Geotechnical Site Development Study
Colliers Hill, Filing 4G
Erie, Colorado

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ATTACHMENTS

1.0 EXECUTIVE SUMMARY

A. G. Wassenaar, Inc. (AGW) completed the geotechnical site development study for the proposed residential development. The data collected during our field exploration and laboratory work and our analysis, opinions, and conclusions are presented. The purpose of our study is to provide design recommendations for planning and site development and preliminary design concepts for foundation systems, interior floor support, and streets.

The subsurface materials encountered in our test borings consist of topsoil, clay, and sand overlying sedimentary bedrock. Claystone and/or sandstone bedrock was encountered at depths ranging from 1 to 17½ feet. Ground water was encountered at depths ranging from 11 to 28½ feet.

Site development considerations should include provisions for the presence of expansive clays and shallow claystone bedrock, isolated locations of shallow ground water, lignite, and coal mines.

Based upon the results of this preliminary study, if the site is overexcavated, it is likely that most of the structures could be founded on spread or pad-type footings bearing on moisture treated fill below frost depth. Preliminary foundation design concepts are presented in the report.

Floors and flatwork being considered for construction on-grade will require a specific risk analysis by the Client because of the potential for movement of the soils encountered. Slabs supported by soil will be subject to movement. Options for floor support are discussed in the report. Foundation subsurface drainage systems will be necessary for all below grade areas. Extensive drain systems will be required when foundations are within 4 feet of ground water.

Water soluble sulfate test results indicate that site and foundation concrete should be designed for very severe sulfate exposure. Preliminary pavement and other geotechnical-related recommendations are presented in the following report. We encourage the Client to read this report in its entirety and not to solely rely on the cursory information contained in this summary.

2.0 PURPOSE

This report presents the results of a geotechnical site development study for the proposed residential development to be located southwest of Weld County Road 10 and Weld County Road 5 in Erie, Colorado. The study was conducted to determine geotechnical design criteria for planning, site evaluation, and development considerations. Preliminary geotechnical design concepts are also presented for foundations, interior floor support, foundation drainage, and street construction. Factual data gathered during the field and laboratory work are summarized on Figures 1 through 7 and in Appendix A. Our opinions and recommendations presented in this report are based on the data generated during the field exploration, laboratory testing, and our experience with similar type projects. This study was performed in general conformance with our Proposal Number 202523, dated April 8, 2020. This report is not intended to provide design criteria for individual foundations or street construction. Additional geotechnical studies will be required to develop these types of final design criteria and construction recommendations.

3.0 PROPOSED CONSTRUCTION

We understand the proposed 204-lot development will include single-family residences and the associated utility and roadway infrastructure. Basements or crawl spaces are planned. The Client prefers to develop the site to avoid, if possible, the use of drilled piers and interior structural floors. Based on the "Colliers Hill Filing 4G – Erie, CO Construction Plans, Grading Plan", Sheets 8 through 11, prepared by Hurst & Associates, Inc. on November 6, 2020, Job Number 2527-2, the maximum cut depth at our test boring locations is 6 feet and the maximum fill depth at our test boring locations is 5 feet. Should the grading plans change, the contents of this report must be reviewed by AGW.

4.0 SITE CONDITIONS

The site is vacant with vegetation consisting of bushes and native grasses. A vacant parcel and Weld County Road 10 are located to the north, Weld County Road 5 and a vacant parcel are located to the east, and residential subdivisions under construction are located to the west and south. The ground surface slopes gently downward to the southwest. A natural drainage runs from the southwest corner of the site towards the northeast. No bedrock outcrops were observed on the site.

5.0 FIELD EXPLORATION

Subsurface conditions were explored by drilling 26 test borings at the approximate locations indicated on Figure 1. The borings were advanced using a 4-inch diameter, continuous flight auger powered by a truck-mounted drill rig. At frequent intervals, samples of the subsurface materials were obtained using a Modified California sampler which was driven into the soil by dropping a 140-pound hammer through a free fall of 30 inches. The Modified California sampler is a 2.5-inch outside diameter by 2-inch inside diameter device. The number of blows required for the sampler to penetrate 12 inches and/or the number of inches that the sampler is driven by 50 blows gives an indication of the consistency or relative density of the soils and bedrock materials encountered. Results of the penetration tests and locations of sampling are presented on the "Test Boring Logs", Figures 2 through 7. Ground water measurements were made at the time of drilling and subsequent to drilling.

6.0 LABORATORY TESTING

The samples obtained during drilling were returned to the laboratory where they were visually classified by a geotechnical engineer. Laboratory testing was then assigned to specific samples to evaluate their engineering properties. The laboratory tests included swell-consolidation tests to evaluate the effect of wetting and loading on the selected samples. Gradation analysis and Atterberg limits tests were conducted to evaluate grain size distribution and plasticity. A standard Proctor test, gradation, and Atterberg tests were performed on a blended bulk sample of the soils anticipated to be used as fill. In addition, representative samples were tested for unconfined compressive strength, water soluble sulfates, pH, resistivity, and chlorides. The test results are summarized on Figures 2 through 7 and in Appendix A.

7.0 SUBSURFACE CONDITIONS

The subsurface materials encountered in our test borings consist of topsoil, clay, and sand overlying sedimentary bedrock. Claystone and/or sandstone bedrock was encountered at depths ranging from 1 to 17½ feet. Ground water was encountered at depths ranging from 11 to 28½ feet. A more complete description of the subsurface conditions is shown on Figures 2 through 7.

7.1 Natural Soil

Topsoil was encountered in all 26 test borings. The topsoil consisted of sandy clay up to 1-foot thick. It was organic, moist, and dark brown.

Clay was encountered in 24 of the 26 test borings. The clay was medium stiff to very stiff, silty, slightly sandy to sandy, with sand lenses, slightly moist to very moist, and brown. The clay has high to very high expansion potential and low consolidation potential.

Sand was encountered in three of the 26 test borings. The sand was medium dense, silty, clayey to very clayey, slightly moist to moist, and brown to light brown. The sand has low expansion and settlement potential.

7.2 Bedrock

Claystone bedrock was encountered in all 26 test borings at depths ranging from 1 to 24 feet. The claystone was firm to very hard, silty, slightly sandy to sandy, with trace gravel to slightly gravelly, iron stained, with sandstone lenses, slightly moist to very moist, and olive to rust to gray. Lignite lenses, between 2 and 5 feet thick, were encountered in the claystone bedrock in four of the 26 test borings at depths ranging from 11 to 24 feet. The claystone has high to very high expansion potential.

Sandstone bedrock was encountered in seven of the 26 test borings at depths ranging from 8 to 28 feet. The sandstone was medium hard to very hard, poorly cemented, silty, very clayey, slightly gravelly, with claystone lenses, moist to wet, and brown to rust to gray to olive. The sandstone has low expansion potential.

Interbedded claystone and sandstone bedrock was encountered in two of the 26 test borings at depths of 6 and 32 feet. The bedrock was hard to very hard, silty, moist, and brown to rust to gray to olive. The interbedded claystone and sandstone has moderate to high expansion potential. Estimated depth and elevation of bedrock are shown on Figures 8 and 9.

7.3 Groundwater

Ground water was encountered in two of the 26 test borings at depths of 18 and 28½ feet at the time of drilling. When we returned five days after drilling, ground water was encountered in five of the 26 test borings at depths ranging from 11 to 27½ feet. Two test borings caved at depths of 22 and 28 feet and two test borings were destroyed when checked five days after drilling. Ground water levels fluctuate with changing seasons and irrigation patterns and are expected to rise after construction is complete and landscape irrigation commences.

8.0 GEOTECHNICAL CONCERNS

8.1 Expansive Soils and Bedrock

Clay and claystone bedrock with high to very high expansion potential were encountered across the site. We believe that the structures will be constructed near expansive materials should traditional methods of grading be employed. Overexcavation and placement of a moisture treated fill to reduce swell potential may be considered. This may allow for shallow foundations and slab-on-grade construction.

8.2 Shallow Ground Water

Ground water was encountered at depths less than 15 feet in portions of the site. Ground water less than 15 feet below the site grading elevation will likely affect utility construction and some site grading operations. Ground water less than 10 feet below the site grading elevation will likely affect foundation excavations. In addition, ground water less than 5 feet below the existing or final ground surface will pose stabilization problems during site grading, foundation construction, and may cause problems during pavement construction. We recommend that foundations be constructed at least 4 feet above ground water level to reduce the potential for future water problems.

Site development should be planned to avoid or manage the ground water. Avoidance may entail raising the site grades to provide sufficient distance between the bottom of foundations and the ground water, allowing only at-grade construction (no basements) or other methods. Removing the ground water may entail the construction of drain systems and/or barriers that draw the ground water down sufficiently to allow below grade construction.

8.3 Lignite and Coal Mines

Lignite lenses were encountered in the claystone bedrock in four of the 26 test borings at depths ranging from 11 to 24 feet. The lignite lenses were between 2 and 5 feet thick. Lignite is a soft coal which is commonly found within the bedrock formation which underlies this site. It can be found in thin layers within claystone or in layers that are very soft and wet to relatively hard and dry. Our experience in areas underlain by this bedrock formation indicates that the presence and amount of lignite in the bedrock can be very erratic in consistency and distribution, exhibiting itself in a random manner across the site. It may also carry ground water. Lignite may be encountered during site grading and in utility excavations. Difficulty may be experienced during excavations of the utility trenches, especially if ground water is encountered. Additionally, placement of excavated lignite during the site grading process will require close monitoring and may require placement in non-structural areas or exporting from the site.

It is our understanding that this site is identified as being underlain by abandoned coal mines on the "Statewide Historic Underground Coal Mine Extents and Reported Coal Mine-Related Subsidence Events Map" available on the Colorado Geological Survey's website. On October 14, 2010, CTL|T issued "Subsidence Investigation, Bridgewater, Weld County Roads 8 and 5, Erie Colorado", CTL|T Project No. CT15,114-130. Colliers Hill, Filing 4G was included in this study.

9.0 SITE DEVELOPMENT

9.1 Overlot Grading

We understand the fill materials to be used at the site will be from on-site cut areas. In general, suitable inorganic on-site or off-site soils may be used for structural fill. Topsoil, soil containing significant vegetation, organic debris or other deleterious material should be excavated and removed from the structural areas. Off-site material considered for new fill should be evaluated by AGW prior to importing to the site. Construction of the fill embankments throughout the site should consist of proper foundation preparation, constructing embankment benching where necessary, disposition of strippings, proper fill placement and compaction, and designing slopes in accordance with the recommendations provided in this report and the applicable governing regulations. The following are general site grading recommendations:

1. It is recommended that AGW be retained on an essentially full-time basis to observe and test the fill placement. AGW should also be retained to provide observations and/or testing of the other items discussed below. The purpose of this observation and testing is to provide the Client with a greater degree of confidence that the work is being performed within the recommendations of this geotechnical study and the project specifications.
2. All topsoil and vegetation should be stripped and removed prior to fill placement. The vegetation, organic soils, or topsoil should be wasted from the site, placed in non-structural areas (e.g., parks, landscaping, tracts, etc.) and/or stockpiled for future use in revegetating the surface of exposed slopes. In no case should these materials be used in the structural areas or where the stability of slopes will be affected.
3. Drainages should be specifically observed by AGW prior to fill placement. Vegetation found at the base of these areas must be removed. Soft or rutting soils should be removed to firm material or the subgrade stabilized, if necessary. The existing drainages tend to collect subsurface water after fill has been placed. Where the grading fill is more than 12 feet deep, a blanket or "burrito" drain should be constructed along the flow line of the drainages to a gravity daylight outfall.
4. Where the existing slopes are steeper than a 5:1 (horizontal:vertical), benching will be required for structural integrity of any fills (see Figure 10).
5. The stripped foundation areas should be observed by AGW prior to fill placement. Any soft soils found in these areas must be removed or stabilized as necessary prior to fill placement.
6. After the fill areas have been cleared, the exposed soils should be scarified to a minimum depth of 6 inches, brought to the proper moisture content, and then compacted according to Appendix B.
7. Should significant amounts of lignite be excavated by individual scrapers, it should be stockpiled or wasted. Significant layers of lignite must not be constructed within the grading fills.
8. The compaction and moisture content of the soils will be dependent upon material types and the depth and location of placement. The specifications outlined in Appendix B are based upon providing a fill with sufficient shear strength to support structures and sufficient moisture to reduce the potential of swell of the expansive soil used in

the fill. The results of a standard Proctor test performed on a bulk sample of the upper level soils likely to be used for fill is shown on Figure A-39 in Appendix A. These results can be used as guideline for contractors to estimate how much additional moisture may be required to bring the on-site soils to the required moisture content.

9. Particular attention should be paid to compaction of the exterior faces of slopes.
10. Placement and compaction of fill should continue to final overlot grade. We recommend that the lots not be left low or "dished-out" and that placement of fill not stop at foundation elevation.
11. Other specifications outlined in Appendix B should be followed.

9.2 Overexcavation and Placement of Moisture Treated Fill

Based on the expansion potential of the clay and claystone bedrock, we recommend that the site be overexcavated if the use of shallow foundations is desired. Our experience indicates that overexcavation and placement of a moisture treated fill would be most effectively performed using mass grading techniques. The ideal time to do this would be during site development operations. As some overexcavation beneath the roadways will likely be required, it would be advantageous to perform this overexcavation during site grading. The following recommendations should be followed in order to enable the placement of a moisture treated fill that could be used for slab and foundation support. These recommendations may be modified during construction if soil conditions differing from those anticipated are encountered.

1. The expansive clay and claystone bedrock should be excavated to a depth of at least 12 feet below the bottom of basement footings or 14 feet below the bottom of crawl space footings (for crawl space products. The base of the excavation should extend, at a minimum, to a width of at least 5 feet beyond the foundation footprint (including any counterforts, covered porches, patios, decks, etc.). Excavations that do not extend to these minimums risk future foundation performance issues. It may be prudent to extend the base of the excavation to 5 feet outside of the front and rear setbacks in order to accommodate potential changes in structure dimension. Additionally, the street subgrade should be overexcavated as described in "Preliminary Street Pavement Design". The street overexcavation should extend to at least 1 foot beyond back of sidewalk (combination sidewalk) or back of curb (detached sidewalk). The excavation should be sloped following current OSHA regulations. We will not be responsible for testing near excavations that do not meet OSHA regulations. A licensed surveyor must verify the extents of the excavation prior to any fill placement.
2. Water flow into the overexcavation may occur in areas of shallow ground water. We believe that the water can be handled during construction by channeling the water in the excavation(s) and pumping from sumps. It may be prudent to provide permanent drains at the base of the overexcavation in these areas. However, if an outfall for the drains cannot be found, they should not be constructed. The drain(s) should be sloped to a positive gravity outfall. Depending on the location of the inflow, chimney drains may be necessary to convey water from sidewall seepage areas to the drain. The configuration of these drains should be determined at the time of construction.
3. Where soft, rutting soils are found beneath planned fill areas, removal, in-place drying, or stabilization may be necessary. Stabilization prior to fill placement may be

accomplished by placing crushed rock or equivalent material, which should be evaluated by AGW prior to use. The material should be spread across the area and worked into the underlying soft or loose soils with fully-loaded rubber-tired equipment. This procedure should continue until scraper-type equipment can be supported on the rock fill with no significant deflection or rutting. In some instances, a geogrid or geotextile stabilization fabric may be economical for use in conjunction with rock stabilization.

4. Should significant amounts of lignite be excavated by individual scrapers, it should be stockpiled or wasted. Significant layers of lignite must not be constructed within the grading fills.
5. Once the excavation depth and width have been verified, fill placement may begin. The bottom of the excavation should be scarified and moistened prior to fill placement. The fill, consisting of the excavated materials, should be placed in maximum 8-inch loose lifts. Moisture should be added and the lift processed. The use of a construction disc to mix and process each lift is suggested. Mixing should be performed until the moisture content is relatively uniform throughout the lift and the majority of the particles are less than 3 inches in dimension. The fill should then be compacted as described in Appendix B.
6. The results of a standard Proctor test performed on a bulk sample of the upper level soils likely to be used for fill is shown on Figure A-39 in Appendix A. These results can be used as guideline for contractors to estimate how much additional moisture may be required to bring the on-site soils to the required moisture content.
7. Essentially full-time observation and testing of fill placement must be performed by AGW. Testing should include in-place moisture content and dry density. Swell-consolidation or other testing may also be performed at the discretion of AGW.
8. Placement and compaction of fill should continue to final overlot grade. We recommend that the lots not be left low or "dished-out" and that placement of fill not stop at foundation elevation. If the residences will not be constructed within two years of completion of the fill, additional effort may be necessary to help maintain the moisture within the fill. This may include the addition of more soil to blanket the compacted fill, the placement of mechanical or chemical barriers, or applying water periodically to the fill surface. We are available to discuss this with you.

It must be understood that while this method is used to reduce the likelihood of future heave, it is not free of risk of foundation movement. While future heave is less likely, the possibility of settlement induced by excess moisture is increased. Therefore, the control and removal of surface water at the site will continue to be very important.

Our experience indicates that clay materials of the type encountered at this site will likely exhibit an average swell of less than 2% under a surcharge load of 1,000 pounds per square foot (psf) when thoroughly mixed with water and processed with typical earthmoving equipment. It is anticipated that if this level of swell reduction is achieved, the foundations may be constructed by placing footings upon the fill. This level of swell should also provide for a low to moderate risk of basement slab movement. However, it must be understood that even with the procedures outlined above, there is a possibility that moderate to high measured swells may be found in the fill. This may require rework of portions of the fill or the use of pier foundations and structural support of interior floors. Additional drilling after the soil modification has been completed will be required to provide final foundation recommendations and basement slab risk assessments for each residence.

9.3 Slopes and Retaining Walls

Slope stability and retaining wall analyses were not conducted as part of this study. In areas where existing slopes exceed 5:1 (horizontal:vertical), benching prior to fill placement will be required (see Figure 10). Construction of conventional fill slopes should be limited to 3 to 1 or flatter. Cut slopes steeper than 2 to 1 should be evaluated for stability. Specific analysis will be necessary if retaining walls are to be constructed.

9.4 Construction Excavation

In our opinion the site grading, utility, and foundation excavations may be constructed using conventional earth-moving equipment for the Front Range area. Excavations deeper than 3 feet should be properly sloped or braced to prevent collapse of potentially caving soils. For planning purposes, sand and any soil influenced by ground water are "Type C" soils, the clay is a "Type B" soil, and the underlying bedrock is a "Type A" soil according to OSHA regulations. A final determination of the soil type must be made by the Contractor's "Competent Person" (as defined by OSHA Regulation). Local, city, county, state, and federal (OSHA) regulations should be followed.

9.5 Utility Construction

In our experience, utility excavations may be constructed using conventional earth-moving equipment for the Front Range area. All excavations should be sloped or shored in the interest of safety, following local and federal (OSHA) regulations. For planning purposes, OSHA soil type designations are discussed under "Construction Excavations". Final determination of the soil types must be made by the contractor's "Competent Person" (as defined by OSHA) at the time of construction.

The presence of ground water may be a constraint upon utility construction in portions of the site. It will be necessary to dewater all trenches constructed below the ground water level. A possible method for dewatering would be to begin construction of the deeper (sewer) utilities at their outfall and to work upstream. Other methods include pumping from the trench in the work area or construction of well points along the trenches. The utility contractor must be made aware of the ground water conditions.

Trench backfill within all structural areas should, as a minimum, be compacted using the same methods and to the same specifications as required for overlot grading. This is especially important where utility lines and laterals are constructed beneath foundation, alley, and driveway areas. Trenches in streets should be compacted to the Town of Erie specifications. Observation and testing of fill placement must be performed during trench backfilling.

The choice of compaction equipment can have a significant effect on the performance of trench fills. It is our experience that utility trench backfills compacted with a compaction wheel attached to an excavator experience more settlement (both in area and magnitude) than those compacted with selfpropelled equipment. While the contractor has control of the means and methods of construction, the Client should be aware of this issue.

9.6 Subsurface Drainage

Clay soils and claystone bedrock were encountered in the test borings. These types of material have a relatively low permeability and can develop a perched water condition. Perched water conditions generally occur after development and construction have taken place, when landscape irrigation and surface drainage conditions are changed.

For these reasons, an overall area drain (underdrain) should be considered for the site. In addition, the overall area drain could also provide for a discharge and collection point for individual foundation drains. If an area drain discharge is not available, the individual foundation drains will discharge collected water to the ground surface near each residence. Surface discharge can result in water recycling to the foundation drain and ponding of water where surface grading is not sufficient for water flow. Foundation drain discharge can also result in algae growth where water continually crosses sidewalks which become ice hazards on walkways and gutters in the winter months.

Typically, overall area drains can be designed and constructed with installation of the sanitary sewer system. However, the Town of Erie should be consulted to determine where an overall system is allowed. The civil engineering company contracted to design the infrastructure should be able to provide this design. We are available to assist in drain design. For the system to work, the area drain must be graded to a positive discharge point. If a permanent outfall for an area drain cannot be determined, the area drain should not be constructed.

If it is decided not to install an overall area drain, an alternative would be to establish points of positive gravity discharge for the gravel bedding beneath the sewer. We also recommend any basement or below grade area be provided with a perimeter subsurface drainage system sloped to drain to a positive gravity discharge such as a sump or connected directly to the overall area drain system.

9.7 Surface Drainage

We recommend that provisions be made to divert surface runoff away from development areas. This may reduce potential problems associated with excess water in structure bearing soils. The site should be designed such that a 10% slope can be established near the structures after foundation construction. Slopes of at least 2% should be planned in landscaped areas once the water is away from the foundations.

10.0 SITE CONCRETE AND CORROSIVITY

Laboratory tests conducted on selected soil samples yielded water soluble sulfates ranging from less than 120 parts per million (ppm) to 24,140 ppm. Based upon these results and our experience in the area, the site soils and bedrock are assigned to possess very severe (S3 or RS3) sulfate exposure per ACI 318 or ACI 332. We recommend the "ACI Manual of Concrete Practice", of the most recent edition be used for proper concrete mix design properties as they relate to these conditions.

The pH test results ranged from 7.9 to 8.4, the resistivity test results at in-situ moisture ranged from 268 and 1,065 ohm·cm, and the chloride test results ranged from 0.0028 to 0.0157%. These results are summarized on Figures 2 through 7 and in Appendix A. The results of this testing should be used as an aid in choosing the construction materials in contact with these soils which will be resistant to the various corrosive forces. Manufacturer's representatives should be contacted regarding the specific corrosivity resistance for their products. In addition, local specifications should be consulted when selecting pipe materials.

11.0 PRELIMINARY FOUNDATION DESIGN CONCEPTS

The foundation recommendations for each structure are dependent upon the subsurface profile and engineering properties of the materials encountered at and near the depth of the proposed foundation. These are dependent upon the final configuration of and construction methods used during overlot grading at the site. The information in the following sections presents preliminary foundation concepts which must be finalized for each building site upon completion of the overlot grading operations. AGW should be retained to perform design level soil and foundation studies after completion of site grading.

11.1 Footings

It likely that the structures could be founded on spread or pad type footings bearing on the moisture treated fill. The footings must be founded below frost depth. The footings will likely be designed for maximum soil bearing pressures ranging from 1,000 to 3,000 psf. Minimum dead load pressure on the order of 700 to 1,000 psf will likely be required.

11.2 Lateral Earth Pressures

Foundation walls with fill on only one side will need to be designed for lateral earth pressures. For this site, lateral earth pressures calculated based upon equivalent fluid densities on the order of 50 to 80 pcf should be anticipated. The preliminary estimates are for properly placed and compacted fill at foundation walls. They should not be used for site retaining walls.

11.3 Interior Floors (Basement Products)

For the basement products, if the site is overexcavated, it is likely that most of the structures will be assessed with low to moderate slab risk performance evaluation. If the risk tolerance for slab movement is zero, structural floors should be constructed.

11.4 First Floor Construction (Crawl Space Products)

Some of the structures may be constructed over crawl spaces. Structural floors will be constructed in the living areas of the residences. For the garage areas, it is likely that there will be a low risk of garage slab movement.

11.5 Drain Systems

Drain systems will be required around the lowest excavation level for below grade spaces for each structure. Either interior or exterior drains may be used for most of the site. Where ground water is within 4 feet of the foundation, a more extensive drain system will be required. This may include gravel across the entire foundation, drain laterals, or combination interior and exterior drains. The drains must be led to a positive gravity outfall or sump. If an overall subdivision area drain is constructed, individual drains should be connected into this system if allowed by the jurisdiction. Subsurface drainage systems will not be necessary for structures with no below grade areas.

11.6 Backfill and Surface Drainage

Foundation backfill should be moistened and compacted to reduce future settlement. The site grading should consider a slope of 10% away from the foundation at the completion of construction. All other drainage swales in landscaped areas should slope at a minimum of 2%.

12.0 PRELIMINARY STREET PAVEMENT DESIGN

Pavement design is based on the engineering properties of the subgrade and pavement materials, the assumed design traffic conditions, and the Town of Erie pavement regulations. Effective pavement structures are composed of various pavement materials bearing upon properly prepared subgrade soils. The following preliminary pavement recommendations are based upon the subsurface conditions encountered and our experience in the area.

It appears the proposed subgrade materials will likely sand, clay, claystone, sandstone, or fill constructed from these materials with AASHTO Soil Classifications of A-6 and A-7-6. The clays and claystone should be overexcavated to a depth of at least 5 feet below the subgrade elevation. The overexcavation should be performed during site grading prior to construction of utilities within the right-of-way. Overexcavation should cover the area from 1 foot beyond back of sidewalk (for attached sidewalk areas) or back of curb (for detached sidewalks). The excavated material may be placed as moisture treated fill (see Appendix B) within the right-of-way. This should result in a reduction in pavement thickness. All fill placed within 5 feet of the subgrade elevation should be placed as moisture treated fill.

