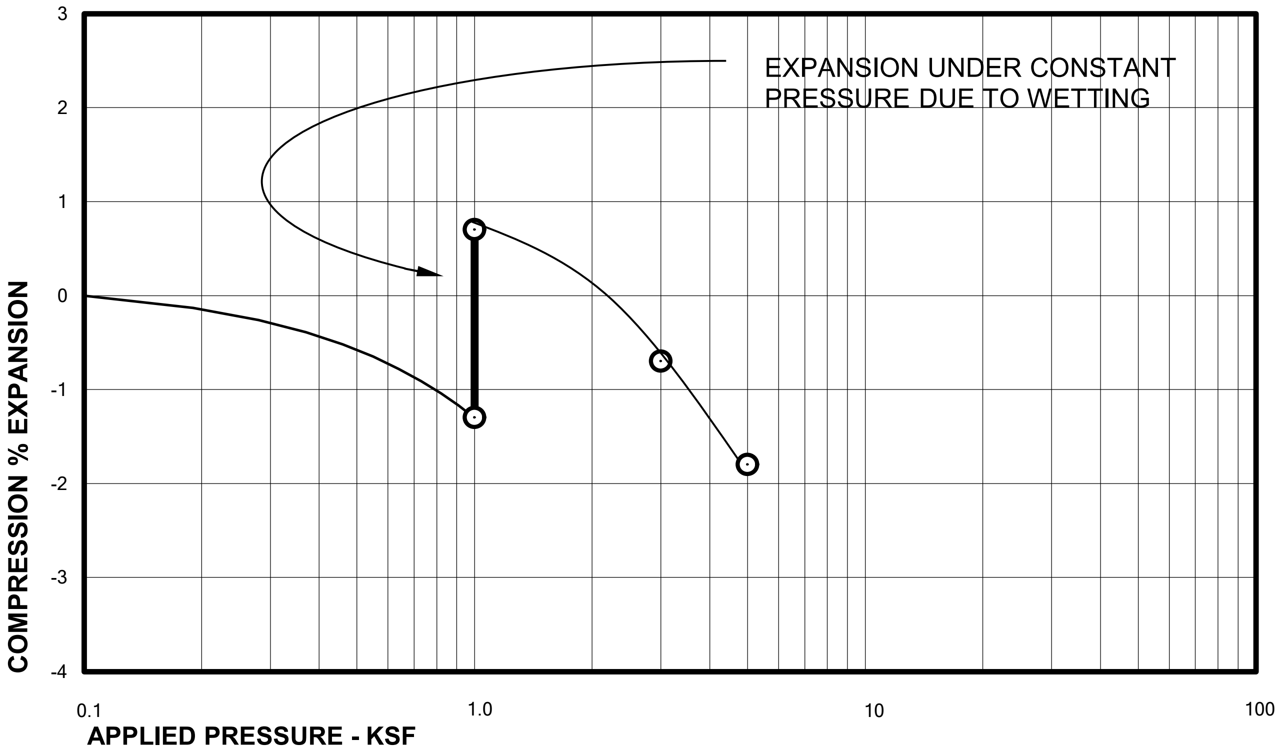


Sample of	WEATHERED CLAYSTONE	DRY UNIT WEIGHT=	99	PCF
From	LOTS 19/20 AT 14 FEET	MOISTURE CONTENT=	22.6	%

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-23

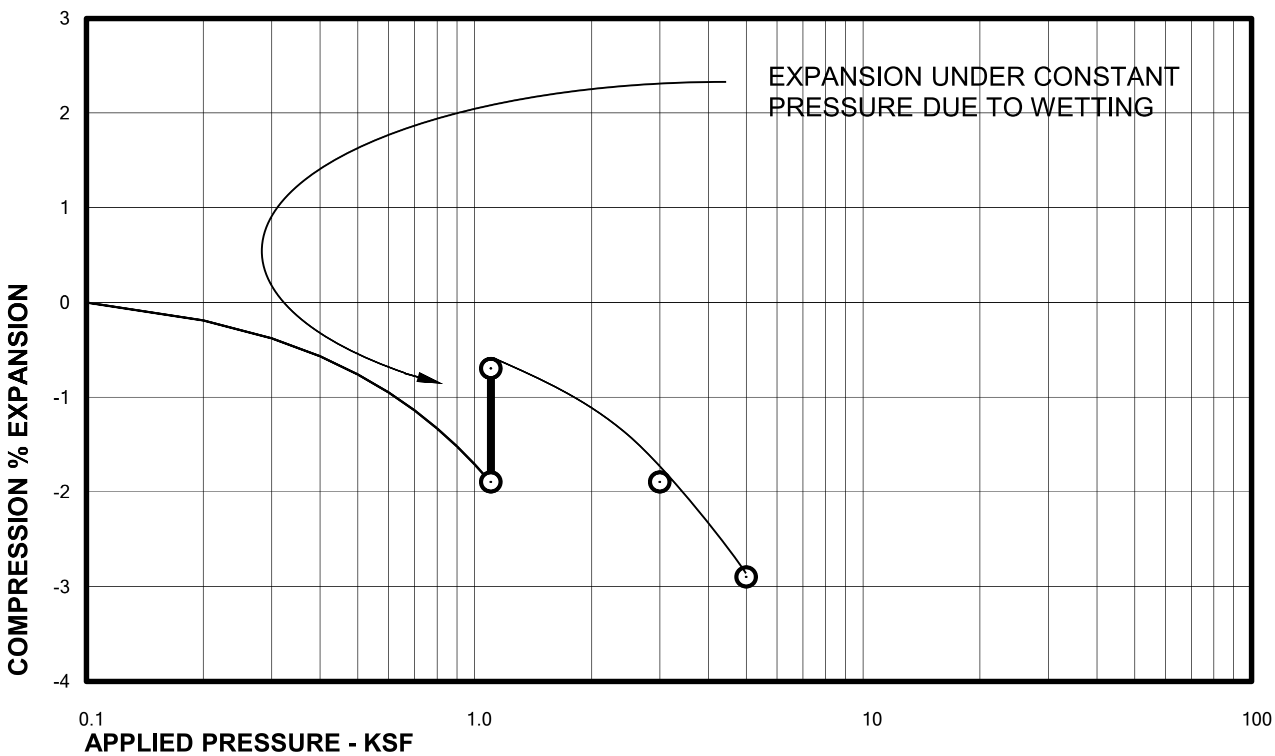


Sample of CLAY, SANDY (CL)