Moisture treatment is the process of removing subgrade materials, adding moisture between 0 to 4% above optimum moisture content, and compacting the subgrade to at least 95% of Proctor maximum dry density. The Client should understand soils treated to 4% above optimum moisture content will have low support values and may be soft and yielding under load. Stabilization by chemical or mechanical means may be necessary to achieve a stable paving platform.

Based upon the subgrade soil classifications, we have estimated the relative strengths of the subgrade soils presented above in order to determine the preliminary pavement thicknesses. Based on this information and utilizing the design methodology determined from the pavement design regulations for the Town of Erie, the alternatives presented below were calculated. These preliminary thickness recommendations are based on a design life of 20 years. It should be emphasized that the design alternatives provided below are preliminary for the materials anticipated. The final design thicknesses could be more or less than indicated depending upon the materials sampled during the final pavement design.

Pavement Thickness Alternatives for Interior Streets

Street Type	HBP / ABC (in)
Collector	5.0 – 6.0 / 8.0 – 10.0
Local Street	4.5 – 5.5 / 8.0 – 10.0

HBP = Hot Bituminous Pavement, ABC = Aggregate Base Course

Proper surface and subsurface drainage are essential for adequate performance of pavements. It has been our experience that water from landscaped areas can infiltrate pavement subgrade soils and result in softening of the subgrade followed by pavement damage. Therefore, provisions should be made to maintain adequate drainage and/or contain runoff from such areas. The Town of Erie requires pavement edge drains for all streets. In addition, water and irrigation lines should be thoroughly pressure tested for leaks prior to placement of pavement materials.

It must be reiterated that the information contained in this section is preliminary in nature. More detailed information will be required by the Town of Erie prior to issuance of a paving permit. Therefore, when overlot grading is complete at the site, a final pavement evaluation must be performed.

13.0 FINAL DESIGN CONSULTATION AND CONSTRUCTION OBSERVATION

This report has been prepared for the exclusive use of Richmond American Homes of Colorado, Inc. to provide geotechnical criteria for the proposed project. The data gathered and the conclusions and recommendations presented herein are based upon the consideration of many factors including, but not limited to, the type of structures proposed, the configuration of the structures, the proposed usage of the site, the configuration of surrounding structures, the geologic setting, the materials encountered, and our understanding of the level of risk acceptable to the Client. Therefore, the conclusions and recommendations contained in this report should not be considered valid for use by others unless accompanied by written authorization from AGW.

AGW should be contacted if the Client desires an explanation of the contents of this report. AGW should be retained to provide future geotechnical services for the site including, but not limited to, design level geotechnical studies, consultation during design, observation and testing during construction, and other geotechnically related services. Failure to contract with AGW for these services or selection of a firm other than AGW to provide these services will eliminate liability for AGW. We are available to discuss this with you.

14.0 GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be tempered by engineering judgment and experience. Therefore, the solutions or recommendations presented in any geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structures will perform as desired or intended. What the engineering recommendations presented in the preceding sections do constitute is our judgement of those measures that increase the chances for the structures and improvements performing satisfactorily. The Developer, Builder, and Owner must understand this concept of risk, as it is they who must ultimately decide what is an acceptable level of risk for the proposed development of the site.

15.0 LIMITATIONS

We believe the professional judgments expressed in this report are consistent with that degree of skill and care ordinarily exercised by practicing design professionals performing similar design services in the same locality, at the same time, at the same site and under the same or similar circumstances and conditions. No other warranty, express or implied, is made. In the event that any changes in the nature, design or location of the facility are made, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing. Because of the constantly changing state of the practice in geotechnical engineering, and the potential for site changes after our field exploration, this report must not be relied upon after a period of three years without our firm being given the opportunity to review and, if necessary, revise our findings.

The test borings drilled for this study were spaced to obtain an understanding of subsurface conditions for design purposes. Variations frequently occur from these conditions which are not indicated by the test borings. These variations are sometimes sufficient to necessitate modifications in the designs. If unexpected subsurface conditions are observed by any party during site development, we must be notified to review our recommendations.

Our scope of services for this project did not include, either specifically or by implication, any research, identification, testing, or assessment relative to past or present contamination of the site by any source, including biological (i.e., mold, fungi, bacteria, etc.). If such contamination were present, it is likely that the exploration and testing conducted for this report would not reveal its existence. If the Client is concerned about the potential for such contamination or pollution, additional studies should be undertaken. We are available to discuss the scope of such studies with you.

Our scope of services for this project did not include a local or global geological risk assessment. Therefore, issues such as mine subsidence, slope stability, faults, etc. were not researched or addressed as part of this study. If the Client is concerned about these issues, we are available to discuss the scope of such studies upon your request.

Sincerely,

A. G. Wassenaar, Inc.

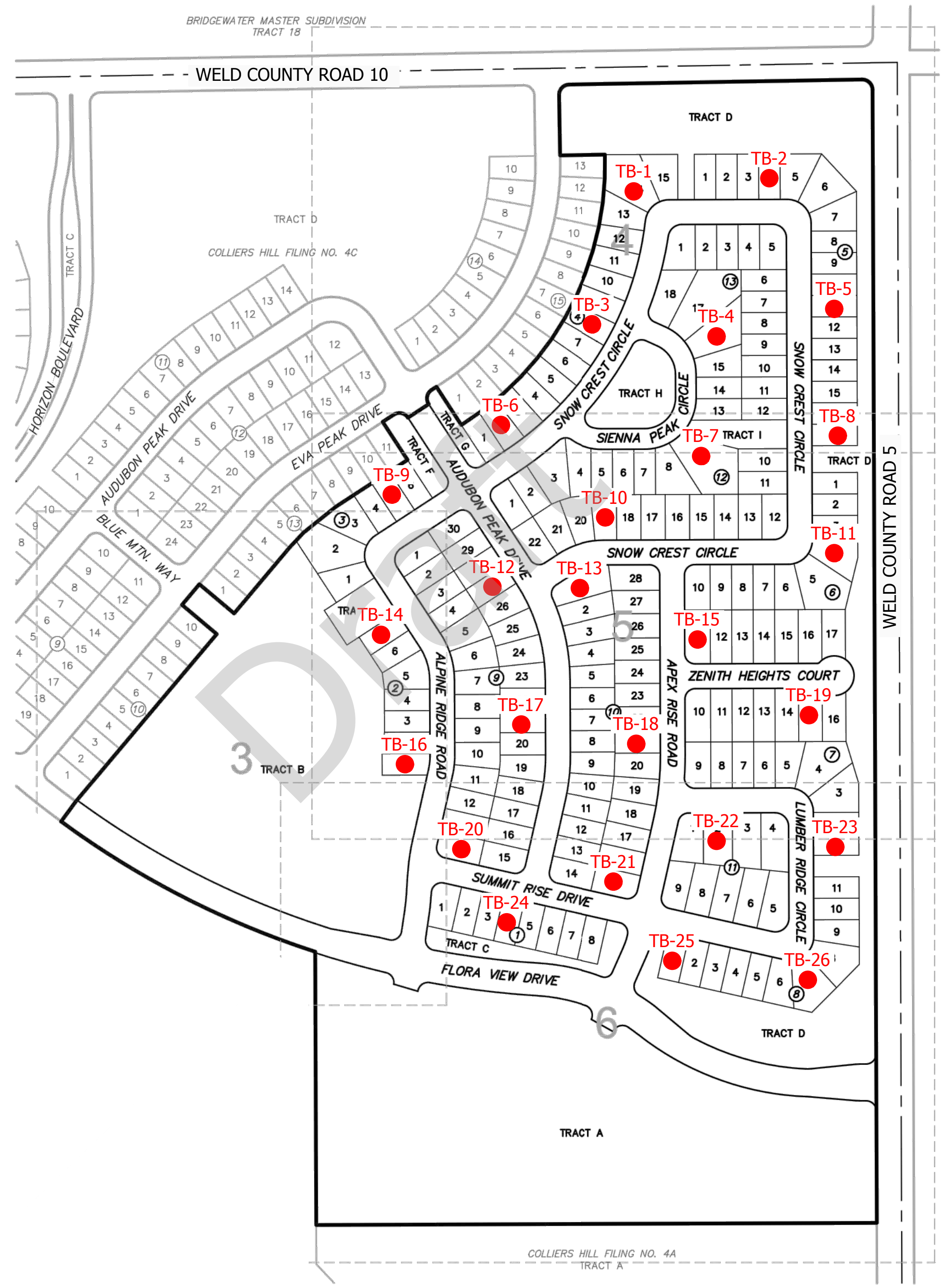
Kathleen A. Noonan, M.S., P.E.
Senior Geotechnical Engineer

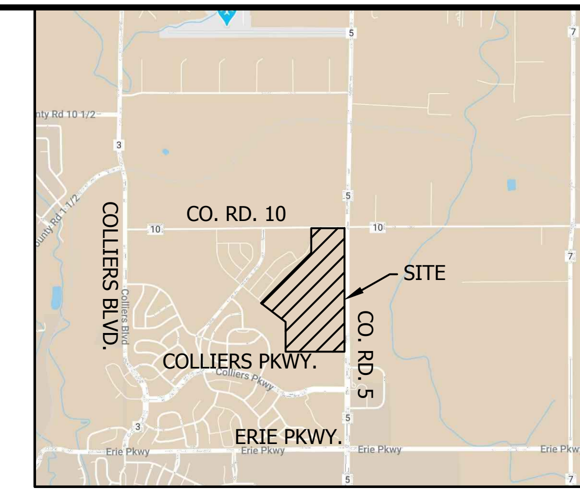
Reviewed By:

Ashley A. McDaniels, P.E.
Project Engineer

COLLIERS HILL, FILING 4G
ERIE, COLORADO

0 400 800
Scale in Feet





VICINITY MAP
NOT TO SCALE

NOTES:
1. TEST BORINGS ARE OVERLAID ON THE "COLLIERS HILL FILING NO. 4G PRELIMINARY PLAT", SHEET 2 OF 7, PREPARED BY HURST & ASSOCIATES INC., PROJECT NO. 2527-02, DATED JANUARY 24, 2020.
2. ALL LOCATIONS ARE APPROXIMATE.

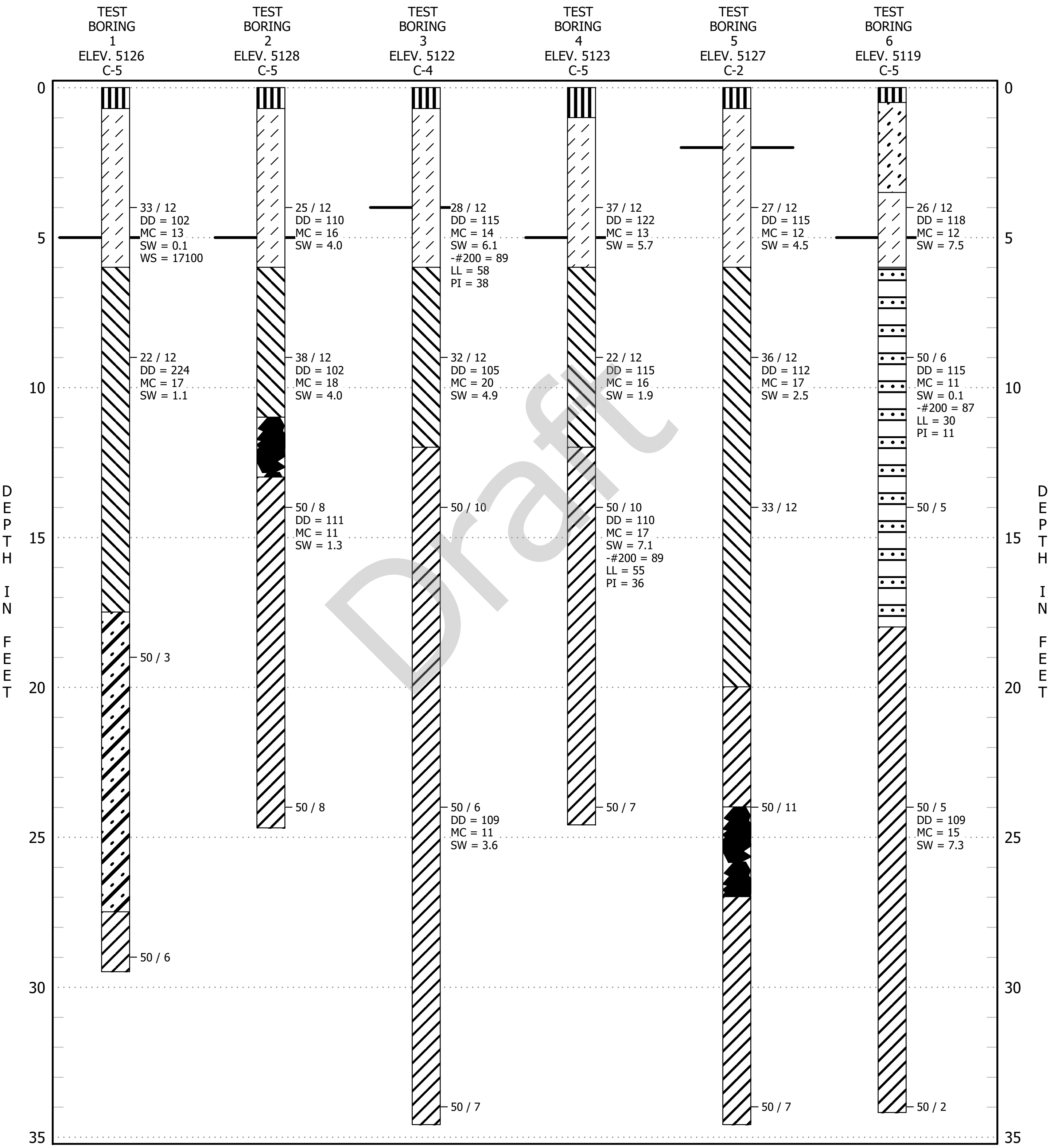
AGW
A.G. WASSENAAR, INC.

SITE PLAN AND VICINITY MAP	PROJECT NO. 202523 FIGURE 1

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

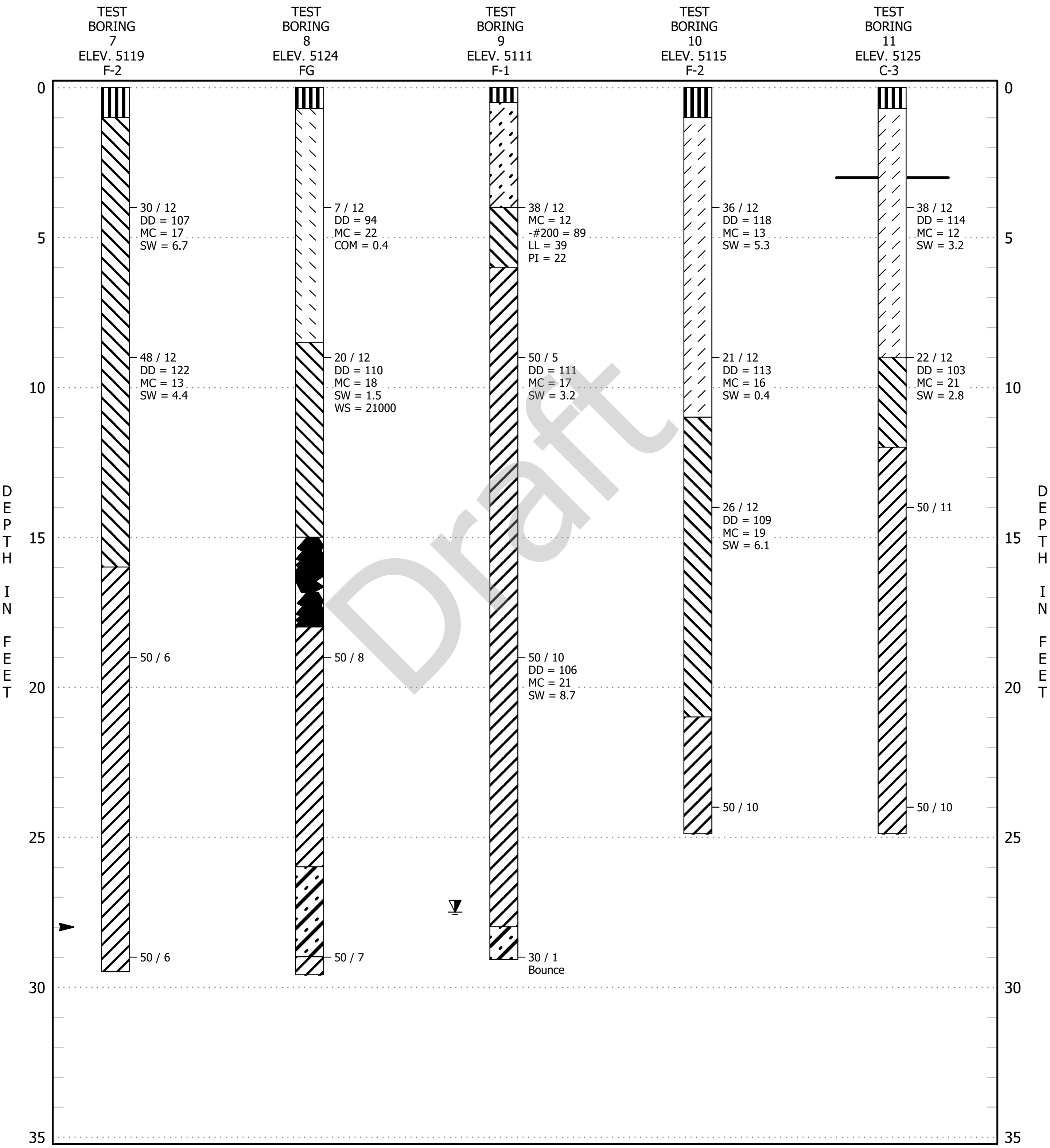
FIGURE 2

AGW

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

FIGURE 3

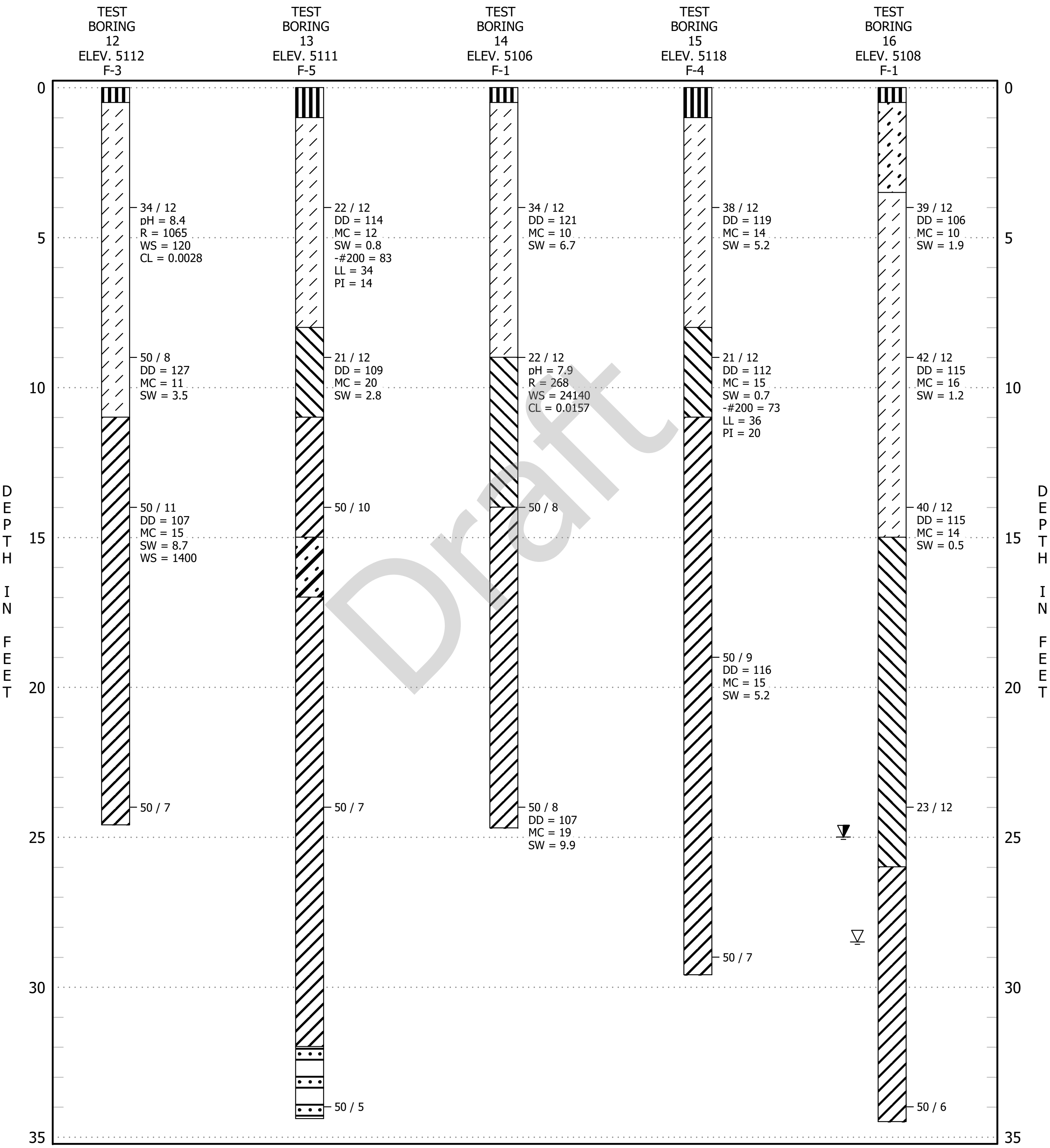
A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc.