From LOTS 21/22 AT 4 FEET

DRY UNIT WEIGHT= 112 PCF

MOISTURE CONTENT= 12.4 %



Sample of WEATHERED CLAYSTONE

From LOTS 21/22 AT 9 FEET

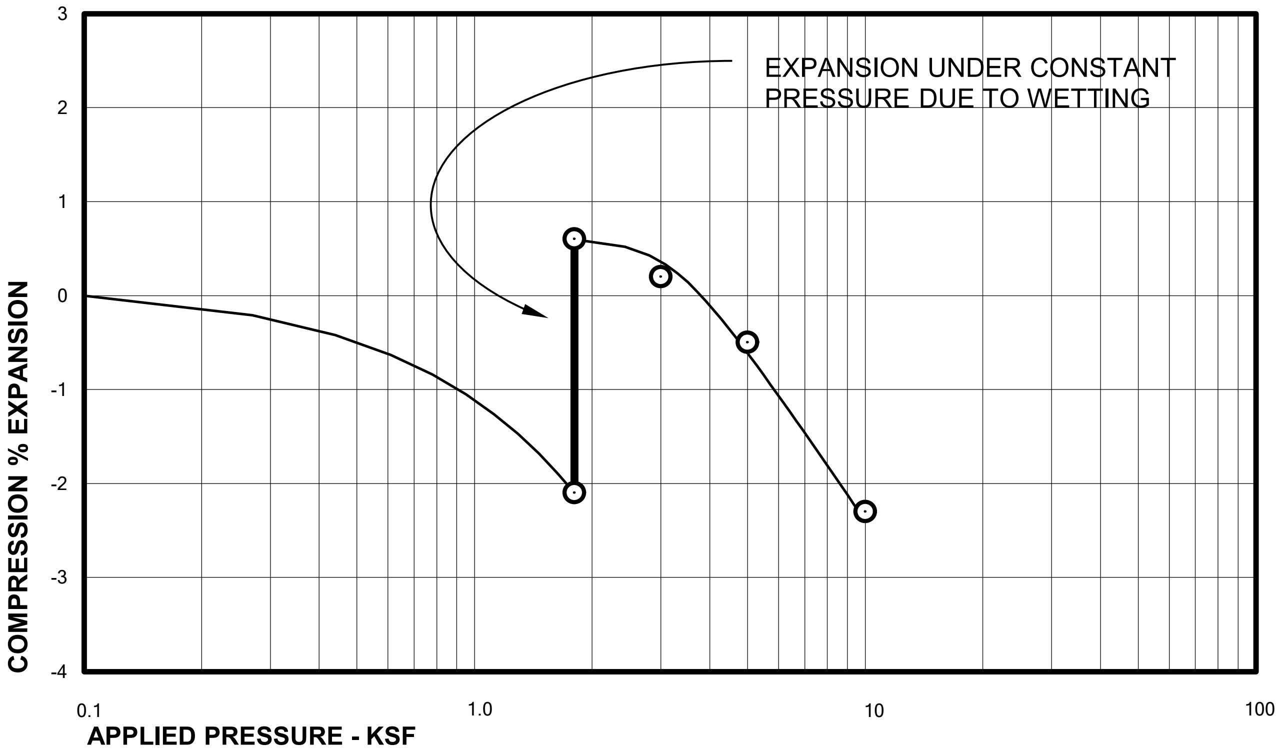
DRY UNIT WEIGHT= 102 PCF

MOISTURE CONTENT= 23.3 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