PROJECT NAME Colliers Hill, Filing 4G

PROJECT NUMBER 202523

PROJECT LOCATION Erie, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

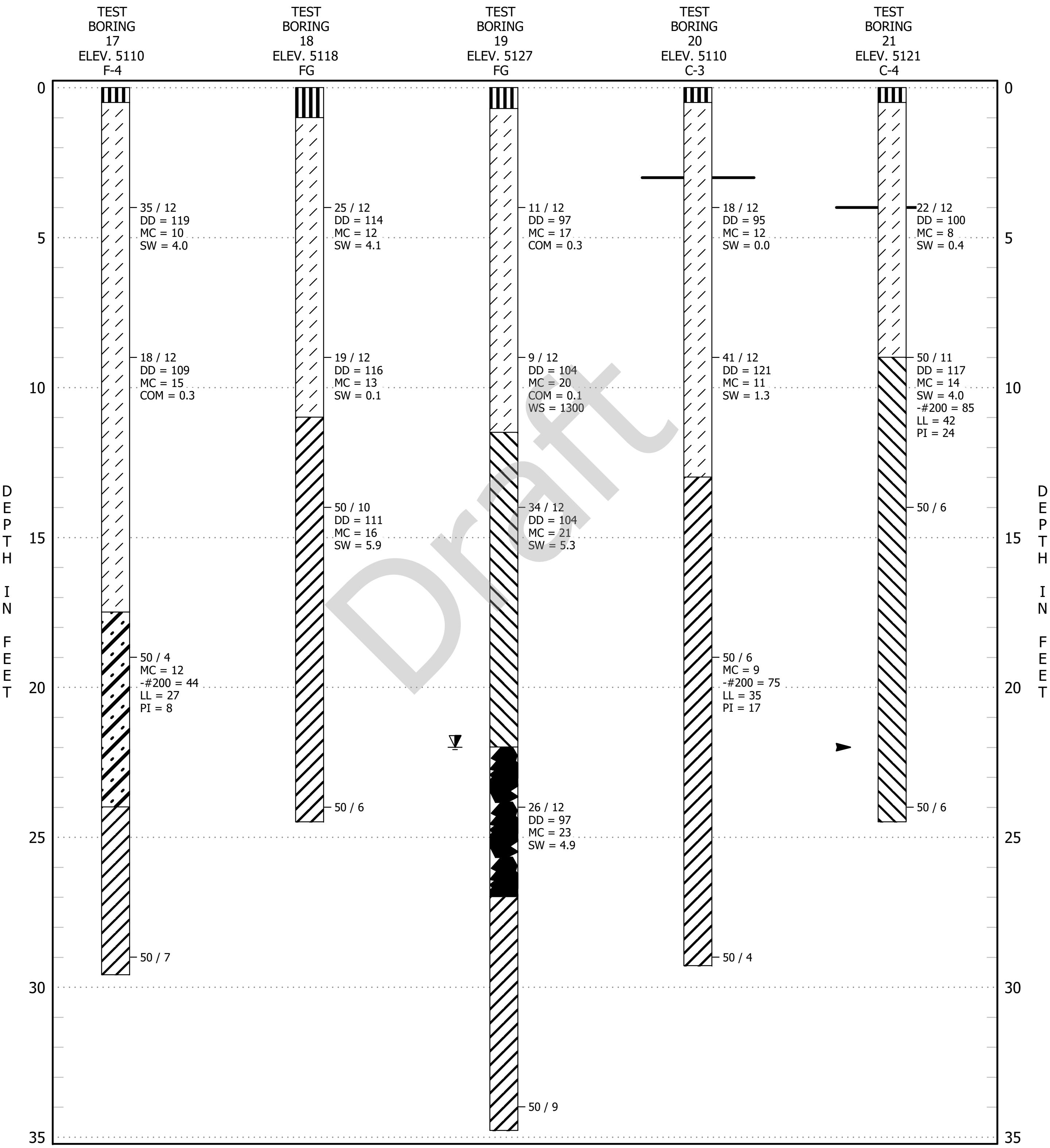
FIGURE 4

U:\PROJECT FILES\2 - GEOTECHNICAL\202523 COLLIERS HILL F4G RICHMOND SD KAN\TO BE SAVED\GINT\202523S_GT2020-11-04 COLLIERS HILL F4G SD.GPJ

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

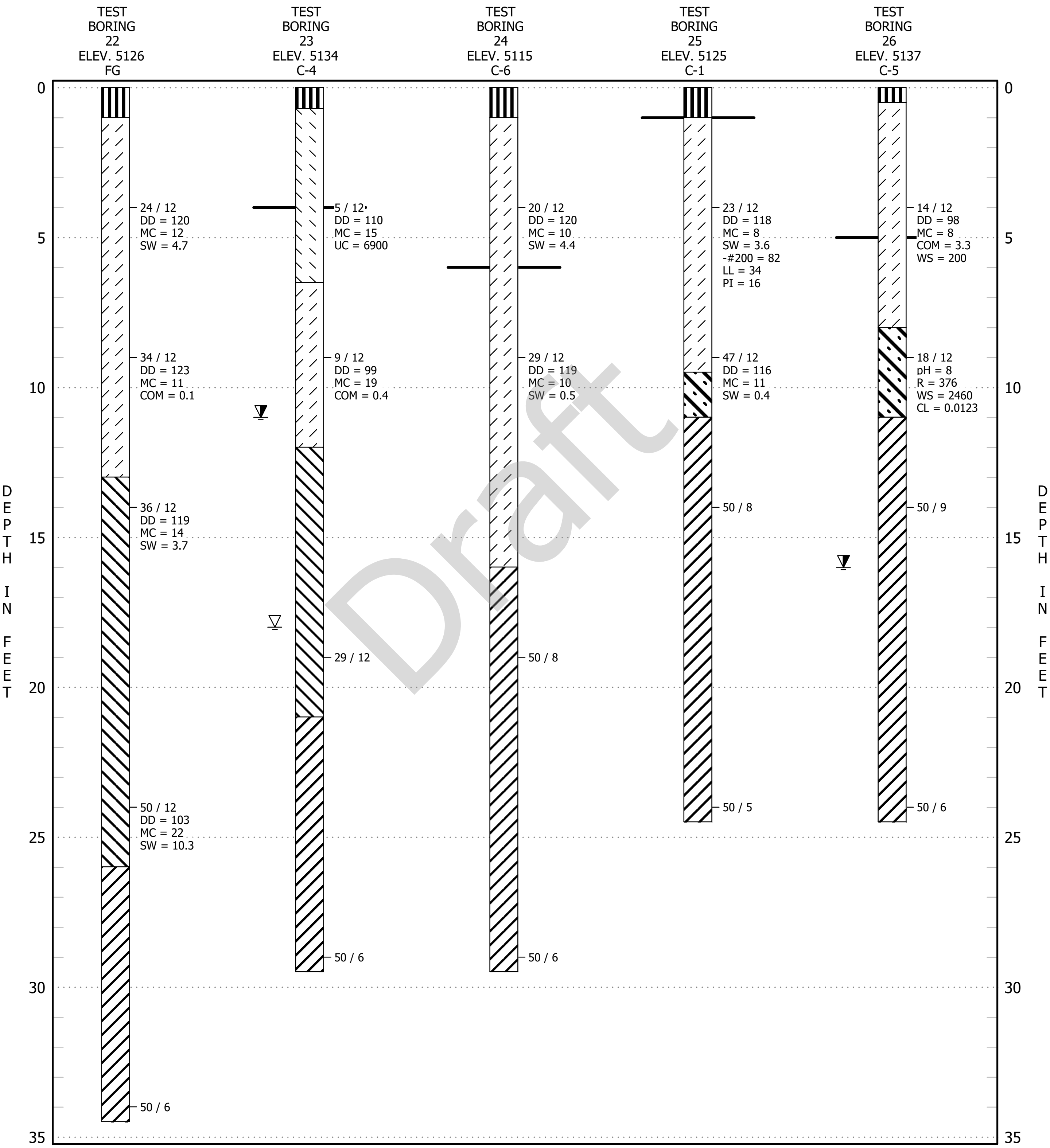
FIGURE 5

U:\PROJECT FILES\2 - GEOTECHNICAL\202523 COLLIERS HILL F4G RICHMOND SD KAN\TO BE SAVED\GINT\202523S_GT2020-11-04 COLLIERS HILL F4G SD.GPJ

AGW
A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

FIGURE 6

U:\PROJECT FILES\2 - GEOTECHNICAL\202523 COLLIERS HILL F4G RICHMOND SD KAN\TO BE SAVED\GINT\202523S_GT2020-11-04 COLLIERS HILL F4G SD.GPJ

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado

SOIL DESCRIPTIONS

- Topsoil, clay, sandy, organic
- Clay, medium stiff
- Clay, stiff to very stiff
- Sand, medium dense, silty, clayey
- Claystone (Bedrock), firm to medium hard
- Claystone (Bedrock), hard to very hard
- Lignite, black
- Sandstone (Bedrock), firm to medium hard
- Sandstone (Bedrock), hard to very hard
- Claystone/Sandstone (Bedrock), interbedded, hard to very hard

ABBREVIATIONS

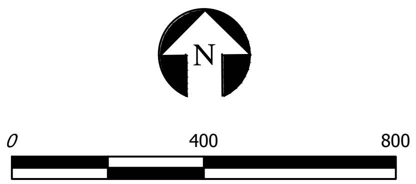
DD	Dry density of sample in pounds per cubic foot (pcf)
MC	Moisture content as a percentage of dry weight of soil (%)
SW	Percent swell under a surcharge of 1000 pounds per square foot (psf) upon wetting (%)
COM	Percent compression under a surcharge of 1000 pounds per square foot (psf) upon wetting (%)
UC	Unconfined compressive strength in pounds per square foot (psf)
-#200	Percent passing the Number 200 sieve (%)
LL	Liquid Limit
PI	Plasticity Index
NP	Non-Plastic
NV	No Value
pH	Acidity or alkalinity of sample in pH units
R	Resistivity in ohms.cm
WS	Water soluble sufates in parts per million (ppm)
CL	Chlorides in percent (%)
x/y	X blows of a 140-pound hammer falling 30 inches were required to drive a 2.5-inch outside diameter sampler Y inches
x/y SS	X blows of a 140-pound hammer falling 30 inches were required to drive a 2.0-inch outside diameter sampler Y inches
C-x	Depth of cut to grade (rounded to the nearest foot)
F-x	Depth of fill to grade (rounded to the nearest foot)
FG	Finished grade (rounded to the nearest foot)
NR	No sample recovered
Bounce	Sampler bounced during driving
B	Bulk sample
AS	Auger sample
	Well to very well cemented layer
	Depth at which practical drilling refusal was encountered
	Water level at time of drilling
	Caved depth at time of drilling
	Water level 5 day(s) after drilling
	Caved depth 5 day(s) after drilling

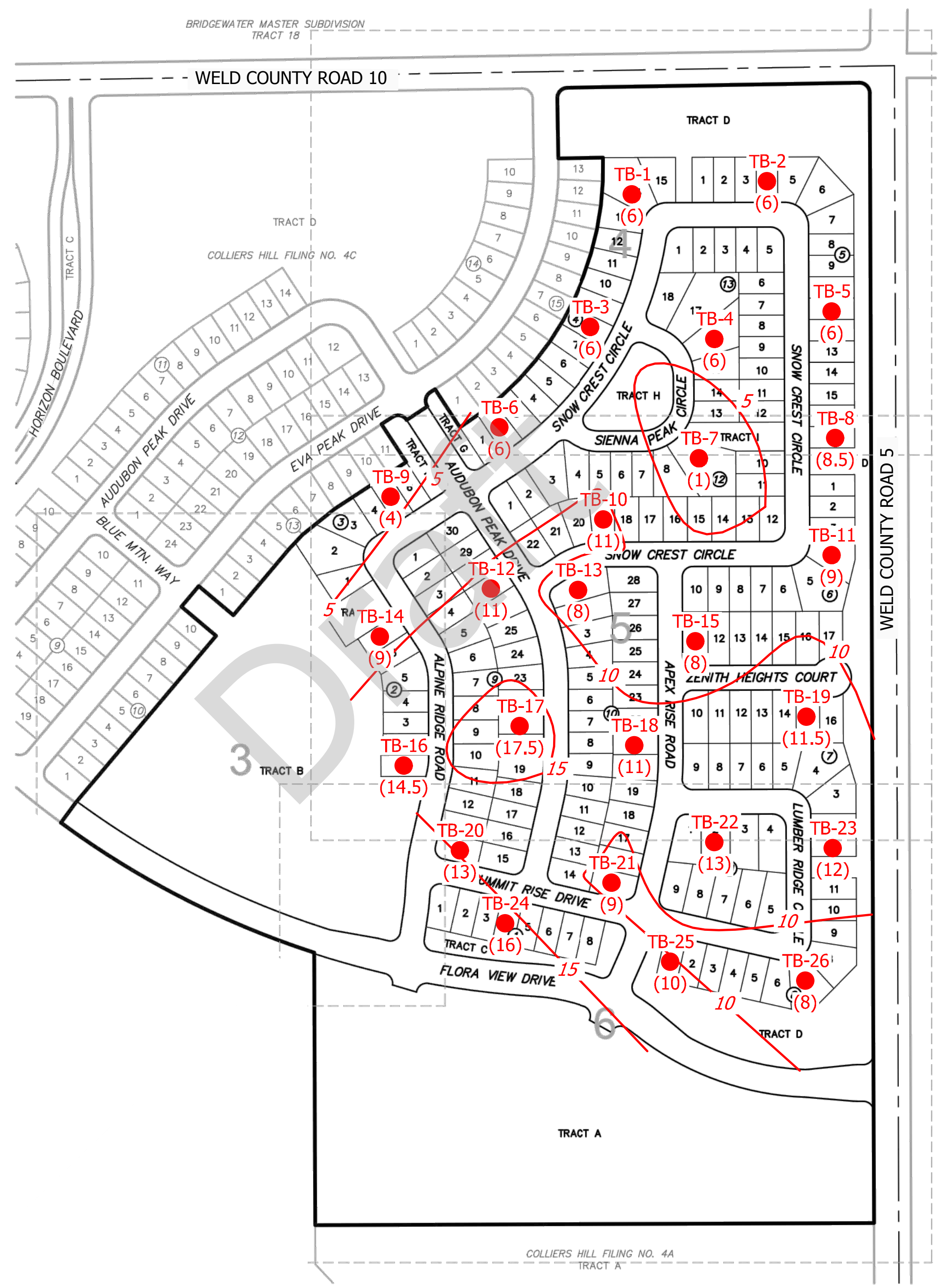
Notes:

1. Test borings were drilled October 30, 2020 .
2. Location of the test borings were staked by others at locations chosen by this firm.
3. The horizontal lines shown on the logs are to differentiate materials and represent the approximate boundaries between materials. The transitions between materials may be gradual.
4. Elevations were obtained from staking provided by others and have been rounded to the nearest foot.
5. Boring logs shown in this report are subject to the limitations, explanations, and conclusions of this report.

LEGEND AND NOTES
FIGURE 7

COLLIERS HILL, FILING 4G
ERIE, COLORADO





NOTES:

1. TEST BORINGS ARE OVERLAID ON THE "COLLIERS HILL FILING NO. 4G PRELIMINARY PLAT", SHEET 2 OF 7, PREPARED BY HURST & ASSOCIATES INC., PROJECT NO. 2527-02, DATED JANUARY 24, 2020.
2. ALL LOCATIONS ARE APPROXIMATE.
3. BEDROCK CONTOURS ARE BASED UPON THE EXTRAPOLATION OF DATA FROM WIDELY SPACED TEST BORINGS. LOCAL AND SIGNIFICANT VARIATIONS MAY OCCUR BETWEEN BORINGS. THIS FIGURE REPRESENTS AN OPINION WHICH IS ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

(XX) BEDROCK ENCOUNTERED AT A DEPTH OF XX FEET

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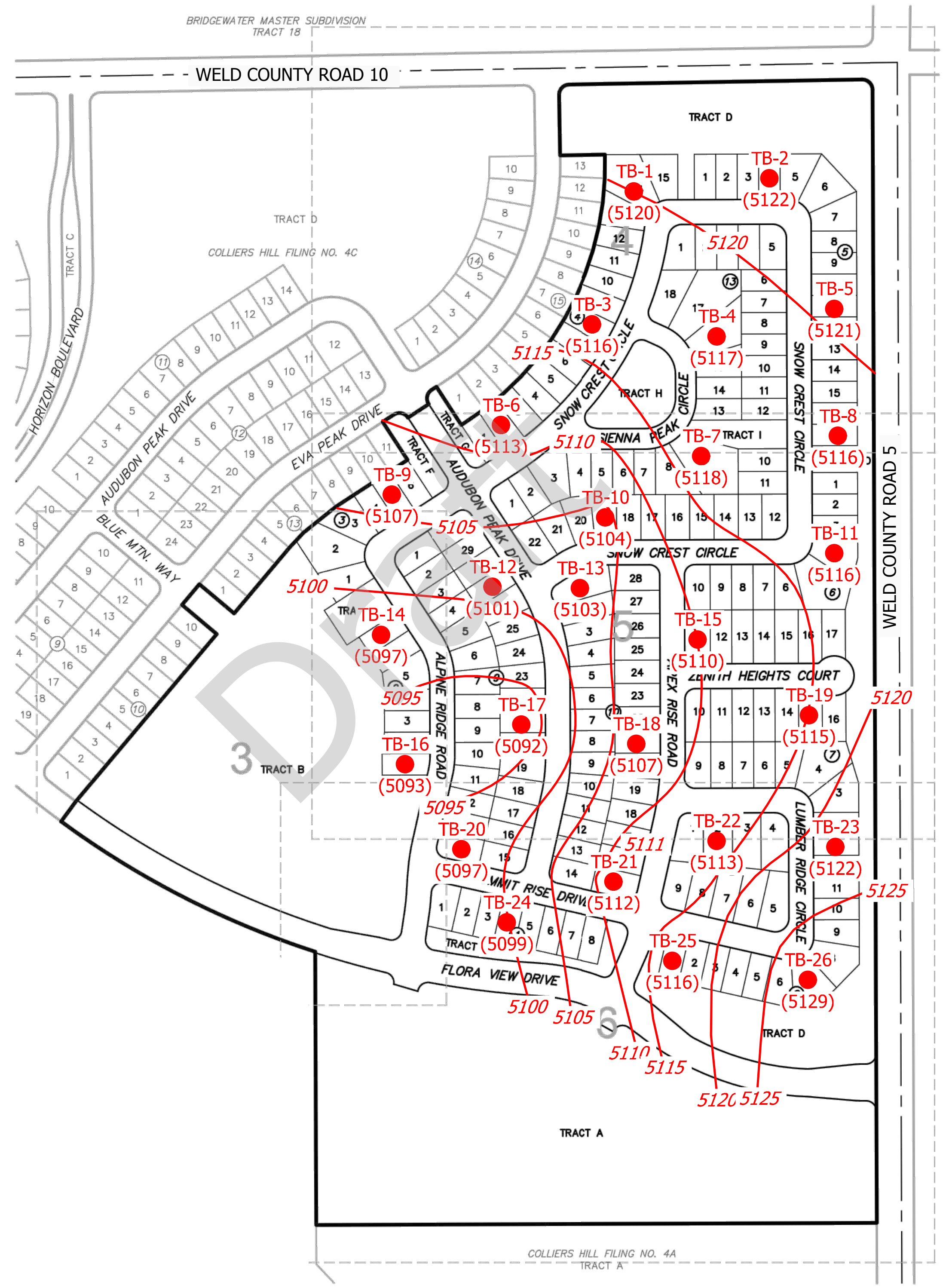
ESTIMATED DEPTH TO BEDROCK	PROJECT NO. 202523 FIGURE 8

COLLIERS HILL, FILING 4G
ERIE, COLORADO

0 400 800
Scale in Feet



NOTES:

1. TEST BORINGS ARE OVERLAID ON THE "COLLIERS HILL FILING NO. 4G PRELIMINARY PLAT", SHEET 2 OF 7, PREPARED BY HURST & ASSOCIATES INC., PROJECT NO. 2527-02, DATED JANUARY 24, 2020.
2. ALL LOCATIONS ARE APPROXIMATE.
3. BEDROCK ELEVATION CONTOURS ARE BASED UPON THE EXTRAPOLATION OF DATA FROM WIDELY SPACED TEST BORINGS. LOCAL AND SIGNIFICANT VARIATIONS MAY OCCUR BETWEEN BORINGS. THIS FIGURE REPRESENTS AN OPINION WHICH IS ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

(XXXX) BEDROCK ENCOUNTERED AT AN ELEVATION OF XXXX FEET

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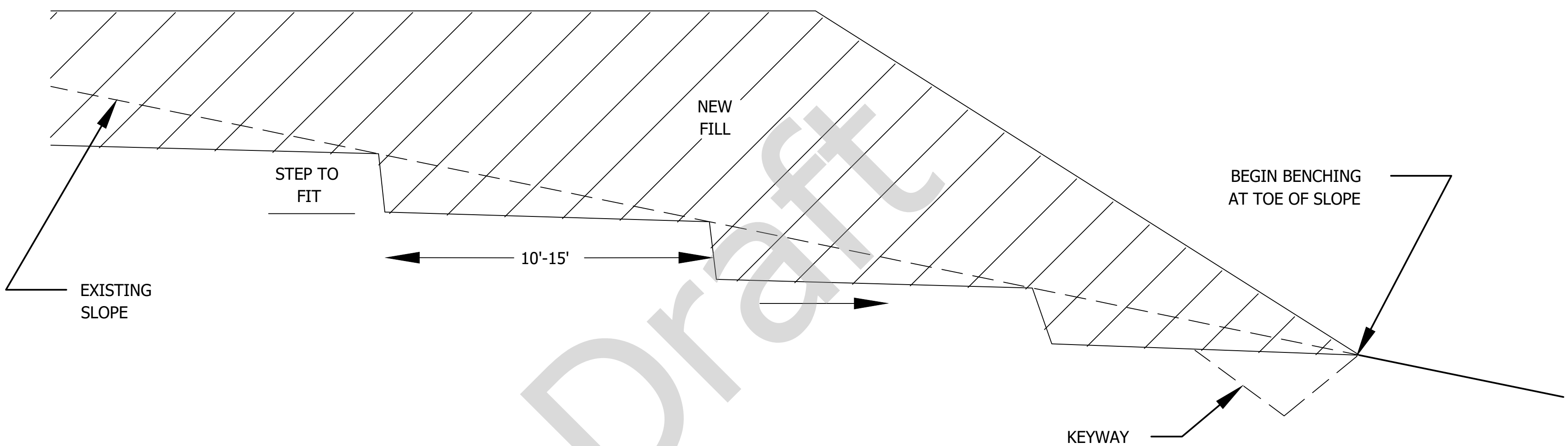
ESTIMATED ELEVATION OF BEDROCK	PROJECT NO. 202523 FIGURE 9



NOTES:

1. BENCHING REQUIRED WHEN EXISTING SLOPE IS 5 : 1 (HORIZONTAL : VERTICAL) OR STEEPER
2. CONTINUE BENCHING UNTIL NATURAL SLOPE FLATTENS OR DAYLIGHTS
3. DRAINS MAY BE REQUIRED IF GROUND WATER IS ENCOUNTERED
4. ADDITIONAL EXCAVATION MAY BE REQUIRED BY AGW IF SLOPE INSTABILITY IS NOTED
5. A KEYWAY MAY BE REQUIRED BY AGW DEPENDING UPON SLOPE CONFIGURATION
6. NOT TO SCALE

AGW
A.G. WASSENAAR, INC.

GENERALIZED BENCHING DETAIL	PROJECT NO. 202523 FIGURE 10

APPENDIX A
LABORATORY TEST RESULTS

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
November 16, 2020

Test Boring Number	Depth (feet)	Soil Type	Natural Dry Density (pcf)	Natural Moisture (%)	Swell / Consolidation (-) (%) [1]	Swell Pressure (psf)	% Passing #200 Sieve	Atterberg		Unconfined Compressive Strength (psf)	pH	Resistivity (ohm•cm)	Water Soluble Sulfates (ppm)	Chlorides (%)
								Liquid Limit LL	Plasticity Index PI					
1	4	Clay, sandy	102	13	0.1	1,500							17,100	
1	9	Claystone, slightly sandy	224	17	1.1	2,700								
2	4	Clay, sandy	110	16	4.0	6,900								
2	9	Claystone, slightly sandy	102	18	4.0	6,500								
2	14	Claystone, slightly sandy	111	11	1.3	2,600								
3	4	Clay, slightly sandy	115	14	6.1	8,400	89	58	38					
3	9	Claystone, slightly sandy	105	20	4.9	5,500								
3	24	Claystone, slightly sandy	109	11	3.6	2,900								
4	4	Clay, sandy	122	13	5.7	19,100								
4	9	Claystone, slightly sandy	115	16	1.9	4,100								
4	14	Claystone, slightly sandy	110	17	7.1	7,800	89	55	36					
5	4	Clay, sandy	115	12	4.5	6,900								
5	9	Claystone, slightly sandy	112	17	2.5	4,200								
6	4	Clay, sandy	118	12	7.5	17,900								
6	9	Claystone/Sandstone, silty	115	11	0.1	2,000	87	30	11					
6	24	Claystone, slightly sandy	109	15	7.3	7,000								
7	4	Claystone, slightly sandy	107	17	6.7	8,400								
7	9	Claystone, slightly sandy	122	13	4.4	10,000								
8	4	Clay, sandy	94	22	-0.4	NA								
8	9	Claystone, slightly sandy	110	18	1.5	2,800							21,000	
9	4	Claystone, slightly sandy		12			89	39	22					
9	9	Claystone, slightly sandy	111	17	3.2	6,600								
9	19	Claystone, slightly sandy	106	21	8.7	11,100								
10	4	Clay, sandy	118	13	5.3	-								
10	9	Clay, sandy	113	16	0.4	2,000								
10	14	Claystone, slightly sandy	109	19	6.1	9,700								

A.G. WASSENAAR, INC.

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
November 16, 2020

Test Boring Number	Depth (feet)	Soil Type	Natural Dry Density (pcf)	Natural Moisture (%)	Swell / Consolidation (-) (%) [1]	Swell Pressure (psf)	% Passing #200 Sieve	Atterberg Liquid Limit LL	Atterberg Plasticity Index PI	Unconfined Compressive Strength (psf)	pH	Resistivity (ohm•cm)	Water Soluble Sulfates (ppm)	Chlorides (%)
11	4	Clay, sandy	114	12	3.2	7,700								
11	9	Claystone, slightly sandy	103	21	2.8	5,000								
12	4	Clay, sandy									8.4	1,065	120	0.0028
12	9	Clay, sandy	127	11	3.5	9,500								
12	14	Claystone, slightly sandy	107	15	8.7	11,300							1,400	
13	4	Clay, sandy	114	12	0.8	3,900	83	34	14					
13	9	Claystone, slightly sandy	109	20	2.8	5,800								
14	4	Clay, sandy	121	10	6.7	13,900								
14	9	Claystone, slightly sandy									7.9	268	24,140	0.0157
14	24	Claystone, slightly sandy	107	19	9.9	13,300								
15	4	Clay, sandy	119	14	5.2	13,900								
15	9	Claystone, sandy, trace gravel	112	15	0.7	1,800	73	36	20					
15	19	Claystone, slightly sandy	116	15	5.2	7,900								
16	4	Clay, sandy	106	10	1.9	2,900								
16	9	Clay, sandy	115	16	1.2	3,700								
16	14	Clay, sandy	115	14	0.5	2,200								
17	4	Clay, sandy	119	10	4.0	9,600								
17	9	Clay, sandy	109	15	-0.3	NA								
17	19	Sandstone, very clayey, slightly gravelly		12			44	27	8					
18	4	Clay, sandy	114	12	4.1	10,800								
18	9	Clay, sandy	116	13	0.1	1,800								
18	14	Claystone, slightly sandy	111	16	5.9	7,400								
19	4	Clay, sandy	97	17	-0.3	NA								
19	9	Clay, sandy	104	20	-0.1	NA							1,300	
19	14	Claystone, slightly sandy	104	21	5.3	7,000								
19	24	Lignite	97	23	4.9	-								

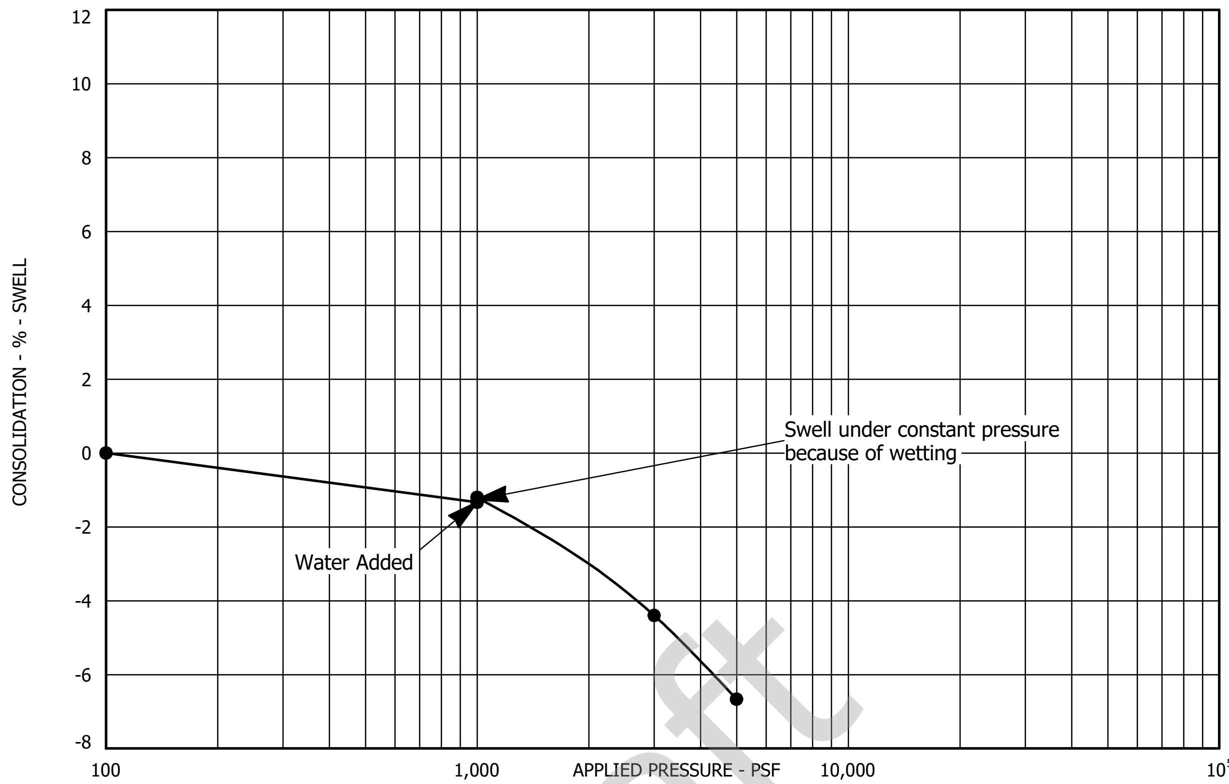
AGW
A.G. WASSENAAR, INC.