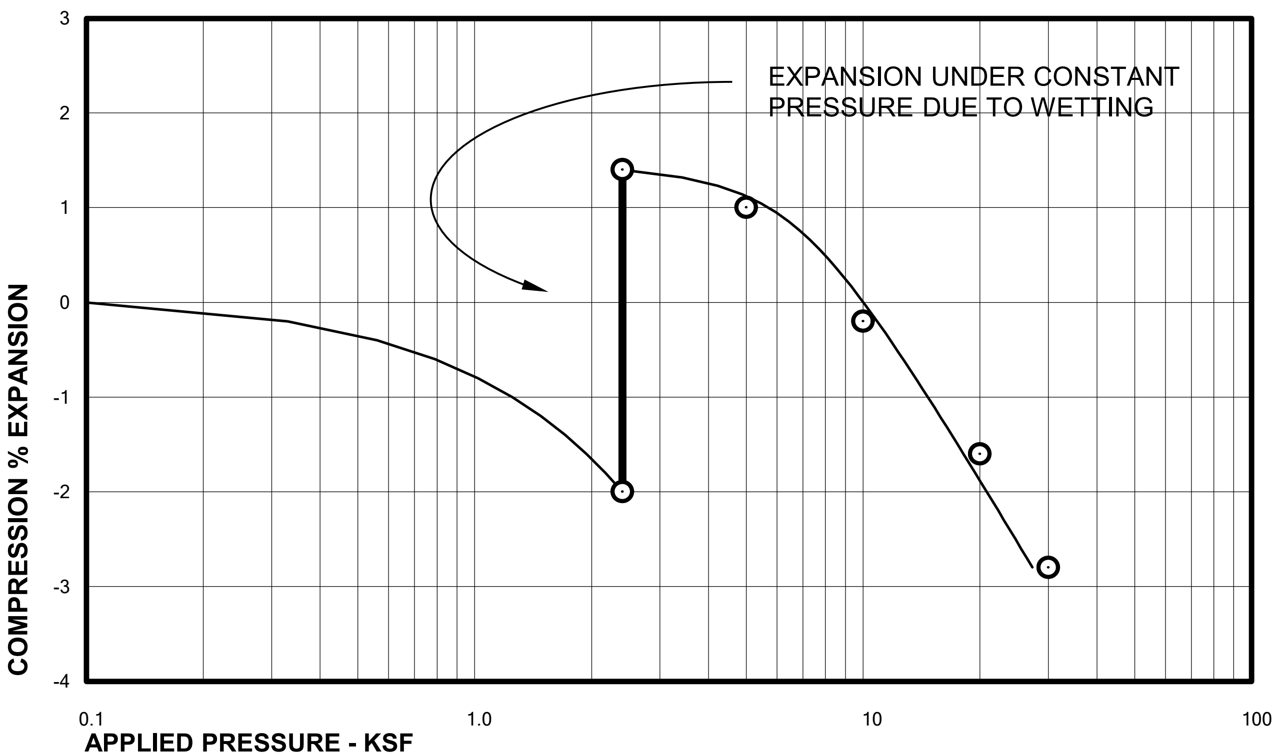
Swell Consolidation Test Results

FIG. B-24



Sample of WEATHERED CLAYSTONE
From LOTS 21/22 AT 14 FEET

DRY UNIT WEIGHT= 105 PCF
MOISTURE CONTENT= 21.6 %



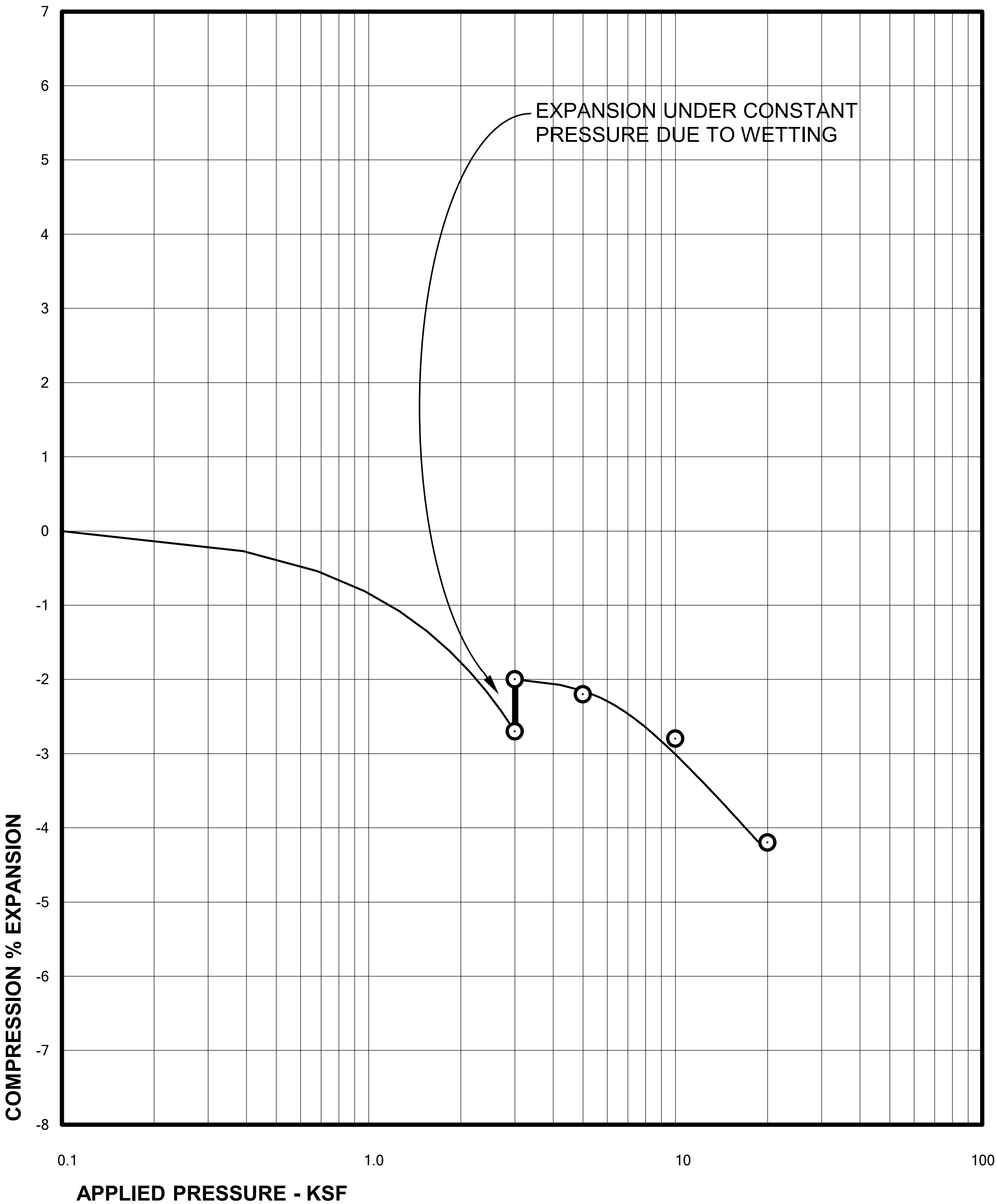
Sample of CLAYSTONE
From LOTS 21/22 AT 19 FEET

DRY UNIT WEIGHT= 106 PCF
MOISTURE CONTENT= 21.0 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-25

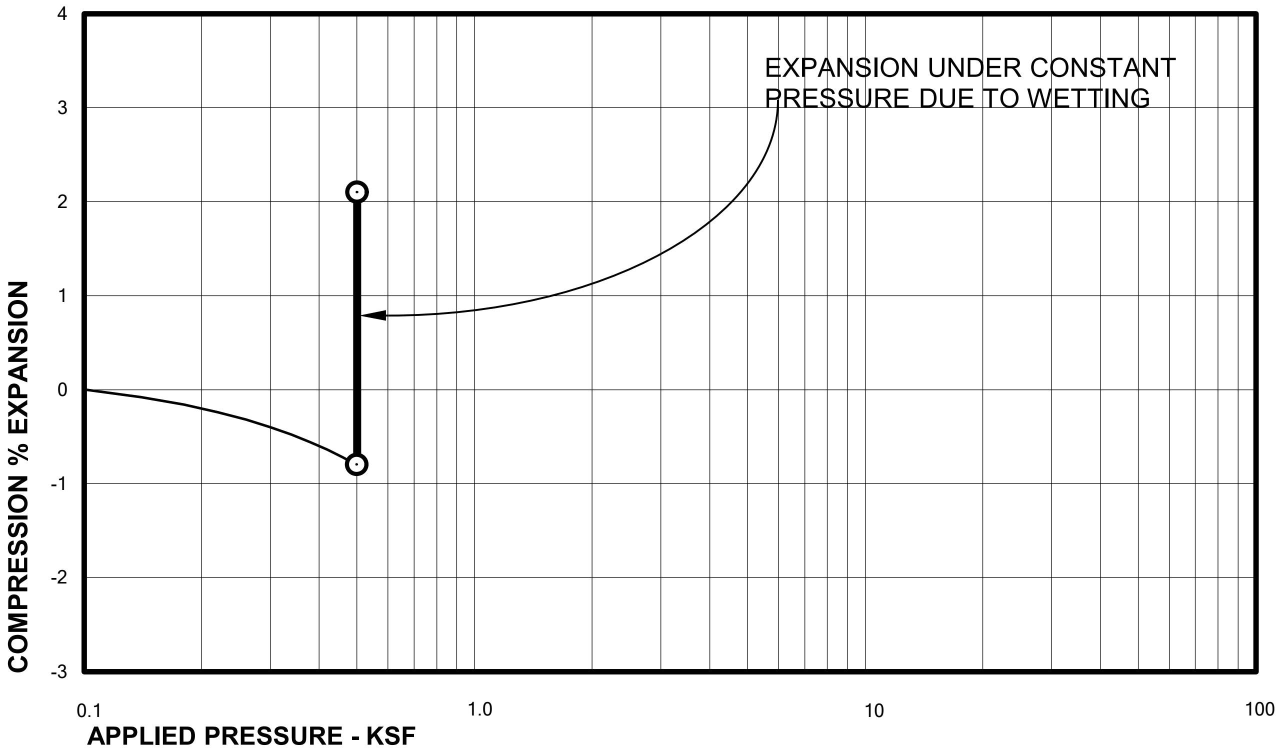


Sample of	CLAYSTONE	DRY UNIT WEIGHT=	108	PCF
From	LOTS 21/22 AT 24 FEET	MOISTURE CONTENT=	19.5	%

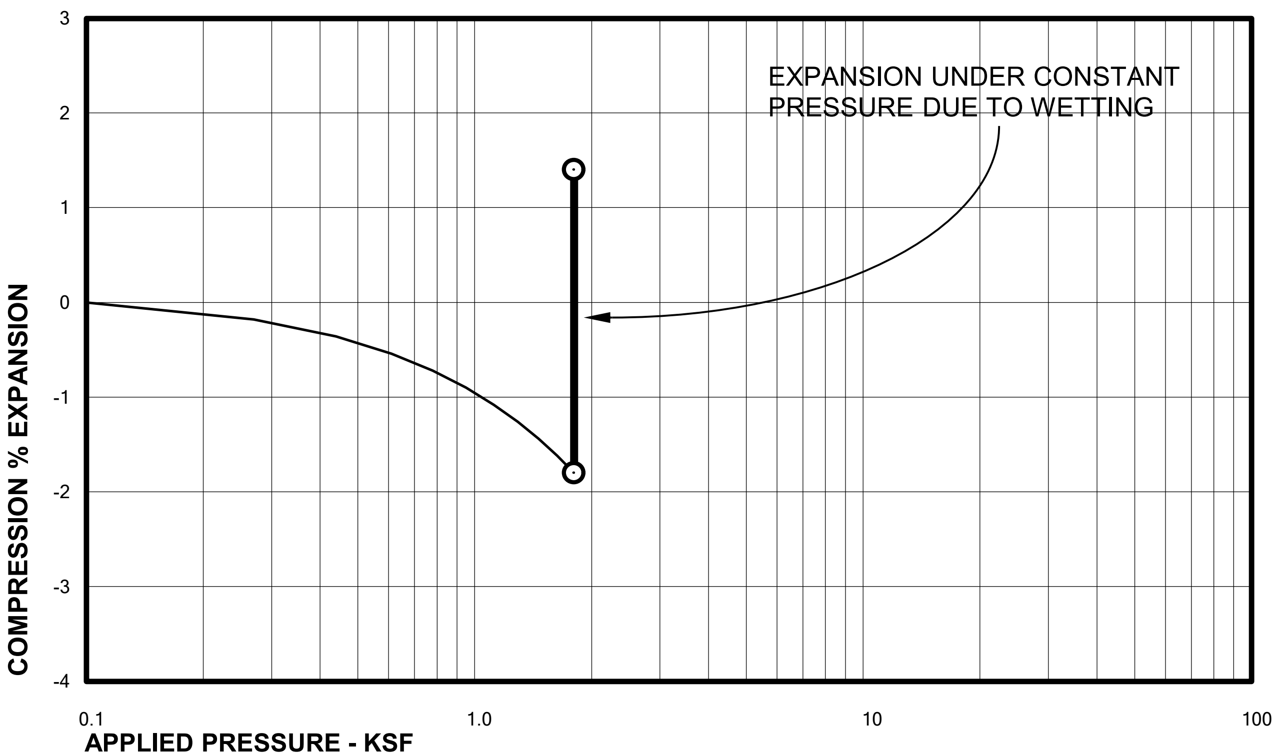
Swell Consolidation Test Results

FIG. B-26

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1



Sample of CLAY, SANDY (CL) DRY UNIT WEIGHT= 108 PCF
From LOTS 23/24 AT 4 FEET MOISTURE CONTENT= 18.2 %



Sample of WEATHERED CLAYSTONE DRY UNIT WEIGHT= 100 PCF
From LOTS 23/24 AT 14 FEET MOISTURE CONTENT= 24.1 %

SUNRISE VILLAGE, LLC
SUNRISE VILLAGE
CTL|T PROJECT NO. DN49,355.001-120-R1

Swell Consolidation Test Results

FIG. B-27

TABLE B - I

SUMMARY OF LABORATORY TEST RESULTS

LOTS	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	SWELL TEST DATA: SWELL (%)	COMPRESSION (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)	SOIL SUCTION VALUE (pF)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTICITY INDEX	SOLUBLE SULFATE CONTENT (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
1/2	4	18.2	104	1.0		500					<0.01		CLAY, SANDY (CL)
1/2	9	30.2	92	1.1		1,100						82	WEATHERED CLAYSTONE
1/2	14	22.5	104	0.5		1,800							INTERBEDDED CLAYSTONE/SANDSTONE
1/2	19	20.7	107									54	INTERBEDDED CLAYSTONE/SANDSTONE
3/4	4	21.3	100		0.2	500			45	27		58	CLAY, SANDY (CL)
3/4	9	31.5	88	0.4		1,100							WEATHERED CLAYSTONE
3/4	14	19.6	108	0.2		1,800							INTERBEDDED CLAYSTONE/SANDSTONE
5/6	4	24.6	89		0.1	500							CLAY, SANDY (CL)
5/6	9	24.1	99	0.3		1,100						57	INTERLAYERED CLAY/SAND
5/6	14	24.7	97		0.4	1,800							INTERBEDDED CLAYSTONE/SANDSTONE
7/8	4	32.1	88		0.1	500		3.05					CLAY, SANDY (CL)
7/8	9	19.6	103	2.0		1,100	4,300	3.56					CLAY, SANDY (CL)
7/8	14	20.3	106	0.4		1,800	3,000	3.82					INTERBEDDED CLAYSTONE/SANDSTONE
7/8	19	29.6	96	1.9		2,400		3.87					CLAYSTONE
7/8	24	25.4	97	1.9		3,000	10,000	4.07					CLAYSTONE
7/8	29	19.6	114	2.0		3,600	14000	4.04					CLAYSTONE