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
November 16, 2020

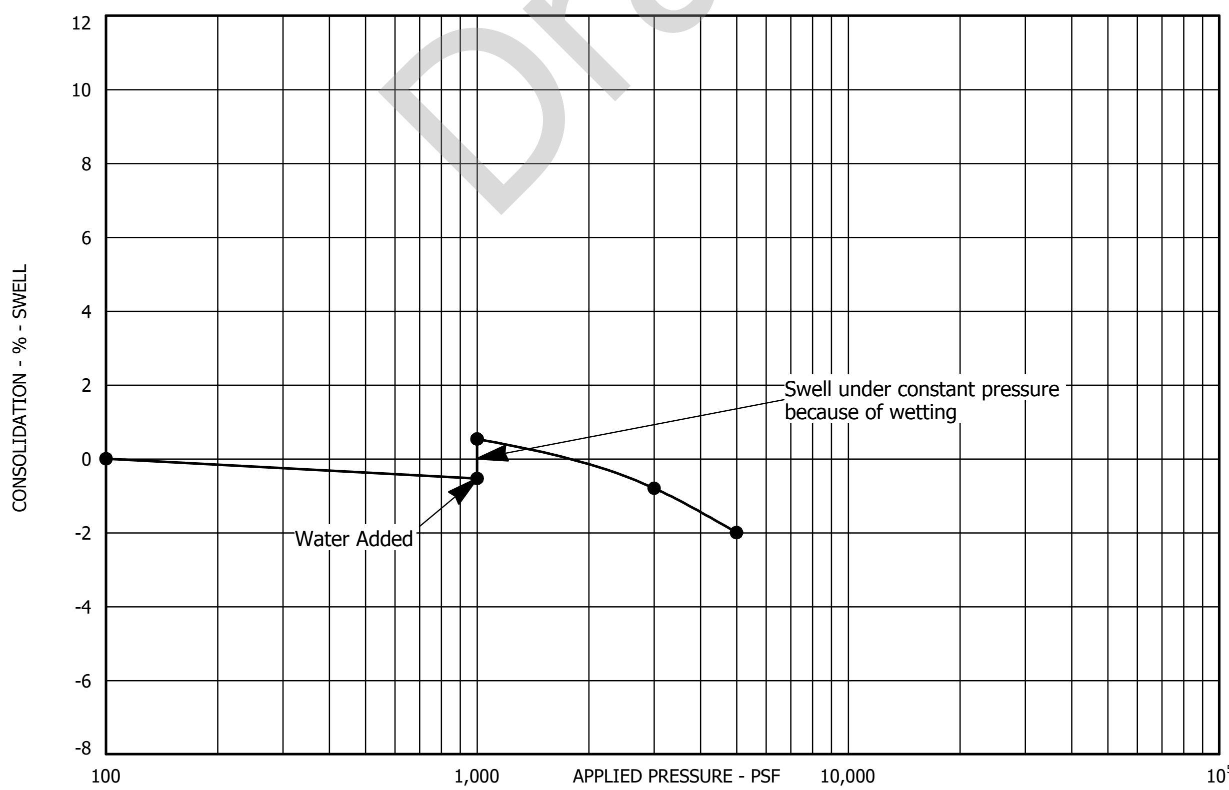
Test Boring Number	Depth (feet)	Soil Type	Natural Dry Density (pcf)	Natural Moisture (%)	Swell / Consolidation (-) (%) [1]	Swell Pressure (psf)	% Passing #200 Sieve	Atterberg Liquid Limit LL	Atterberg Plasticity Index PI	Unconfined Compressive Strength (psf)	pH	Resistivity (ohm•cm)	Water Soluble Sulfates (ppm)	Chlorides (%)
20	4	Clay, sandy	95	12	0.0	NA								
20	9	Clay, sandy	121	11	1.3	5,000								
20	19	Claystone, sandy, slightly gravelly		9			75	35	17					
21	4	Clay, sandy	100	8	0.4	-								
21	9	Claystone, sandy	117	14	4.0	8,400	85	42	24					
22	4	Clay, sandy	120	12	4.7	12,400								
22	9	Clay, sandy	123	11	-0.1	NA								
22	14	Claystone, sandy	119	14	3.7	7,100								
22	24	Claystone, slightly sandy	103	22	10.3	8,300								
23	4	Clay, sandy	110	15						6,900				
23	9	Clay, sandy	99	19	-0.4	NA								
24	4	Clay, sandy	120	10	4.4	7,600								
24	9	Clay, sandy	119	10	0.5	2,000								
25	4	Clay, sandy	118	8	3.6	6,800	82	34	16					
25	9	Sandstone, very clayey	116	11	0.4	2,000								
26	4	Clay, sandy											200	
26	9	Sandstone, very clayey									8.0	376	2,460	0.0123
Bulk [2]	NA	Clay, slightly sandy, trace gravel	104.5 [3]	19.2 [3]			87	37	19				1,400	

Notes:
NA - Not Applicable
[1] Indicates percent swell or consolidation when wetted under a 1,000 psf load
[2] Bulk is a blended bulk sample obtained from the auger cuttings of various test borings.
[3] Maximum dry density (MDD) and optimum moisture content (OMC)

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 1 at a depth of 4 feet
Dry Unit Weight (pcf): 102
Sample Description: Clay, sandy
Moisture Content (%): 13



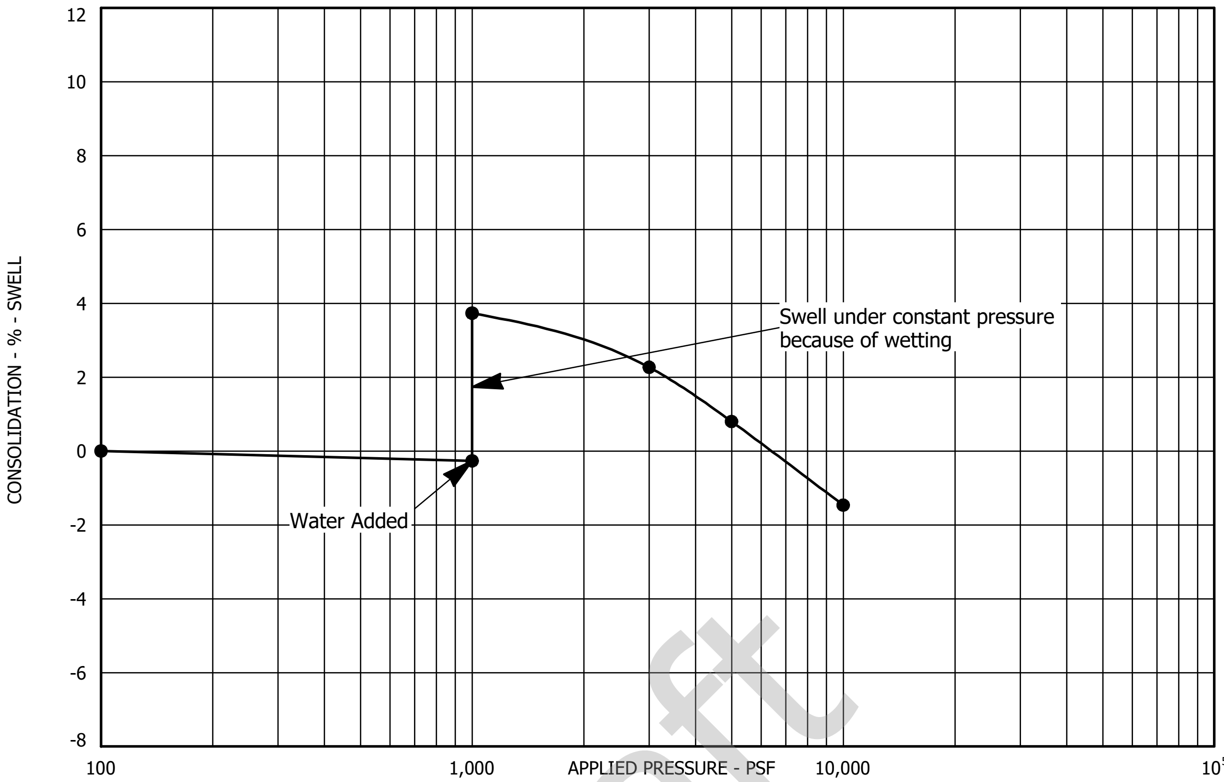
Sample Location: Test Boring No. 1 at a depth of 9 feet
Dry Unit Weight (pcf): 224
Sample Description: Claystone, slightly sandy
Moisture Content (%): 17

SWELL - CONSOLIDATION TEST RESULTS

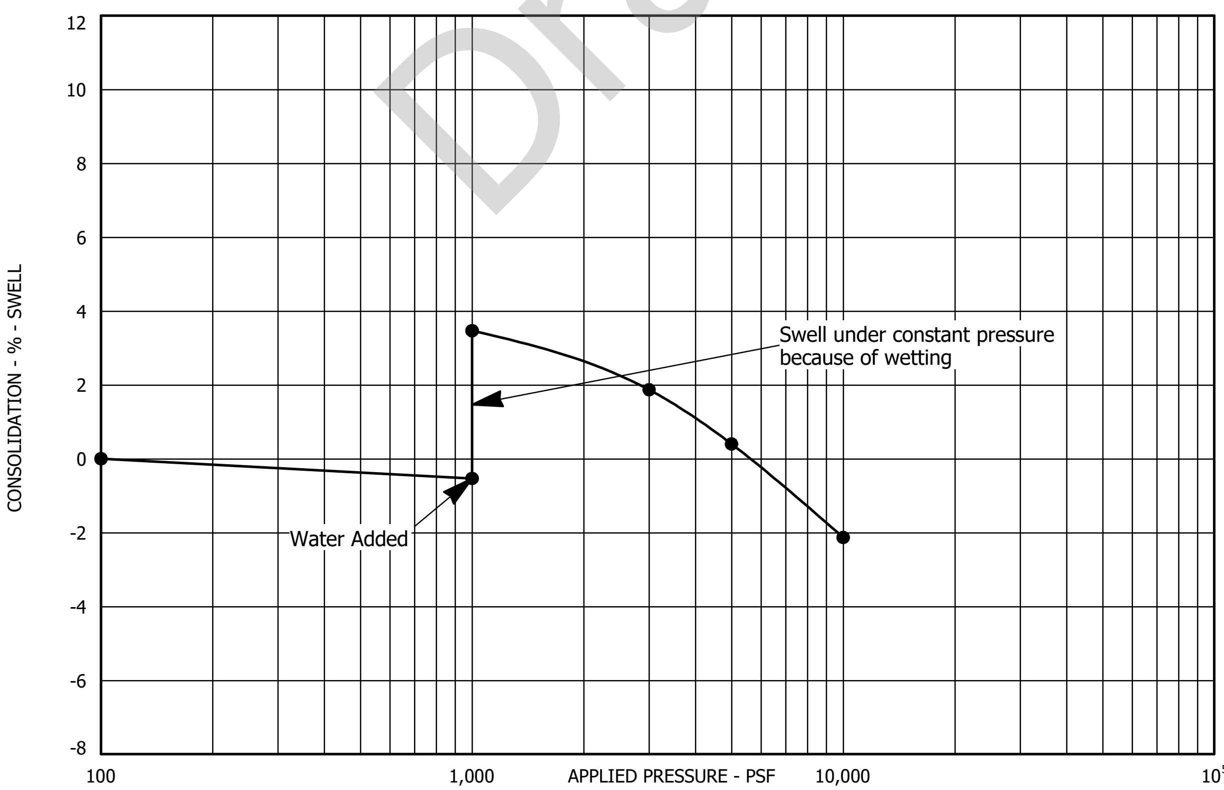
FIGURE A-1

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 2 at a depth of 4 feet	Dry Unit Weight (pcf)	110
Sample Description	Clay, sandy	Moisture Content (%)	16

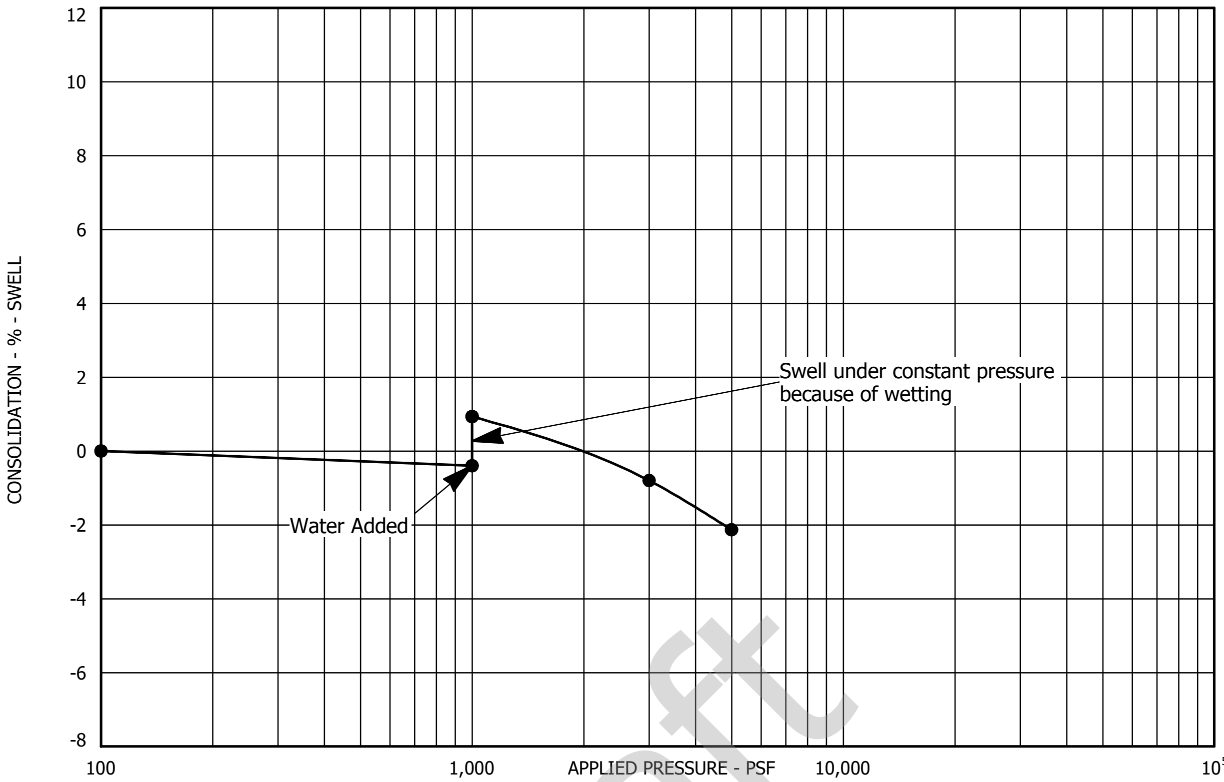


Sample Location	Test Boring No. 2 at a depth of 9 feet	Dry Unit Weight (pcf)	102
Sample Description	Claystone, slightly sandy	Moisture Content (%)	18

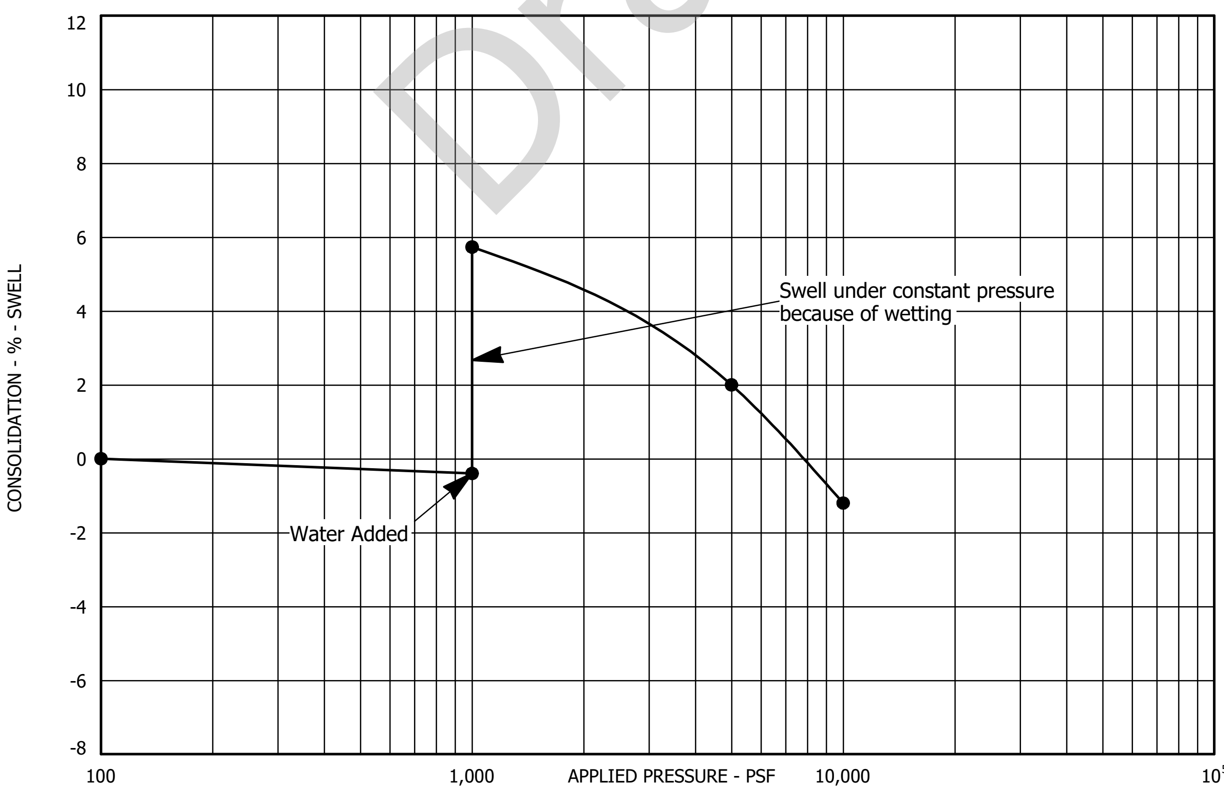
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-2

PROJECT NO. 202523



Sample Location: Test Boring No. 2 at a depth of 14 feet
Dry Unit Weight (pcf): 111
Sample Description: Claystone, slightly sandy
Moisture Content (%): 11



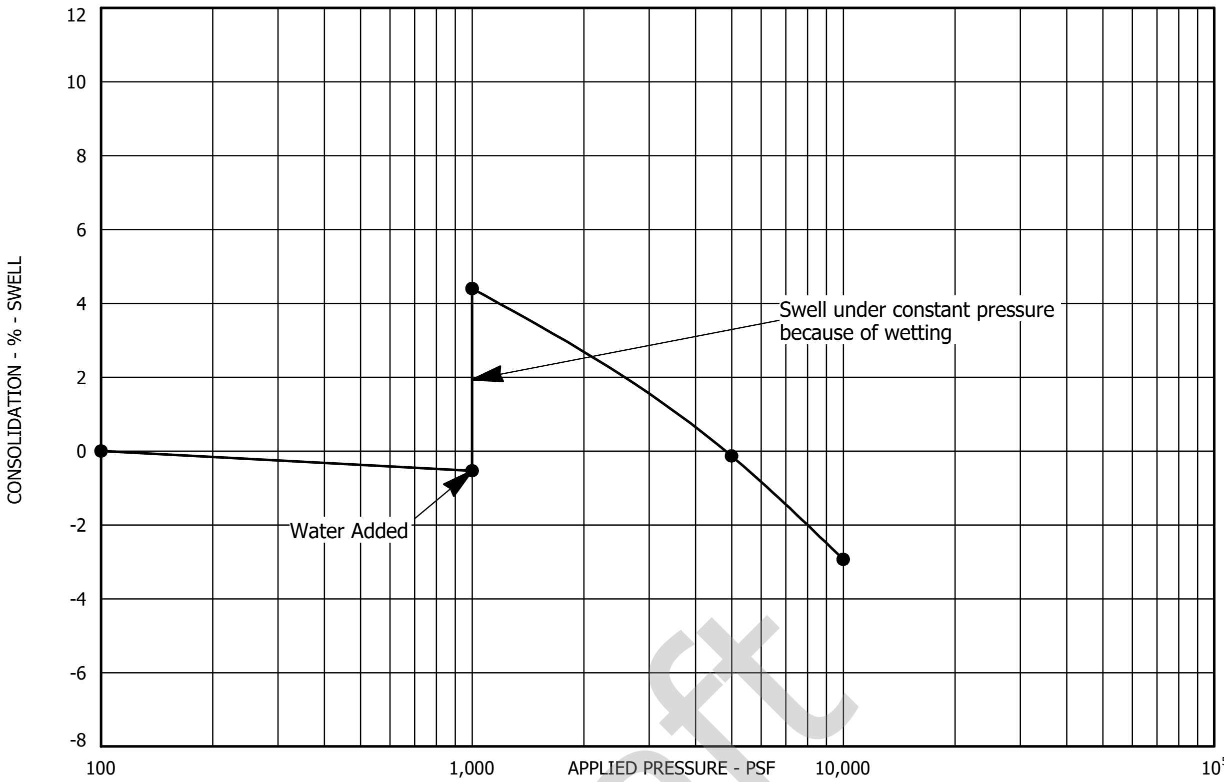
Sample Location: Test Boring No. 3 at a depth of 4 feet
Dry Unit Weight (pcf): 115
Sample Description: Clay, slightly sandy
Moisture Content (%): 14

SWELL - CONSOLIDATION TEST RESULTS

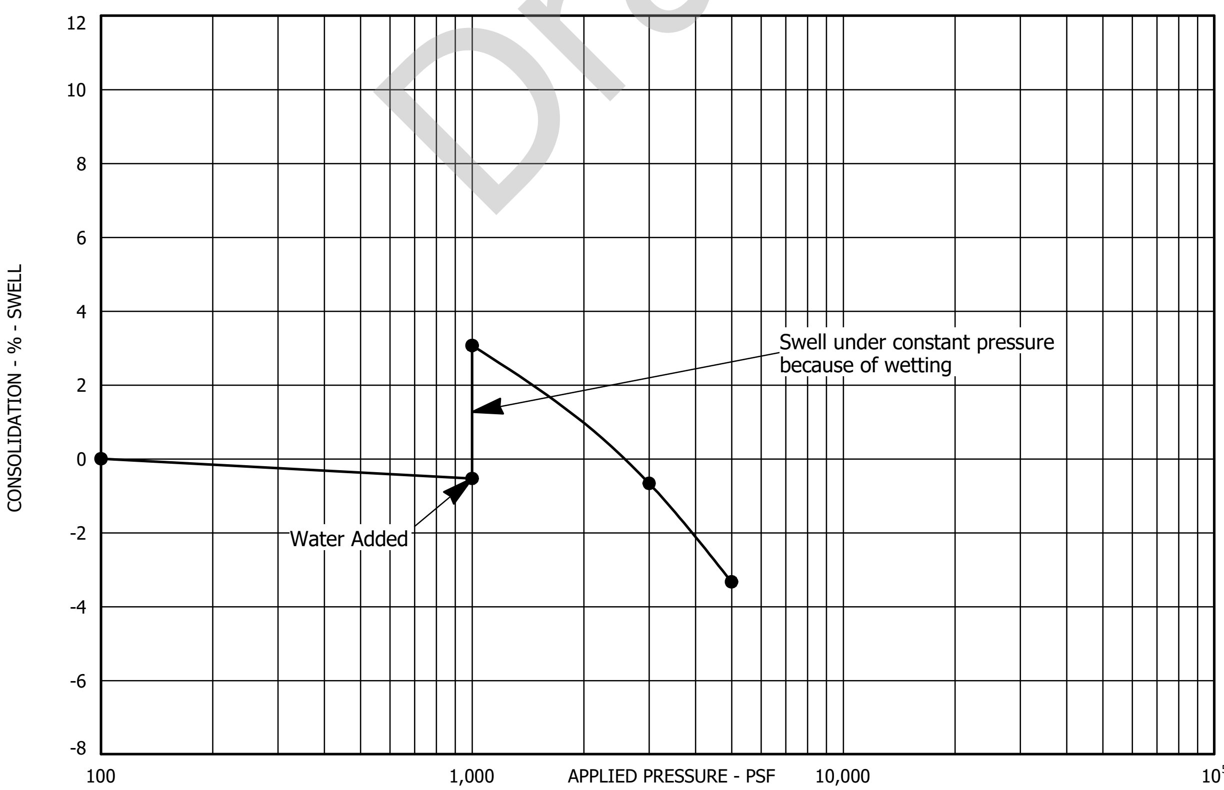
FIGURE A-3

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 3 at a depth of 9 feet	Dry Unit Weight (pcf)	105
Sample Description	Claystone, slightly sandy	Moisture Content (%)	20



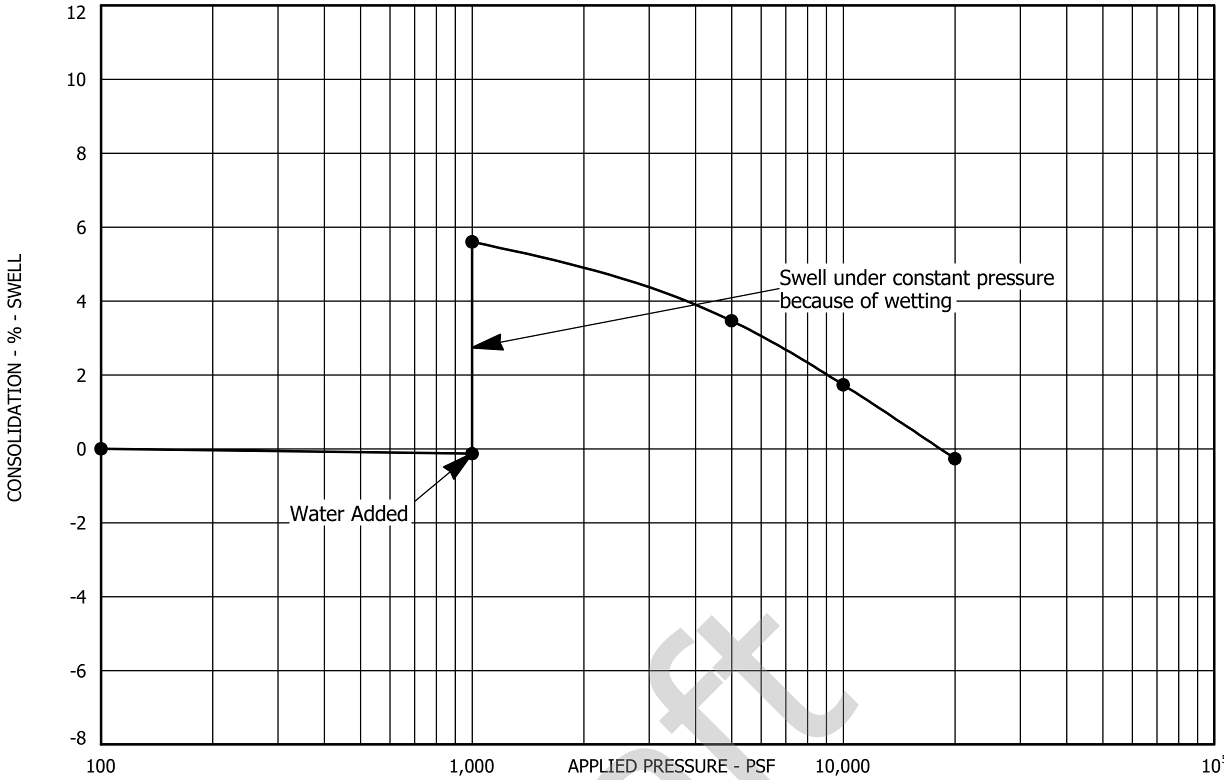
Sample Location	Test Boring No. 3 at a depth of 24 feet	Dry Unit Weight (pcf)	109
Sample Description	Claystone, slightly sandy	Moisture Content (%)	11

SWELL - CONSOLIDATION TEST RESULTS

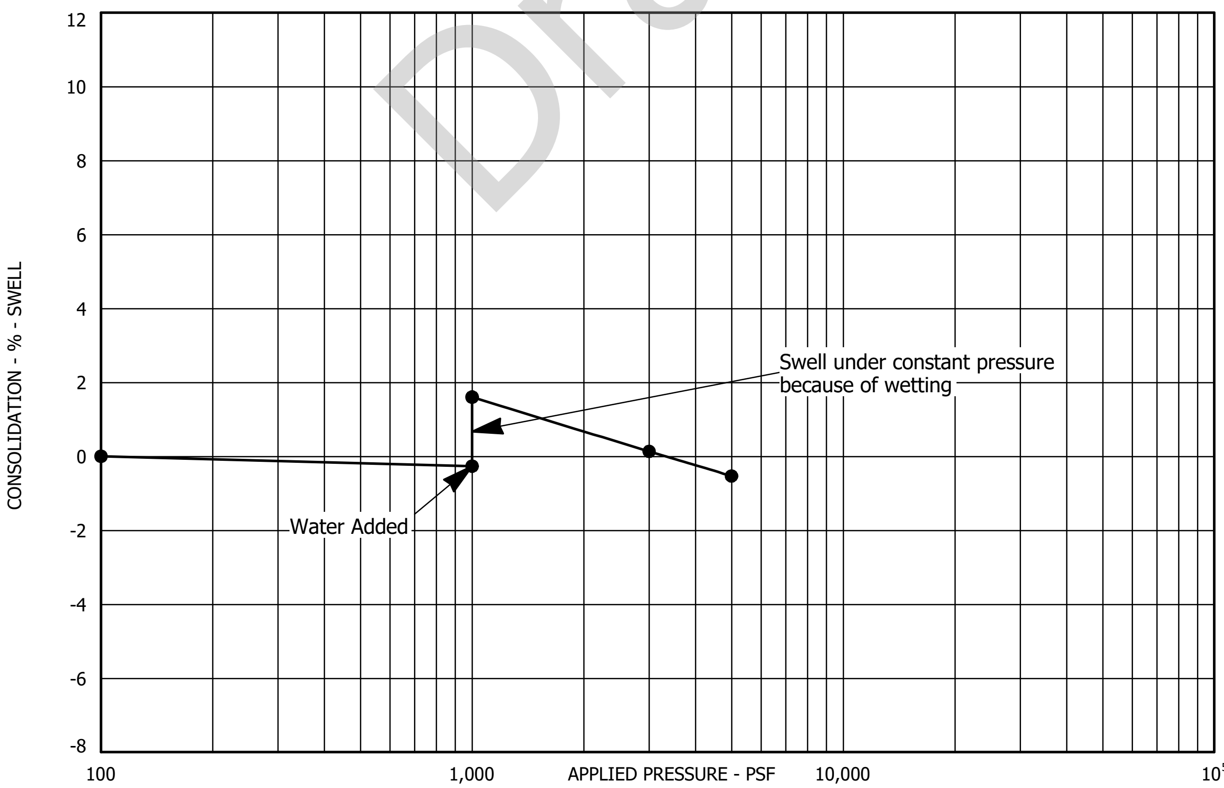
FIGURE A-4

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 4 at a depth of 4 feet	Dry Unit Weight (pcf)	122
Sample Description	Clay, sandy	Moisture Content (%)	13



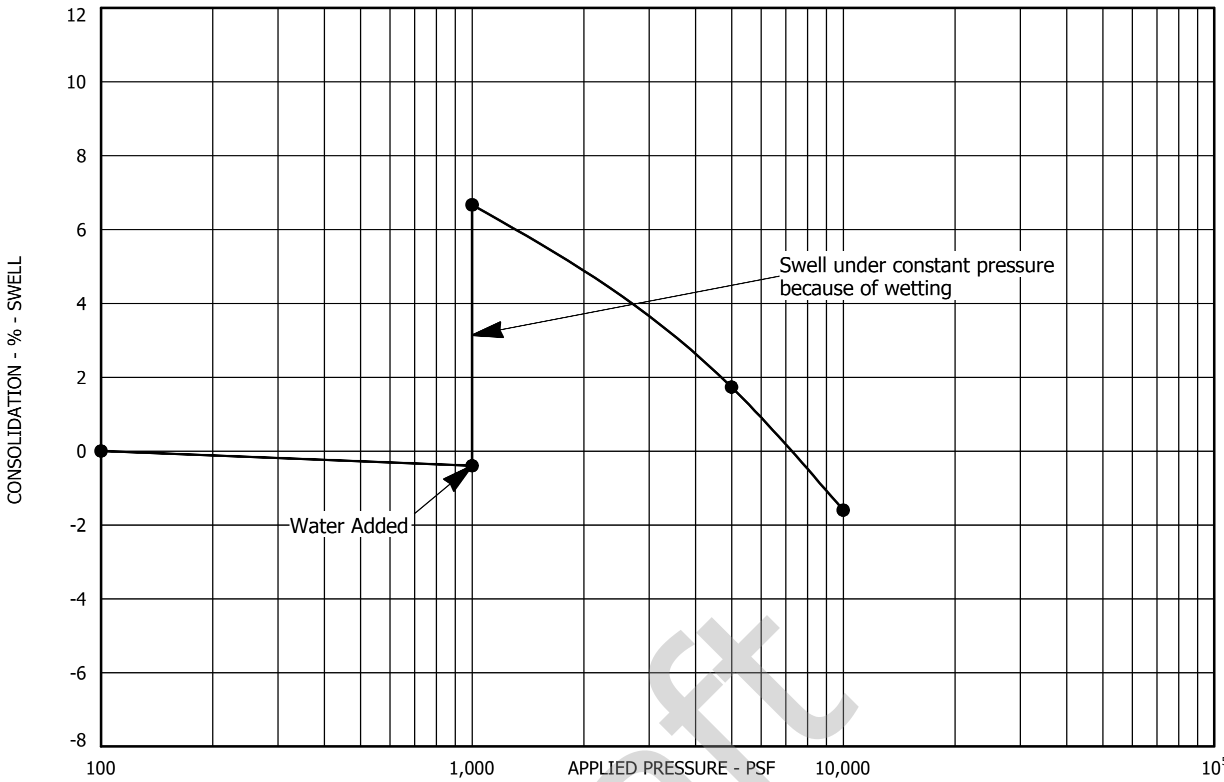
Sample Location	Test Boring No. 4 at a depth of 9 feet	Dry Unit Weight (pcf)	115
Sample Description	Claystone, slightly sandy	Moisture Content (%)	16

SWELL - CONSOLIDATION TEST RESULTS

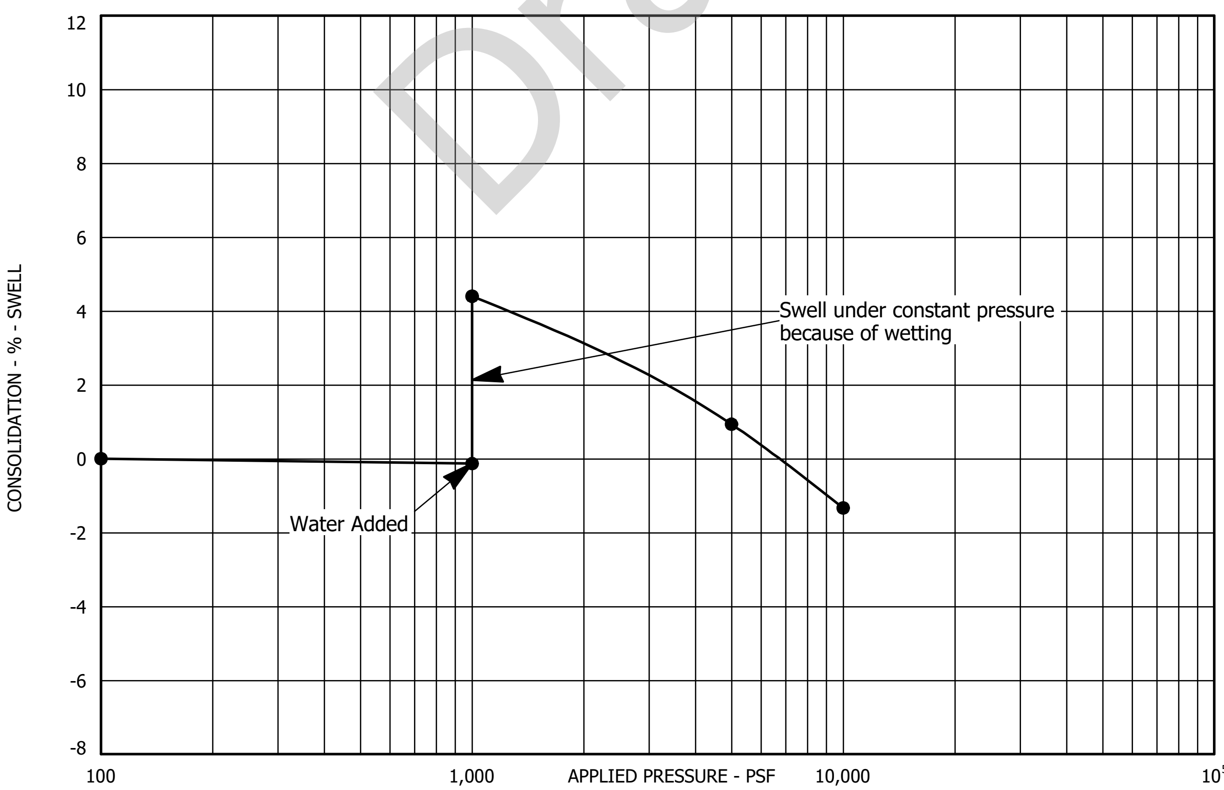
FIGURE A-5

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 4 at a depth of 14 feet	Dry Unit Weight (pcf)	110
Sample Description	Claystone, slightly sandy	Moisture Content (%)	17

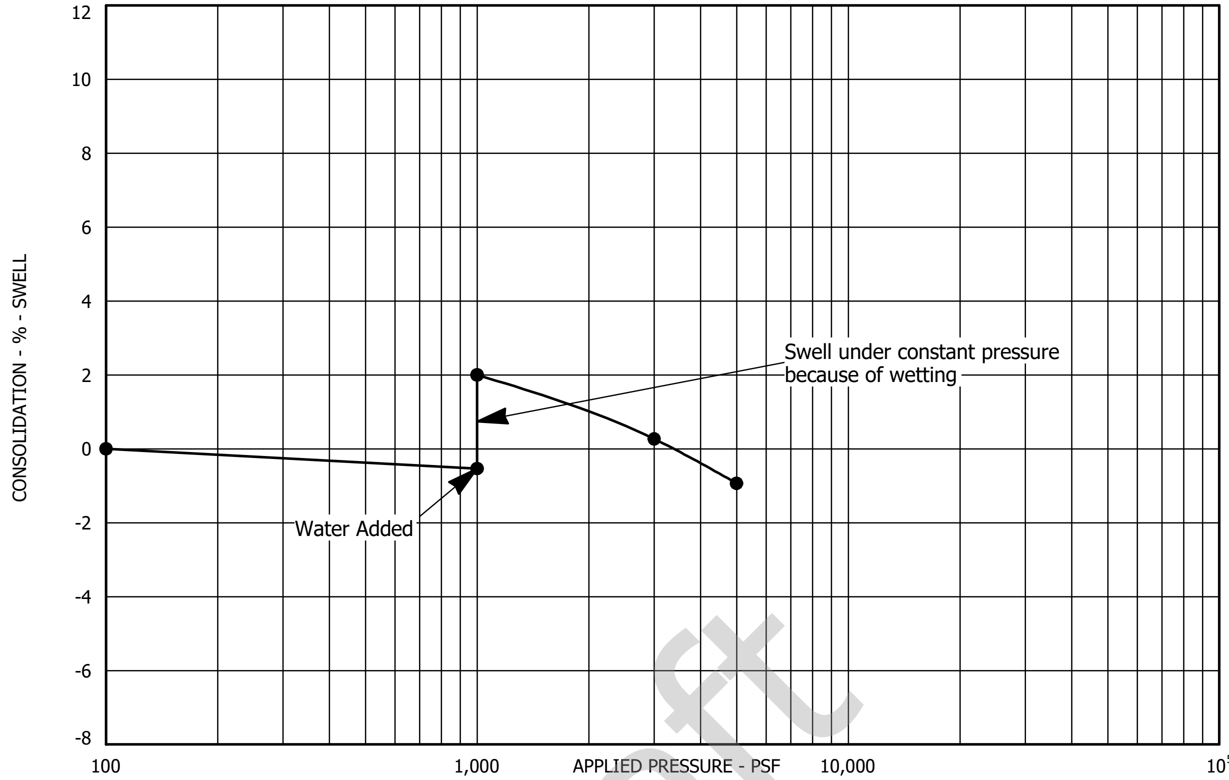


Sample Location	Test Boring No. 5 at a depth of 4 feet	Dry Unit Weight (pcf)	115
Sample Description	Clay, sandy	Moisture Content (%)	12

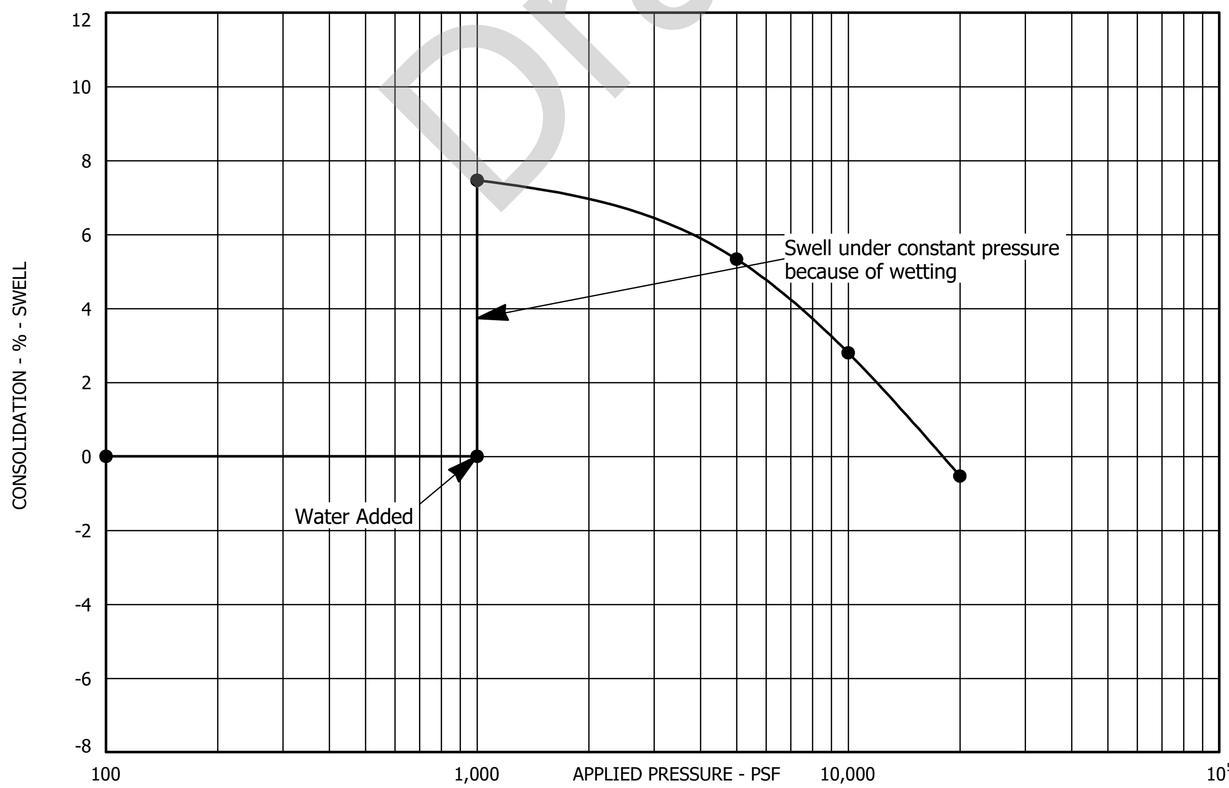
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-6

PROJECT NO. 202523



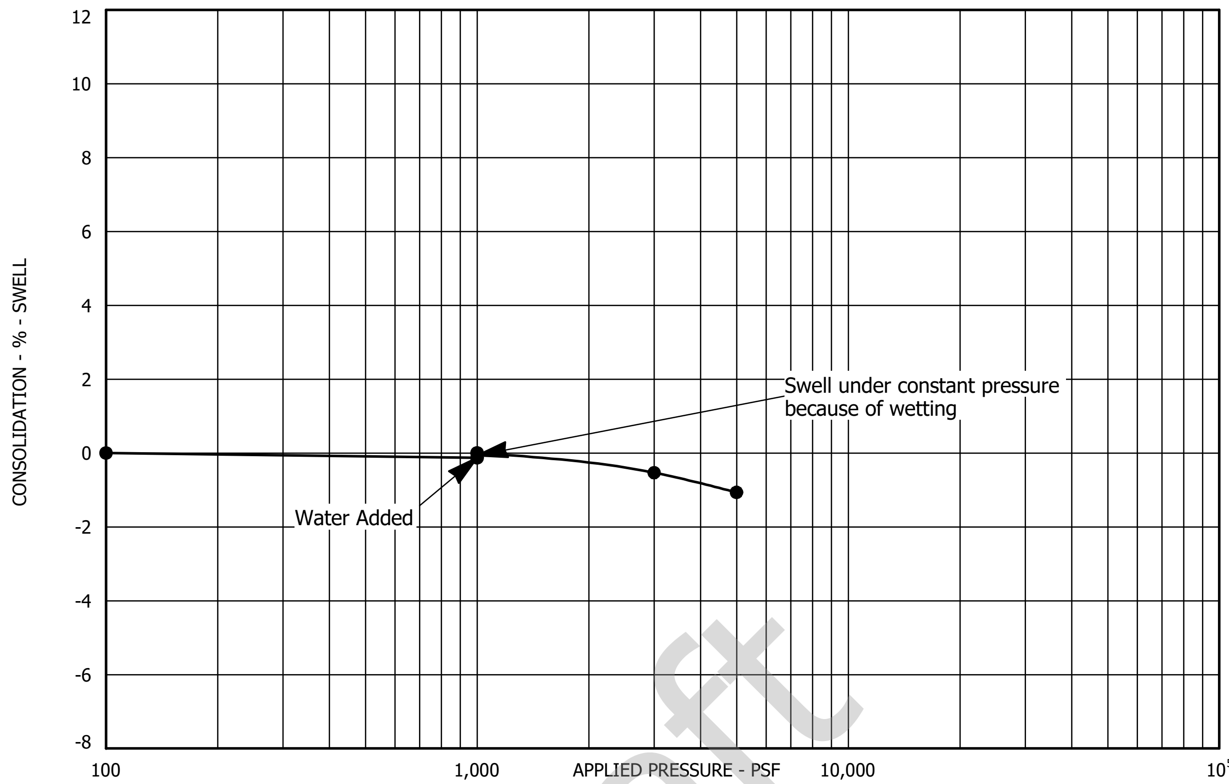
Sample Location: Test Boring No. 5 at a depth of 9 feet | Dry Unit Weight (pcf): 112
Sample Description: Claystone, slightly sandy | Moisture Content (%): 17



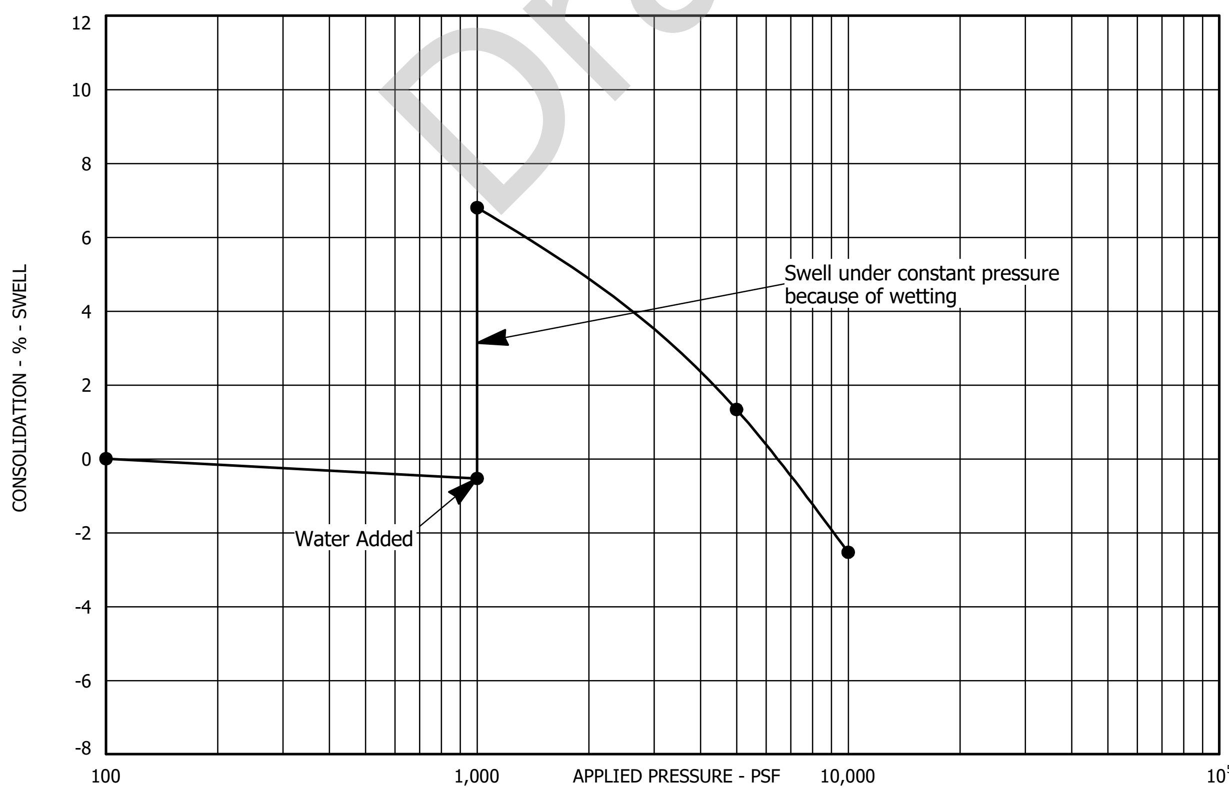
Sample Location: Test Boring No. 6 at a depth of 4 feet | Dry Unit Weight (pcf): 118
Sample Description: Clay, sandy | Moisture Content (%): 12