9/10	4	23.2	99	0.8		1,100						63	CLAY, SANDY (CL)
9/10	9	20.9	107	0.5		1,800							INTERBEDDED CLAYSTONE/SANDSTONE
9/10	14	16.0	114									42	INTERBEDDED CLAYSTONE/SANDSTONE
11/12	4	19.6	95		0.1	1,100					0.04		CLAY, SANDY (CL)
11/12	9	19.1	105		0.2	1,800						45	INTERBEDDED CLAYSTONE/SANDSTONE
11/12	14	16.2	108	2.0		2,400			50	25		39	INTERBEDDED CLAYSTONE/SANDSTONE
13/14	4	11.0	116	1.5		1,800	5,900	4.60					CLAY, SANDY (CL)
13/14	9	20.9	102	2.0		2,400	8,000	4.01					CLAYSTONE
13/14	14	18.5	104		0.2	3,000		3.76					INTERBEDDED CLAYSTONE/SANDSTONE
13/14	19	24.0	100	1.5		3,600		4.03					CLAYSTONE
13/14	24	15.2	117	0.1		4,300		3.81					CLAYSTONE
15/16	4	22.7	87		1.1	1,800			64	45		71	CLAY, SANDY (CL)
15/16	9	23.8	91		1.6	2,400						40	INTERLAYERED CLAY/SAND
15/16	14	26.1	98	1.0		3,000							WEATHERED CLAYSTONE
17/18	4	21.9	103	0.3		1,800					0.04		CLAY, SANDY (CL)
17/18	9	21.9	103	1.6		2,400			50	31		69	INTERLAYERED CLAY/SAND
17/18	19	21.7	101		0.2	3,000							CLAYSTONE
19/20	4	18.4	106		0.2	1,100							CLAY, SANDY (CL)
19/20	9	20.8	99		0.2	1,800							INTERLAYERED CLAY/SAND
19/20	14	22.6	99	1.0		2,400						79	WEATHERED CLAYSTONE
21/22	4	12.4	112	2.0		1,000	3,900	4.25					CLAY, SANDY (CL)
21/22	9	23.3	102	1.2		1,100	3,000	3.65					WEATHERED CLAYSTONE
21/22	14	21.6	105	2.7		1,800	9,000	3.84					WEATHERED CLAYSTONE
21/22	19	21.0	106	3.4		2,400	20,000	4.08					CLAYSTONE
21/22	24	19.5	108	0.7		3,000	8,900	3.98					CLAYSTONE
23/24	4	18.2	108	2.9		500					0.18		CLAY, SANDY (CL)
23/24	9	13.2	112									24	SAND, CLAYEY (SC)
23/24	14	24.1	100	3.2		1,800							WEATHERED CLAYSTONE

APPENDIX C

GUIDELINE SITE GRADING SPECIFICATIONS
Sunrise Village
Arvada, Colorado

GUIDELINE SITE GRADING SPECIFICATIONS

Sunrise Village
Arvada, 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 overlot 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 Representative shall be the Owner's representative. The Soils Representative 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. 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.

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 (1 to 4 percent above optimum moisture content for clay and within 2 percent of optimum moisture content for sand) and compacted to not less than 95 percent of maximum dry density as determined in accordance with ASTM D 698.

5. 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. Claystone bedrock should be broken down to three (3) inches or smaller in size. 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.

6. MOISTURE CONTENT

Fill material classifying as CH and CL shall be moisture conditioned to between 1 to 4 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 Representative, 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 Representative, 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.

7. 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 Representative, 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 for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other approved equipment. 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.

8. 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 not 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).

9. 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.

10. DENSITY TESTS

Field density tests shall be made by the Soils Representative 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.

11. 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 Representative indicates that the moisture content and density of previously placed materials are as specified.

12. NOTICE REGARDING START OF GRADING

The Contractor shall submit notification to the Soils Representative 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.

13. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Representative, 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.

14. 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.