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-7



Sample Location: Test Boring No. 6 at a depth of 9 feet
Sample Description: Claystone/Sandstone, silty
Dry Unit Weight (pcf): 115
Moisture Content (%): 11



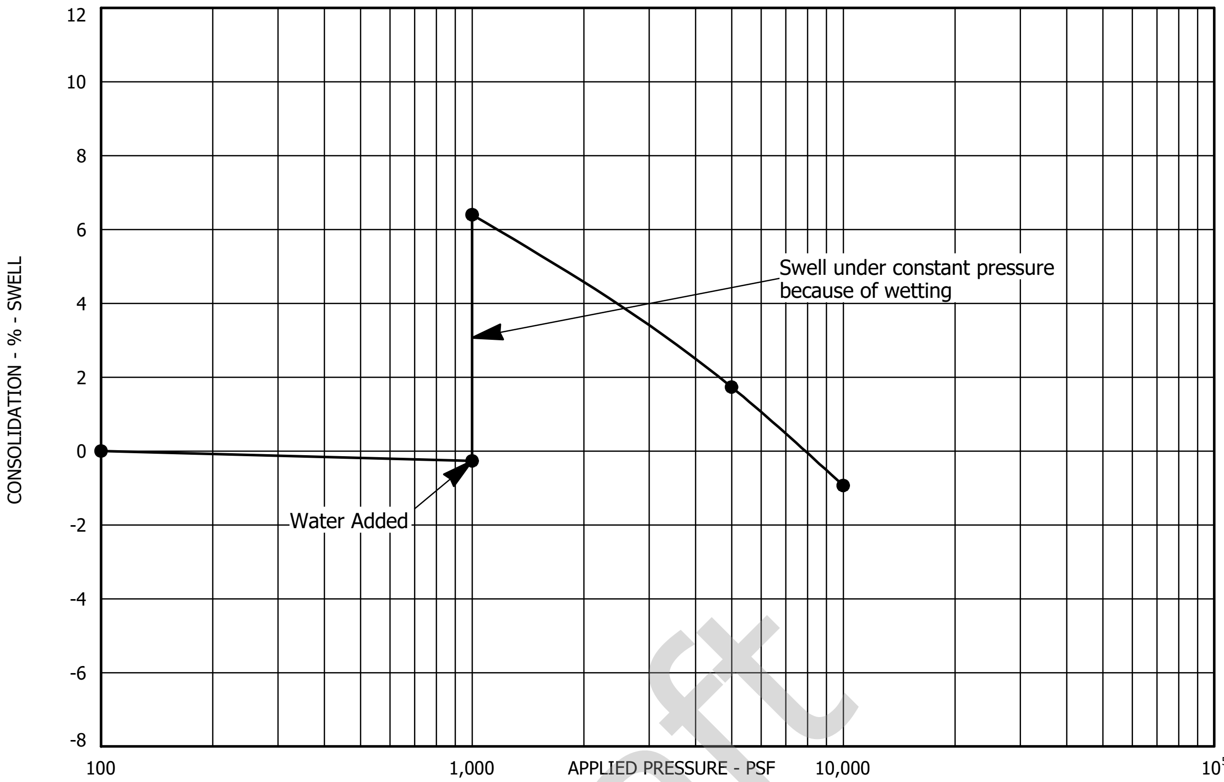
Sample Location: Test Boring No. 6 at a depth of 24 feet
Sample Description: Claystone, slightly sandy
Dry Unit Weight (pcf): 109
Moisture Content (%): 15

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-8

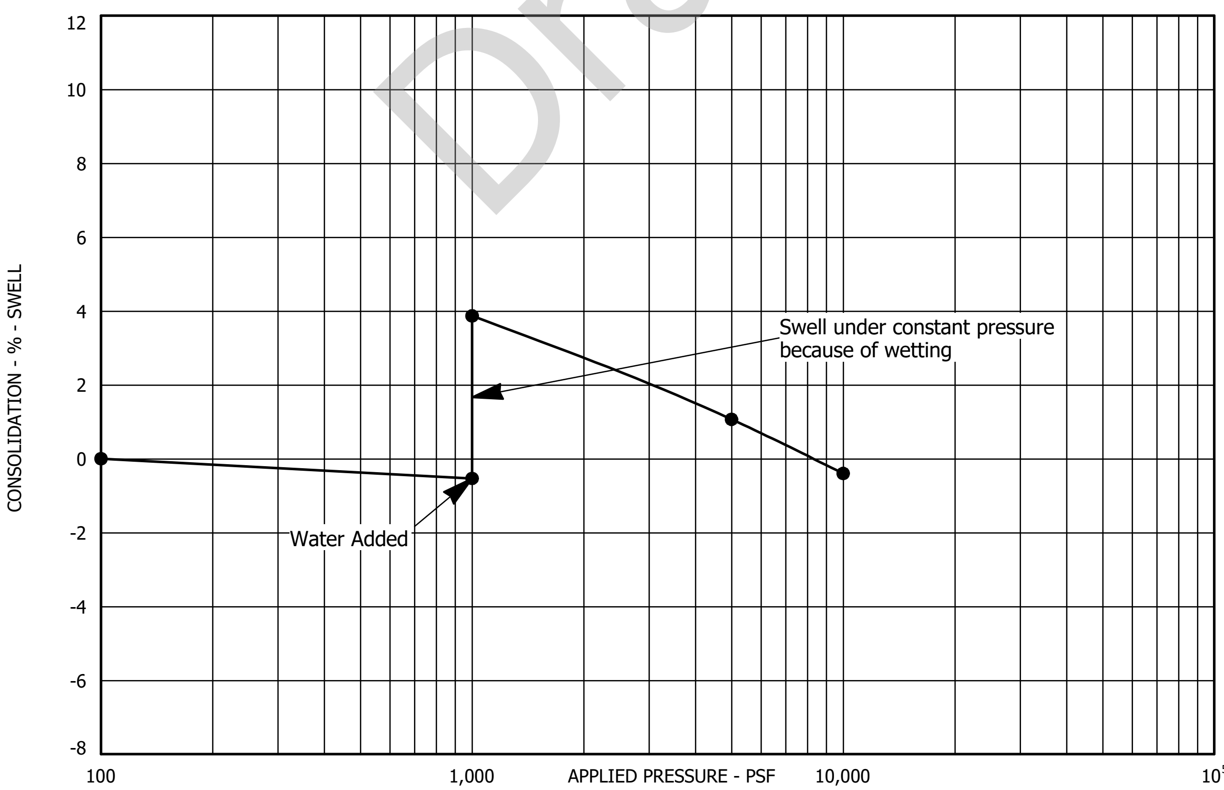
PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 7 at a depth of 4 feet — Dry Unit Weight (pcf): 107

Sample Description: Claystone, slightly sandy — Moisture Content (%): 17



Sample Location: Test Boring No. 7 at a depth of 9 feet — Dry Unit Weight (pcf): 122

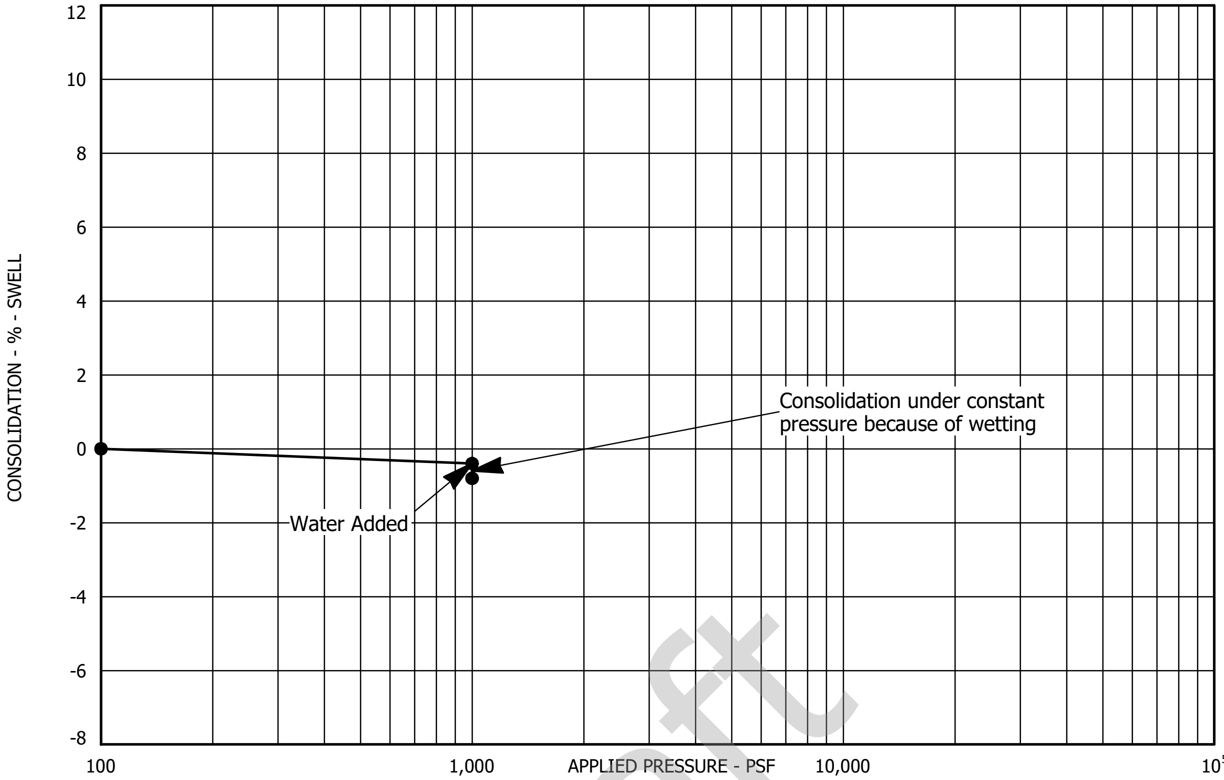
Sample Description: Claystone, slightly sandy — Moisture Content (%): 13

SWELL - CONSOLIDATION TEST RESULTS

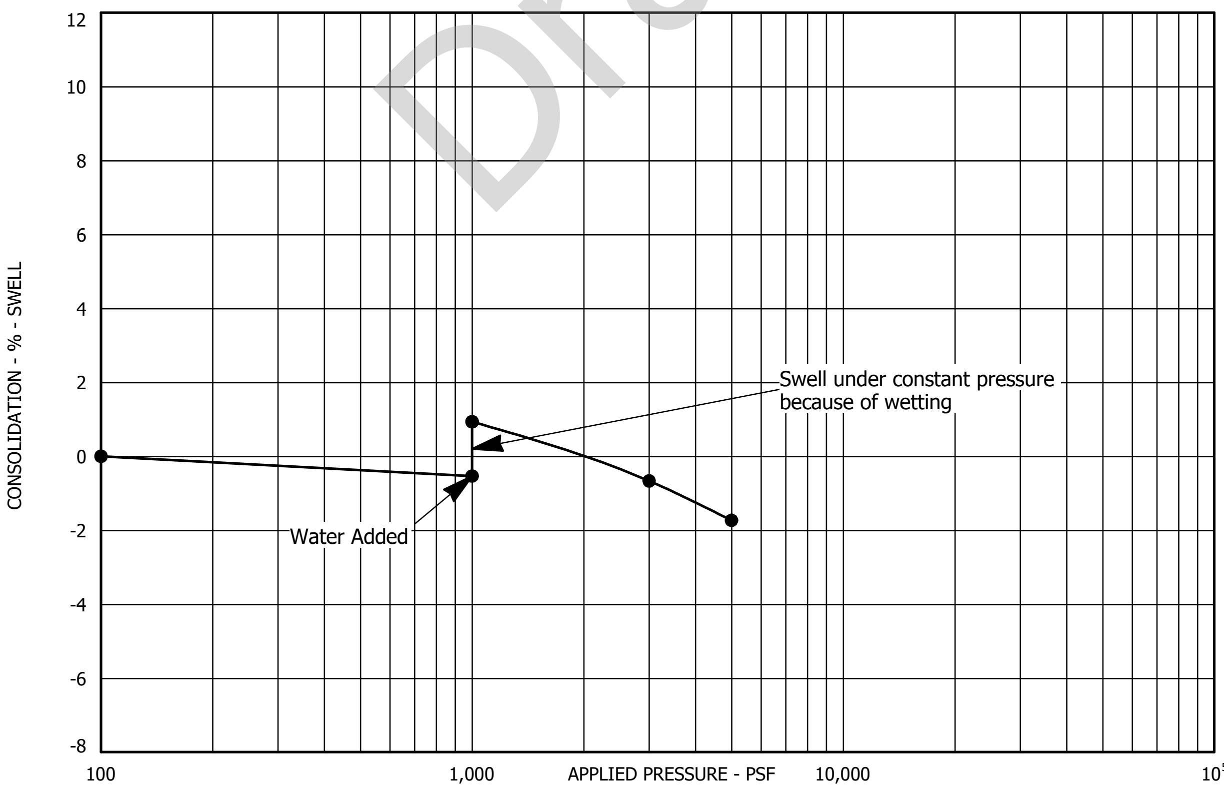
FIGURE A-9

PROJECT NO. 202523

AGW
A.G. WASSENAAR, INC.



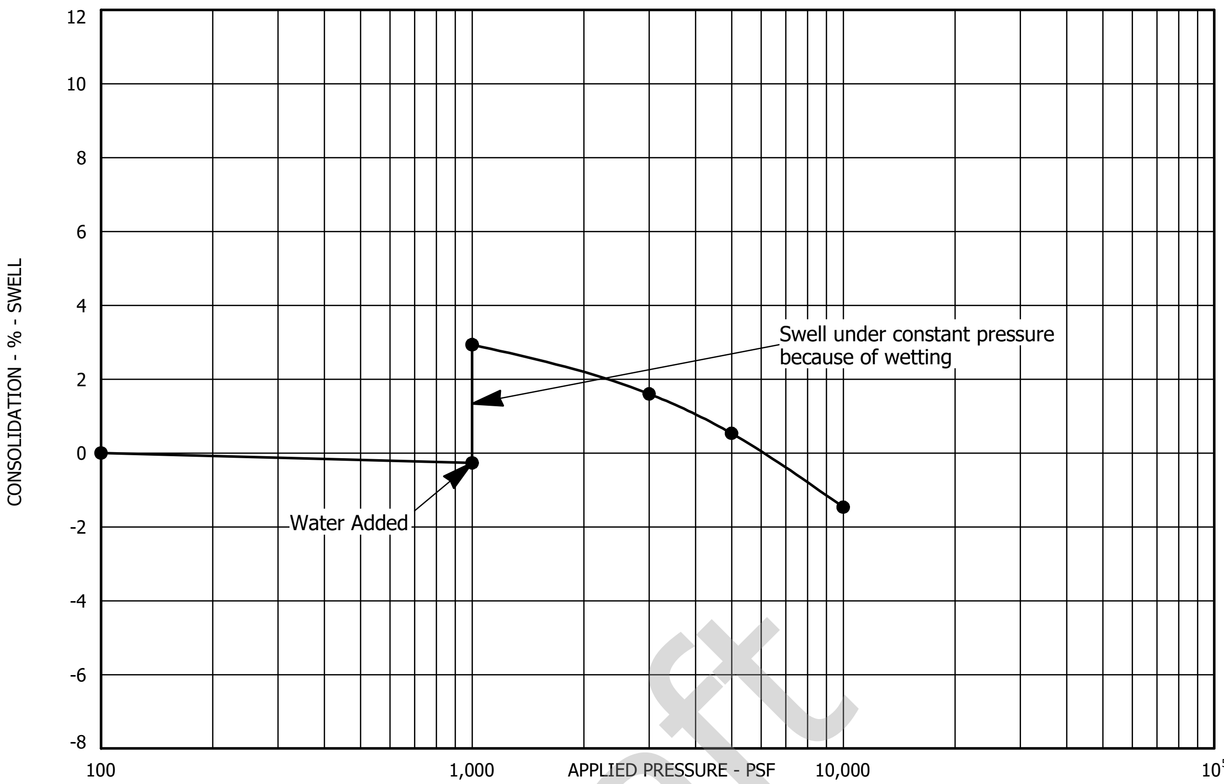
Sample Location	Test Boring No. 8 at a depth of 4 feet	Dry Unit Weight (pcf)	94
Sample Description	Clay, sandy	Moisture Content (%)	22



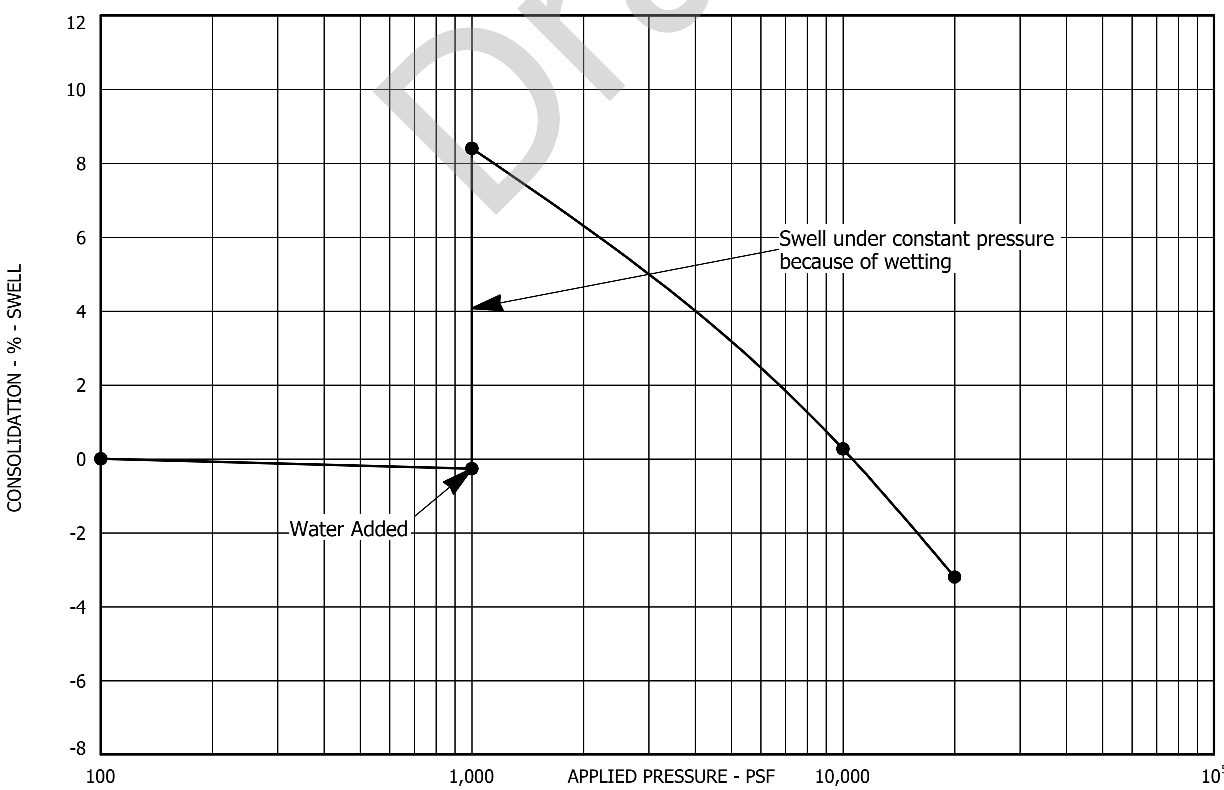
Sample Location	Test Boring No. 8 at a depth of 9 feet	Dry Unit Weight (pcf)	110
Sample Description	Claystone, slightly sandy	Moisture Content (%)	18

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-10



Sample Location	Test Boring No. 9 at a depth of 9 feet	Dry Unit Weight (pcf)	111
Sample Description	Claystone, slightly sandy	Moisture Content (%)	17

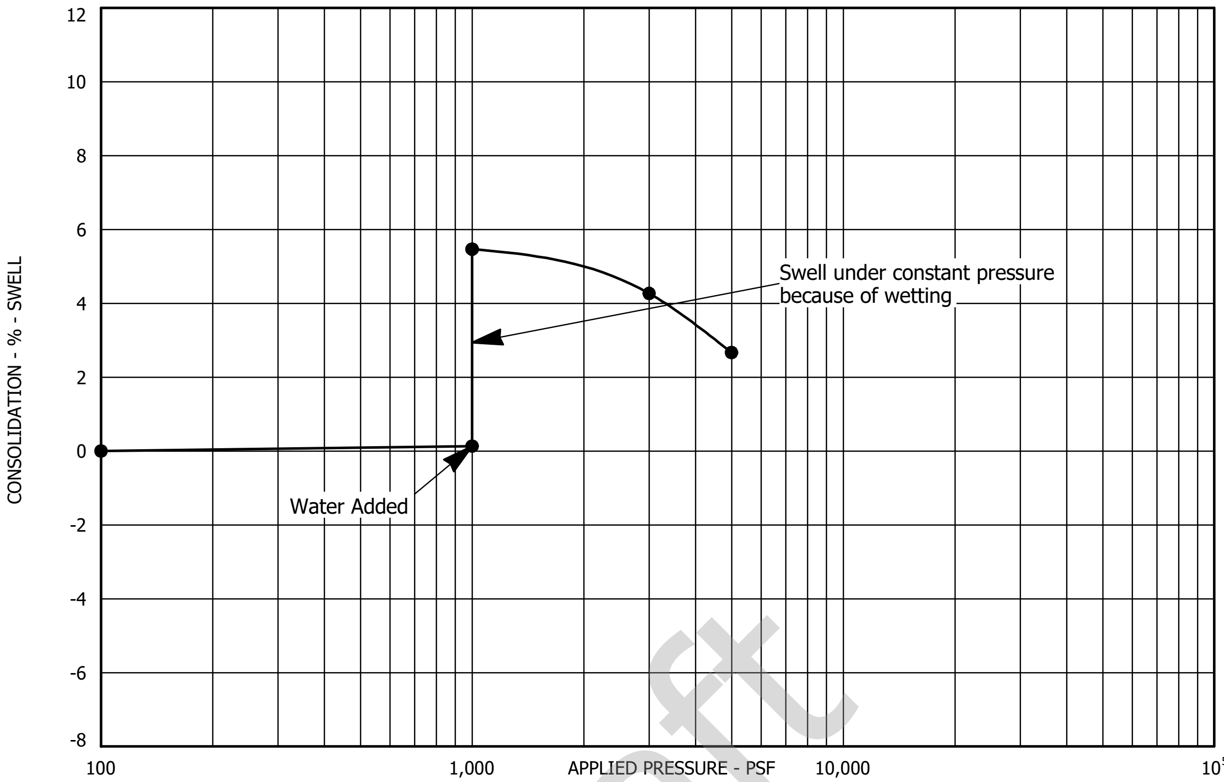


Sample Location	Test Boring No. 9 at a depth of 19 feet	Dry Unit Weight (pcf)	106
Sample Description	Claystone, slightly sandy	Moisture Content (%)	21

SWELL - CONSOLIDATION TEST RESULTS

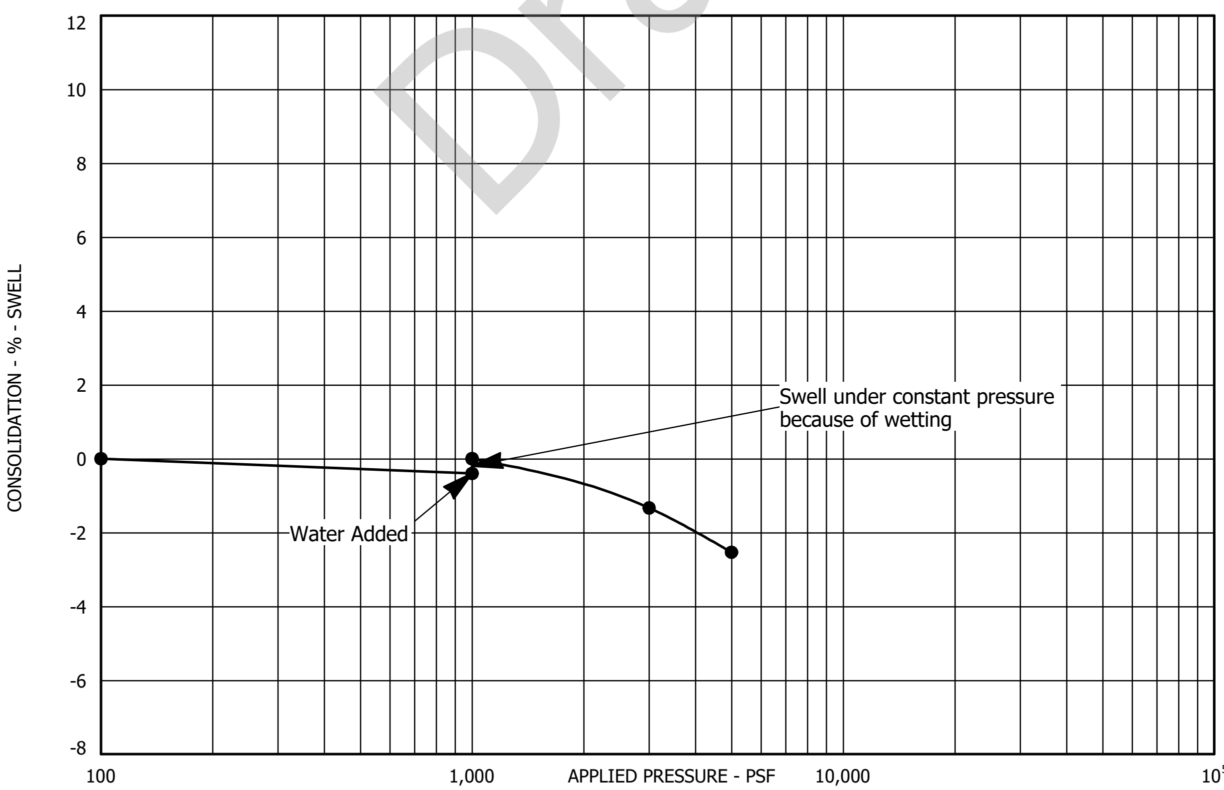
FIGURE A-11

A.G. WASSENAAR, INC.



Sample Location ___ Test Boring No. 10 at a depth of 4 feet ___ Dry Unit Weight (pcf) ___ 118

Sample Description ___ Clay, sandy ___ Moisture Content (%) ___ 13



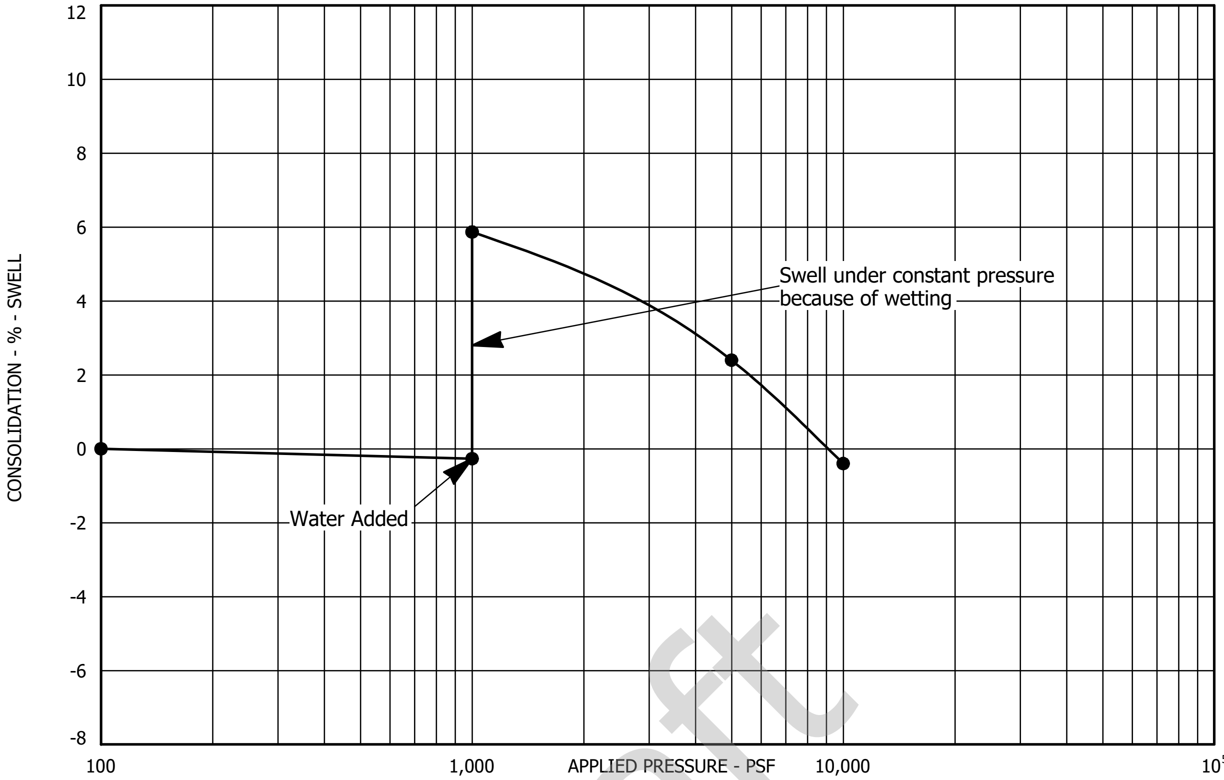
Sample Location ___ Test Boring No. 10 at a depth of 9 feet ___ Dry Unit Weight (pcf) ___ 113

Sample Description ___ Clay, sandy ___ Moisture Content (%) ___ 16

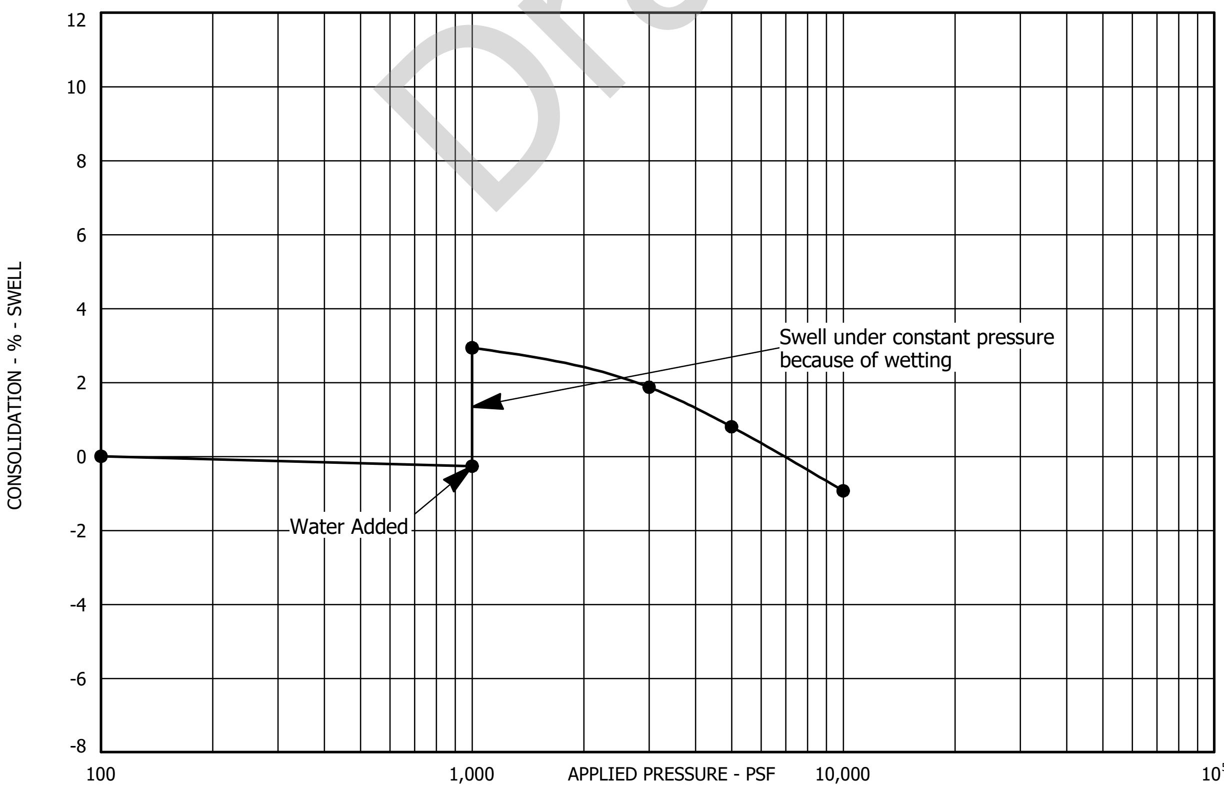
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-12

PROJECT NO. 202523



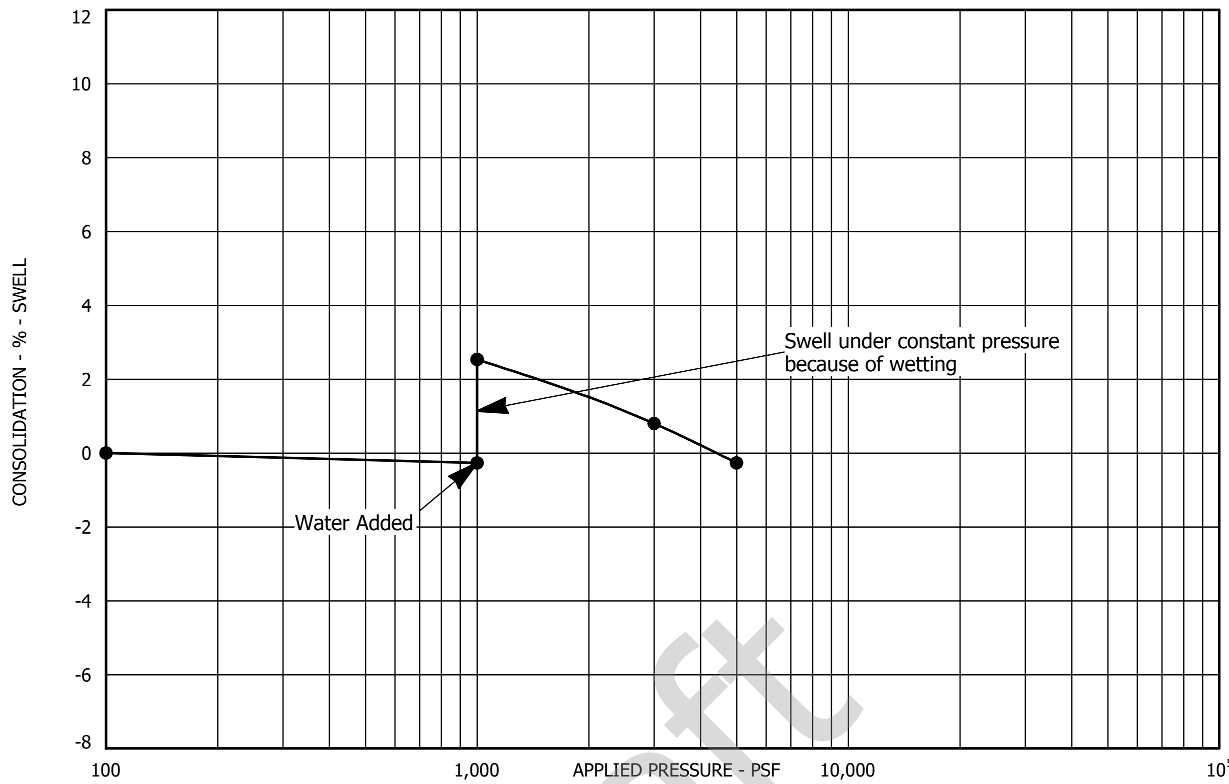
Sample Location	Test Boring No. 10 at a depth of 14 feet	Dry Unit Weight (pcf)	109
Sample Description	Claystone, slightly sandy	Moisture Content (%)	19



Sample Location	Test Boring No. 11 at a depth of 4 feet	Dry Unit Weight (pcf)	114
Sample Description	Clay, sandy	Moisture Content (%)	12

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-13

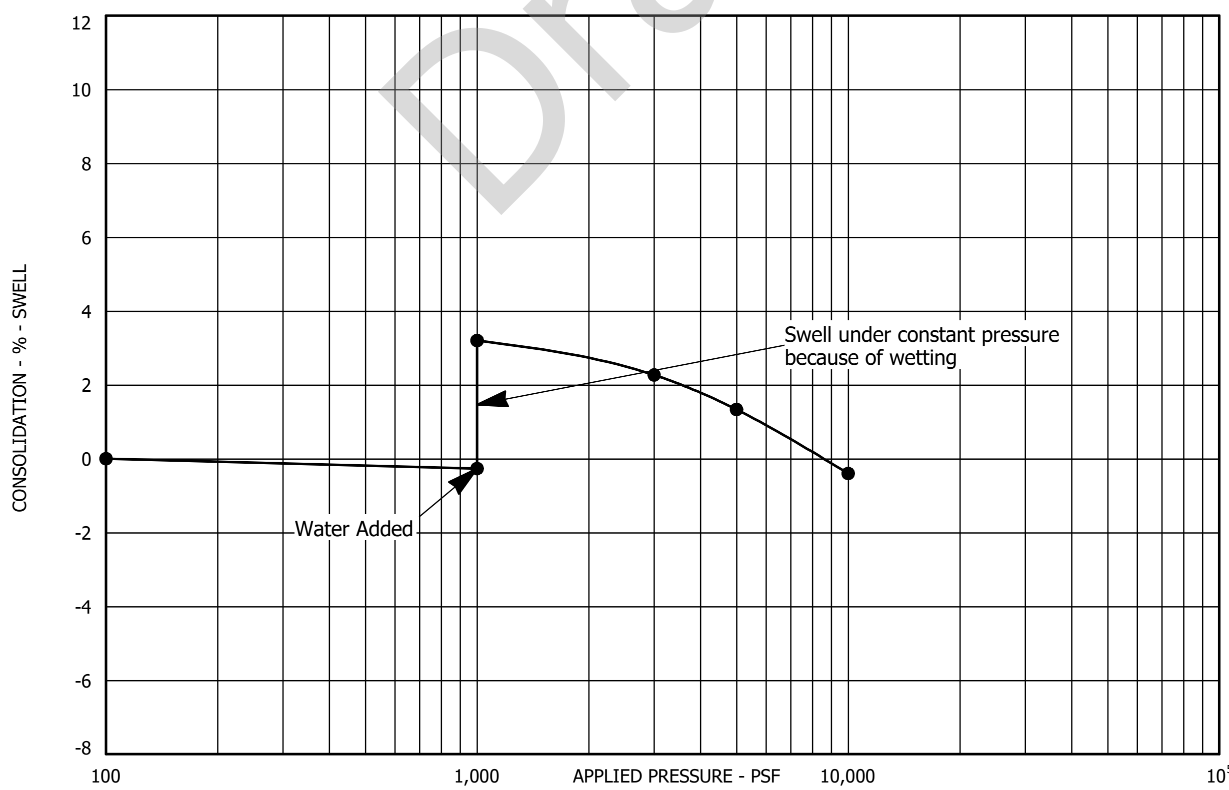


Sample Location Test Boring No. 11 at a depth of 9 feet

Sample Description Claystone, slightly sandy

Dry Unit Weight (pcf) 103

Moisture Content (%) 21



Sample Location Test Boring No. 12 at a depth of 9 feet

Sample Description Clay, sandy

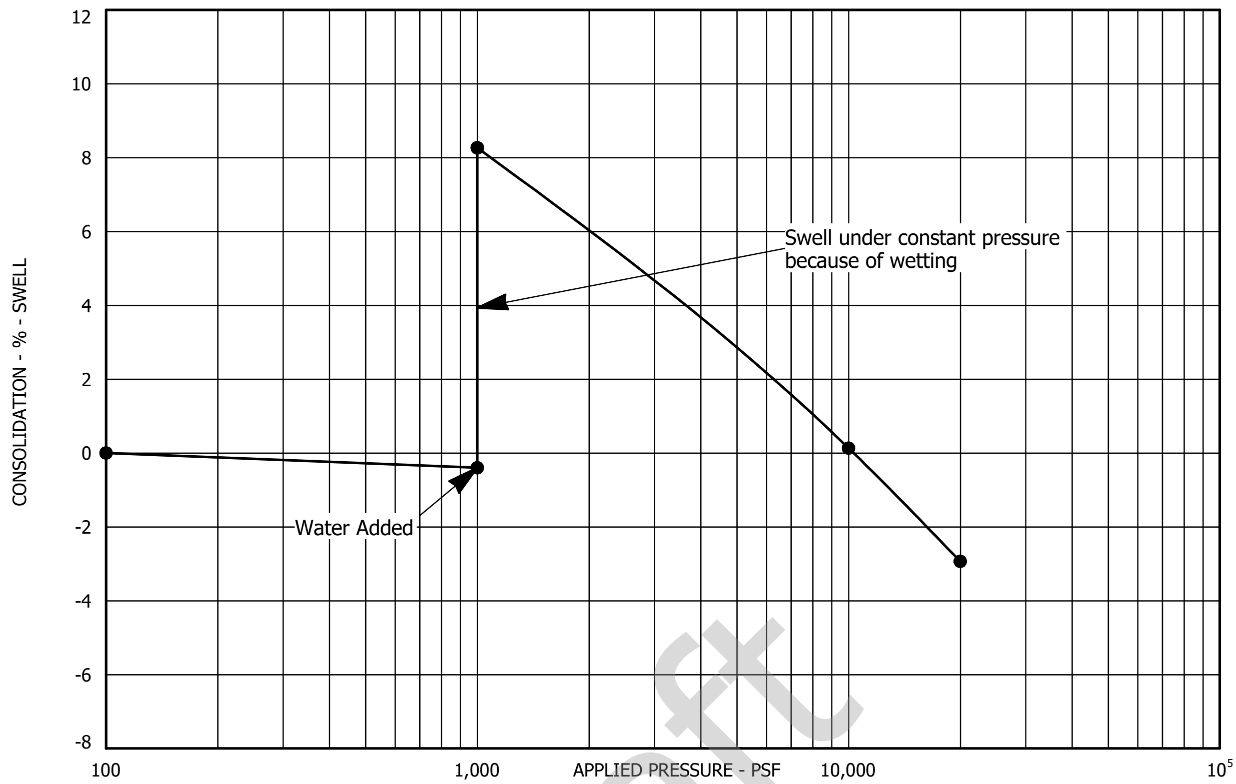
Dry Unit Weight (pcf) 127

Moisture Content (%) 11

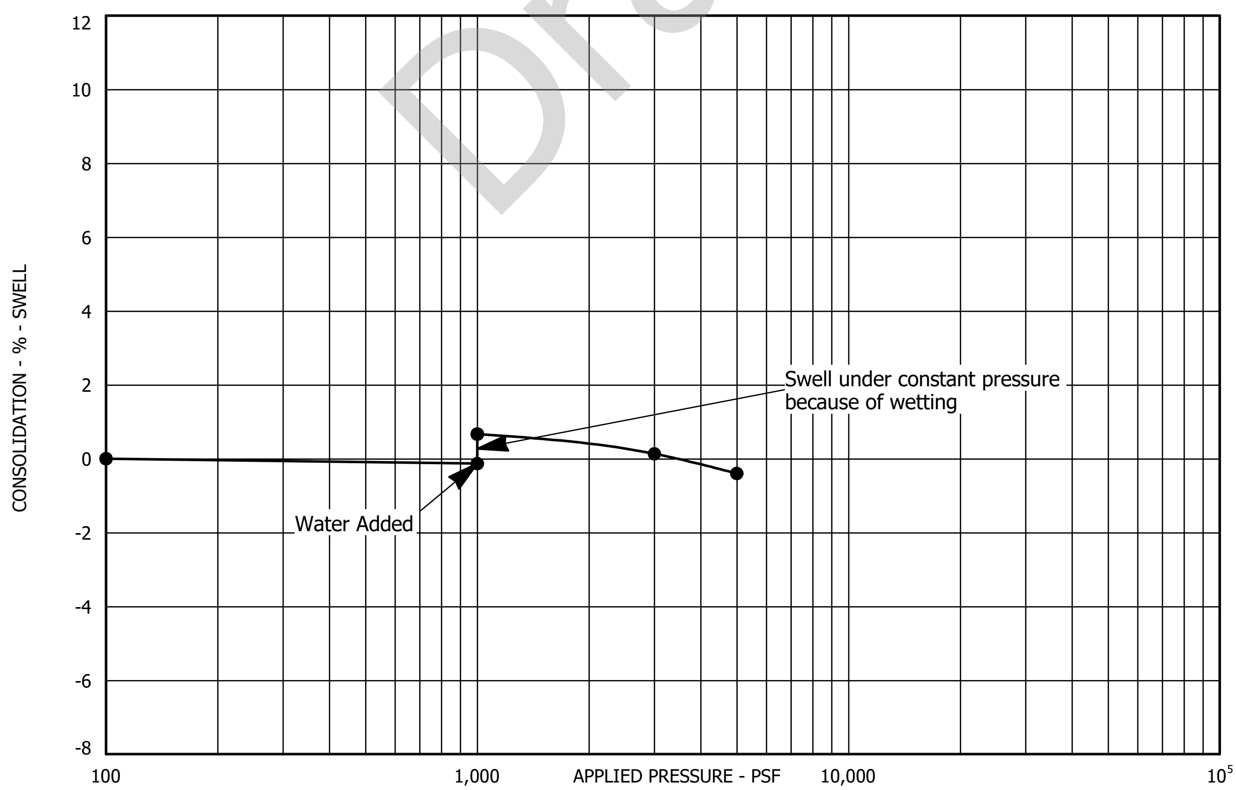
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-14

PROJECT NO. 202523



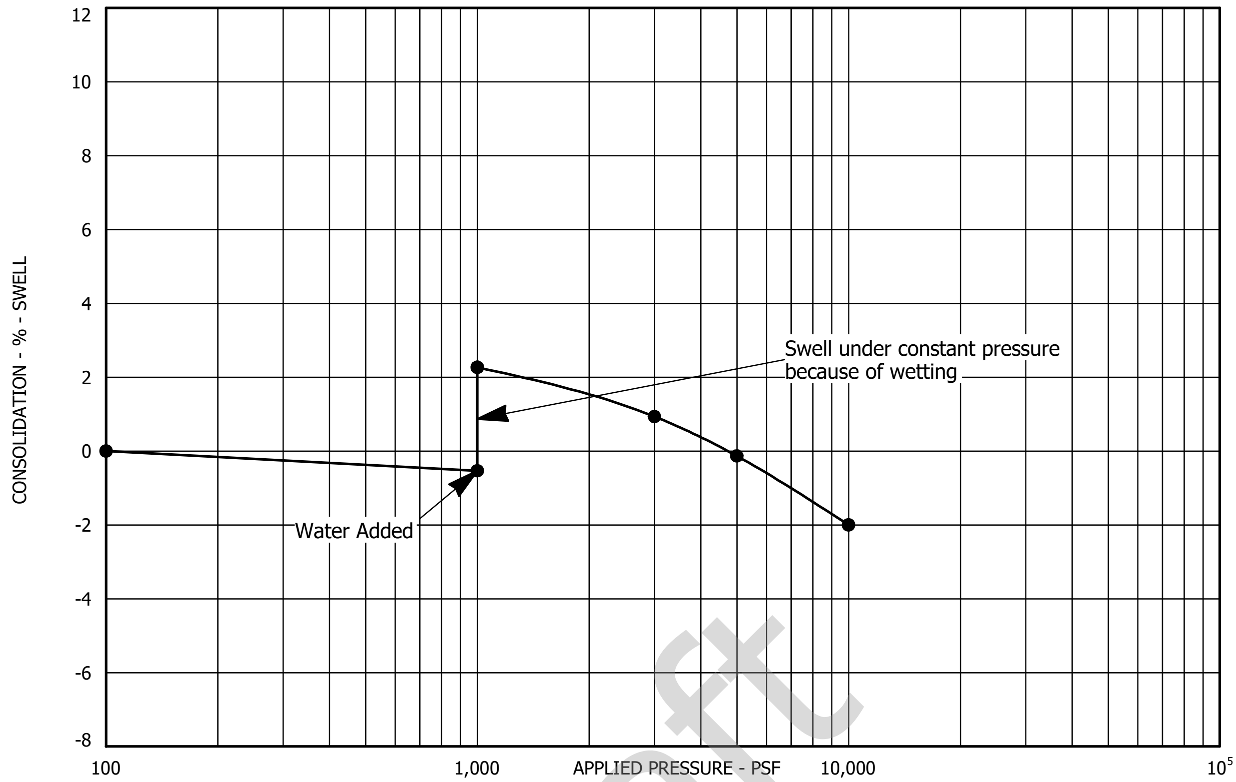
Sample Location	Test Boring No. 12 at a depth of 14 feet	Dry Unit Weight (pcf)	107
Sample Description	Claystone, slightly sandy	Moisture Content (%)	15



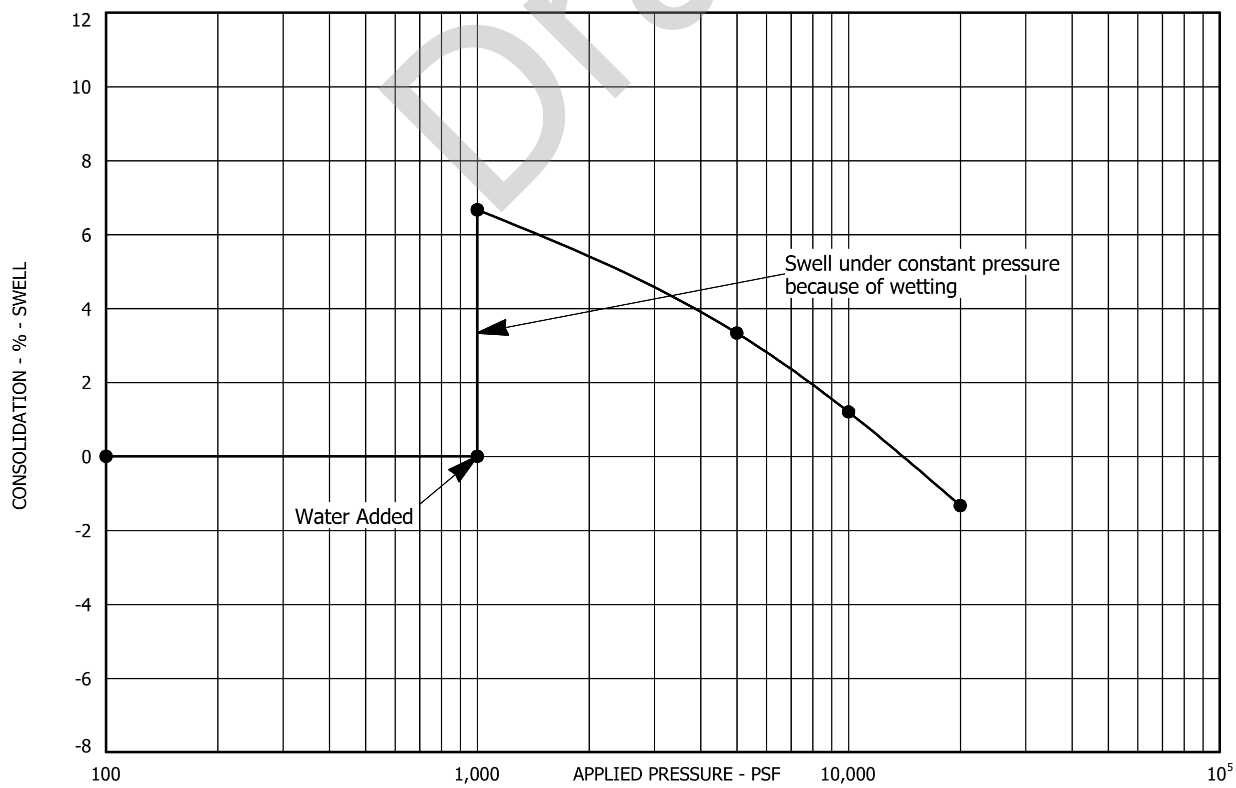
Sample Location	Test Boring No. 13 at a depth of 4 feet	Dry Unit Weight (pcf)	114
Sample Description	Clay, sandy	Moisture Content (%)	12

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-15



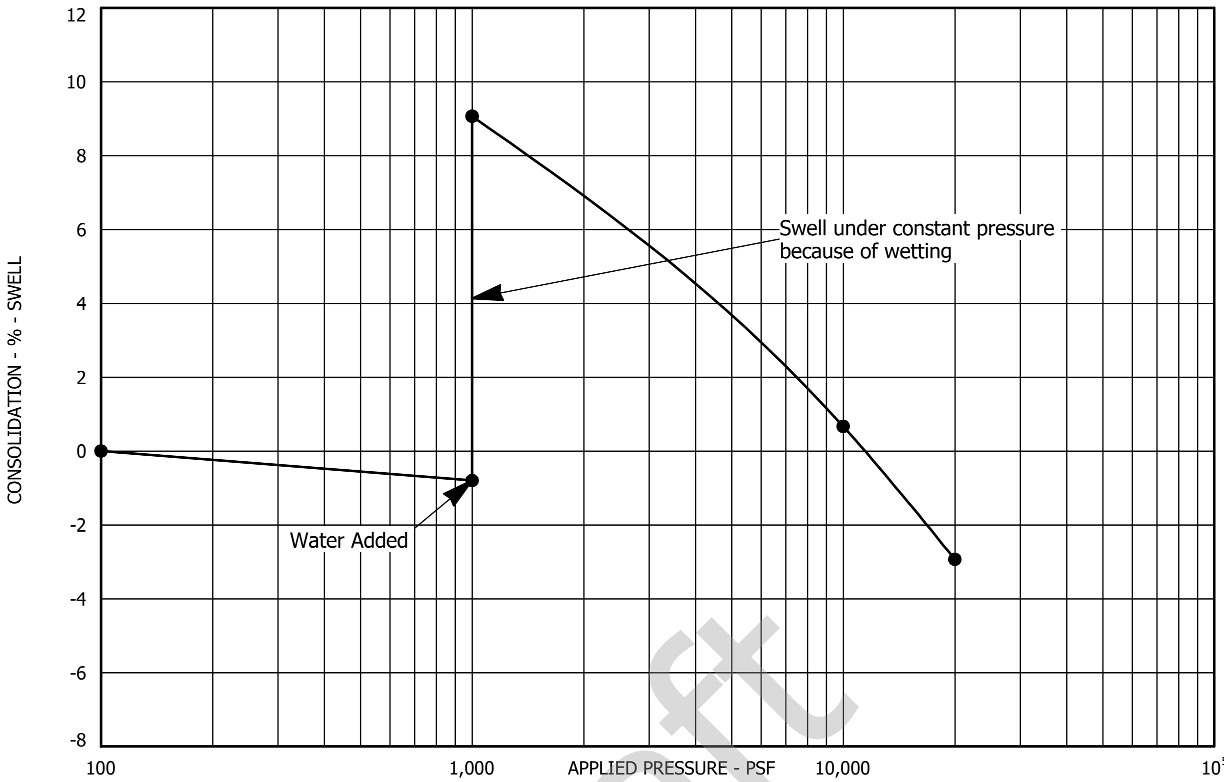
Sample Location	Test Boring No. 13 at a depth of 9 feet	Dry Unit Weight (pcf)	109
Sample Description	Claystone, slightly sandy	Moisture Content (%)	20



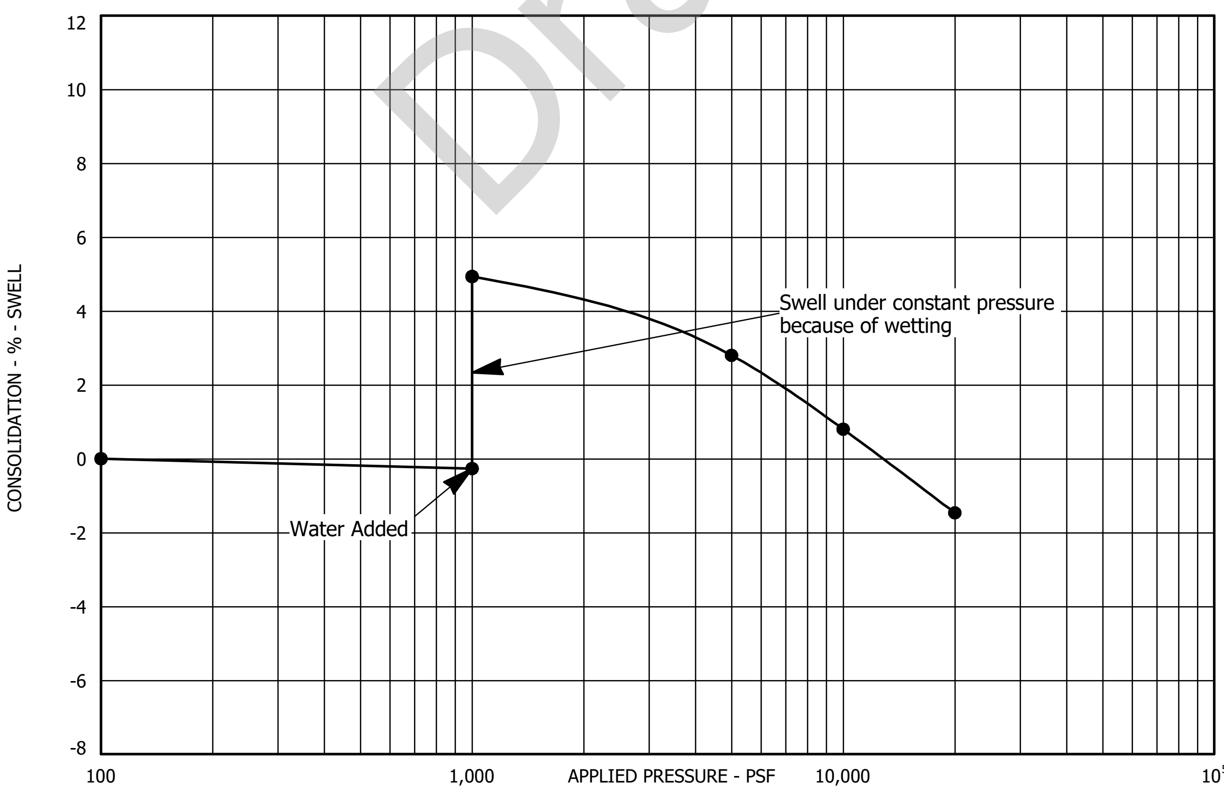
Sample Location	Test Boring No. 14 at a depth of 4 feet	Dry Unit Weight (pcf)	121
Sample Description	Clay, sandy	Moisture Content (%)	10

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-16



Sample Location: Test Boring No. 14 at a depth of 24 feet
Dry Unit Weight (pcf): 107
Sample Description: Claystone, slightly sandy
Moisture Content (%): 19



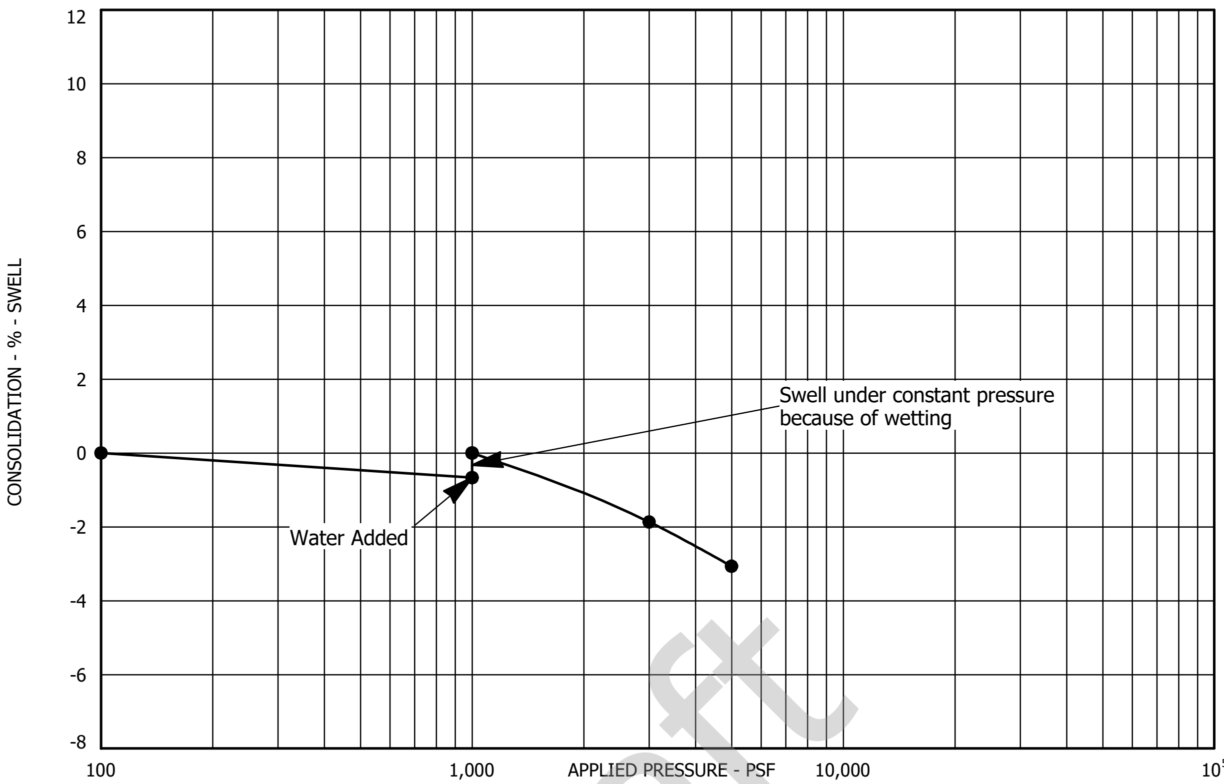
Sample Location: Test Boring No. 15 at a depth of 4 feet
Dry Unit Weight (pcf): 119
Sample Description: Clay, sandy
Moisture Content (%): 14

SWELL - CONSOLIDATION TEST RESULTS

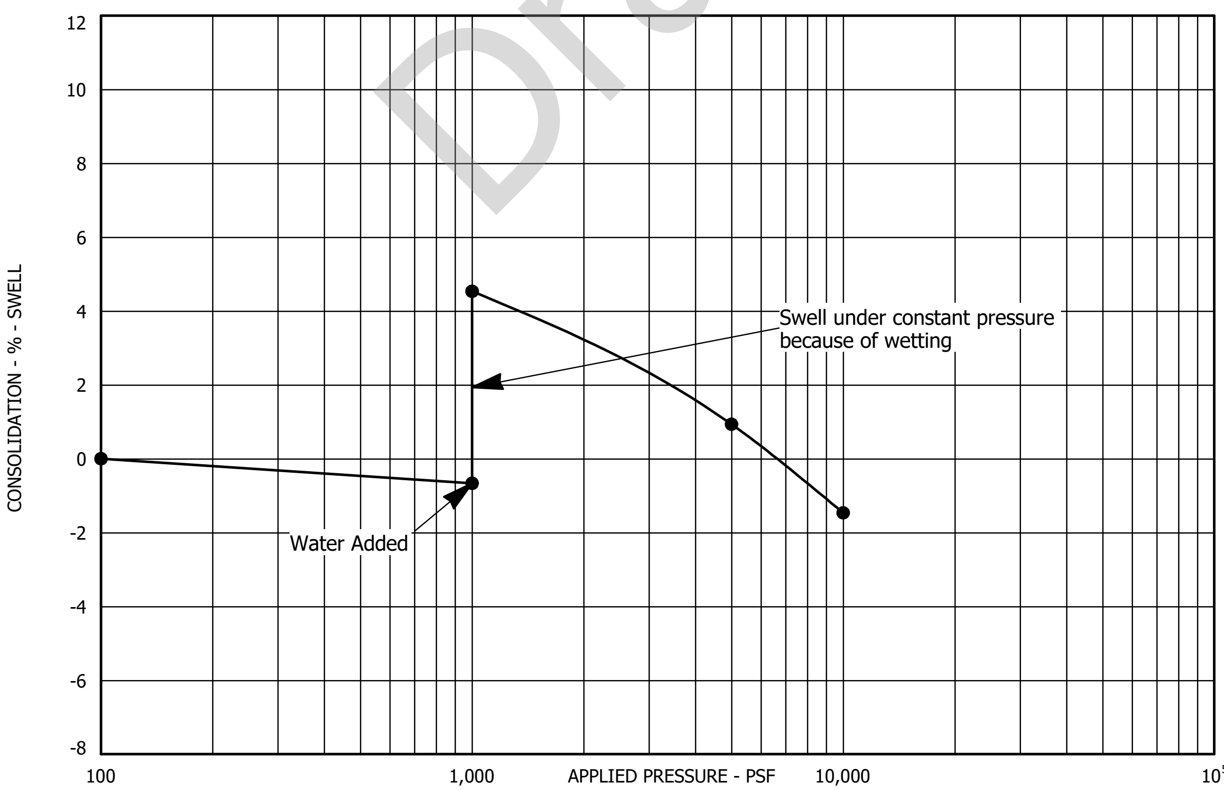
FIGURE A-17

PROJECT NO. 202523

AGW
A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 15 at a depth of 9 feet	Dry Unit Weight (pcf)	112
Sample Description	Claystone, sandy, trace gravel	Moisture Content (%)	15



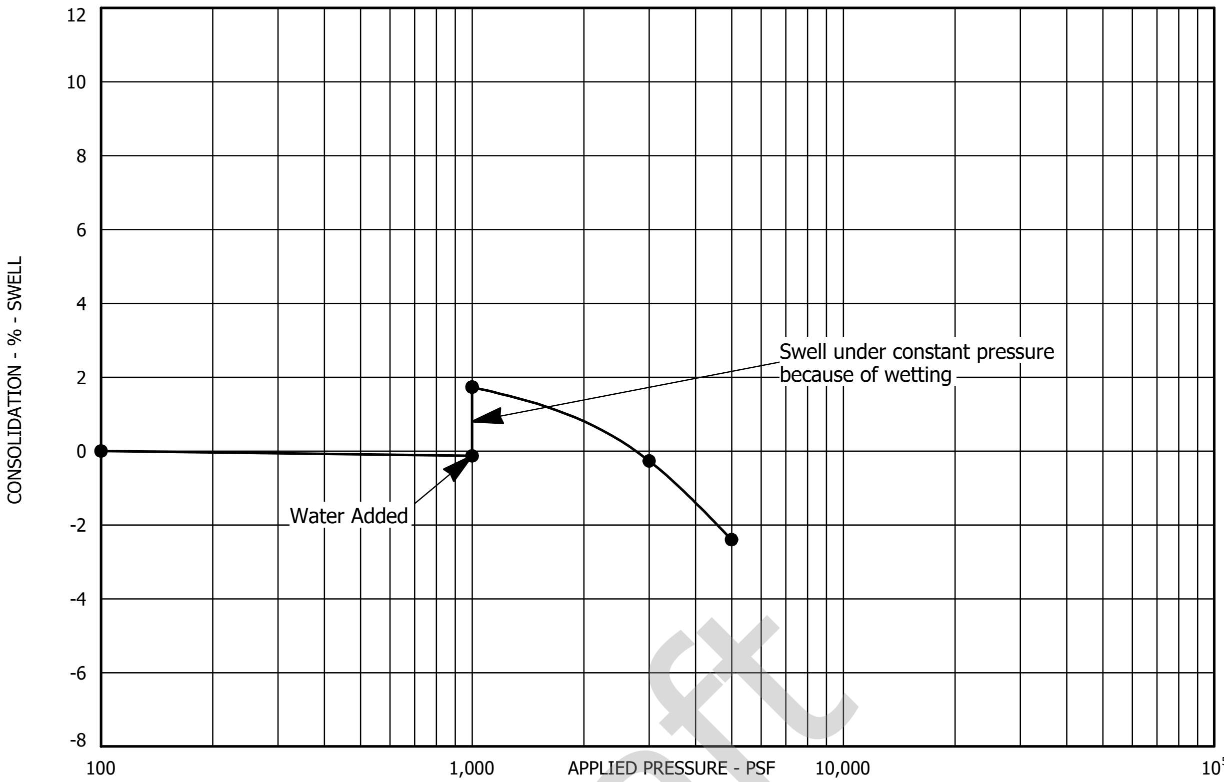
Sample Location	Test Boring No. 15 at a depth of 19 feet	Dry Unit Weight (pcf)	116
Sample Description	Claystone, slightly sandy	Moisture Content (%)	15

SWELL - CONSOLIDATION TEST RESULTS

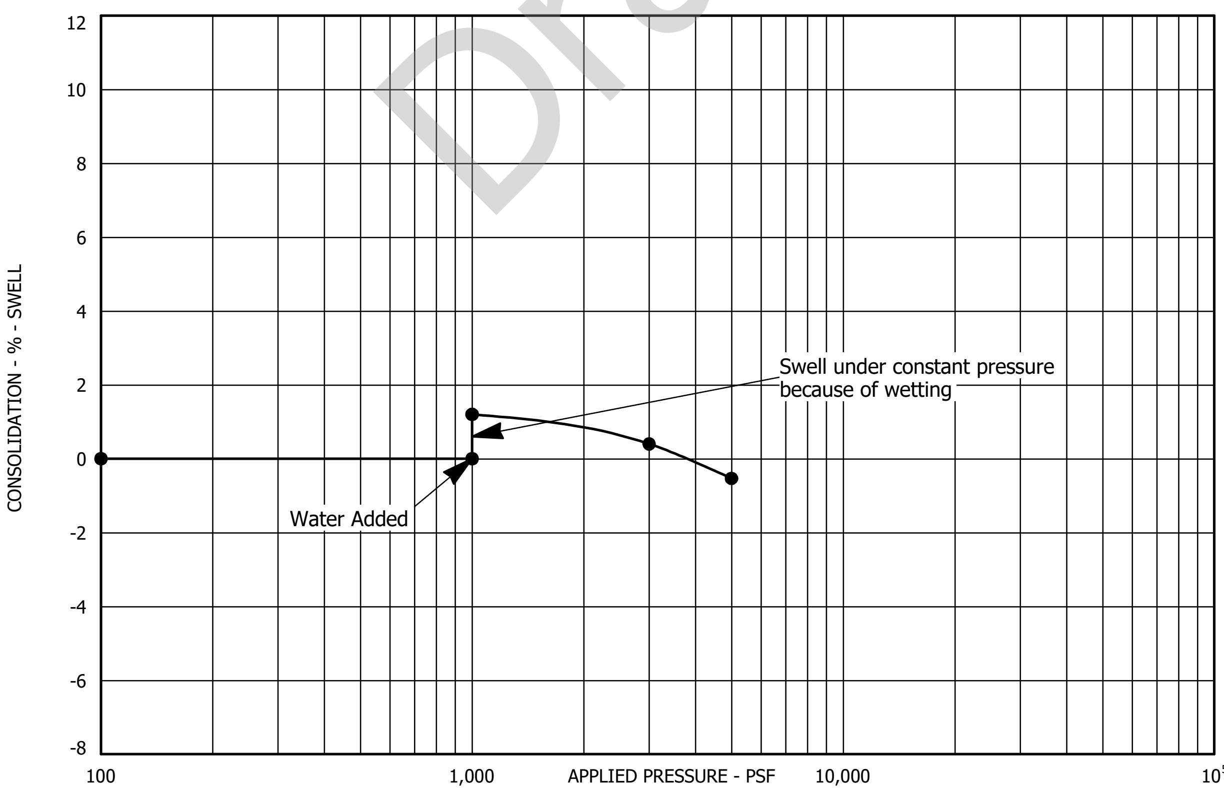
FIGURE A-18

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 16 at a depth of 4 feet
Dry Unit Weight (pcf): 106
Sample Description: Clay, sandy
Moisture Content (%): 10

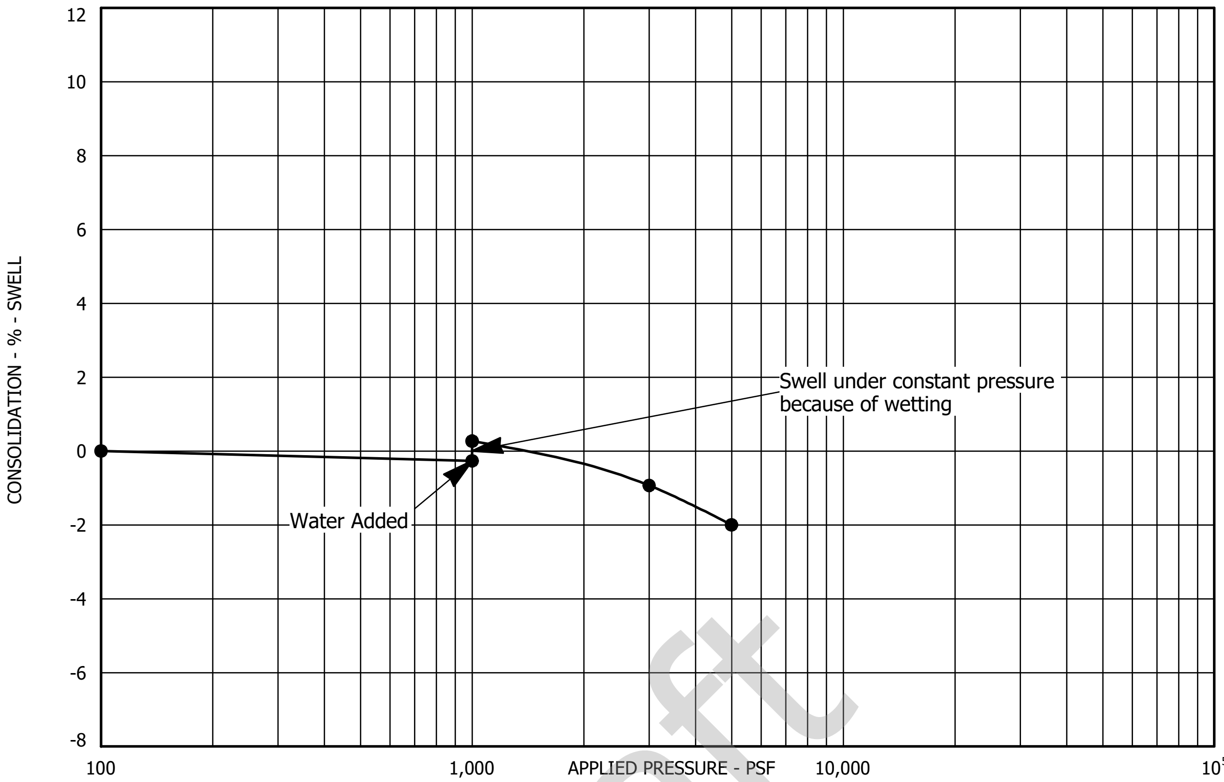


Sample Location: Test Boring No. 16 at a depth of 9 feet
Dry Unit Weight (pcf): 115
Sample Description: Clay, sandy
Moisture Content (%): 16

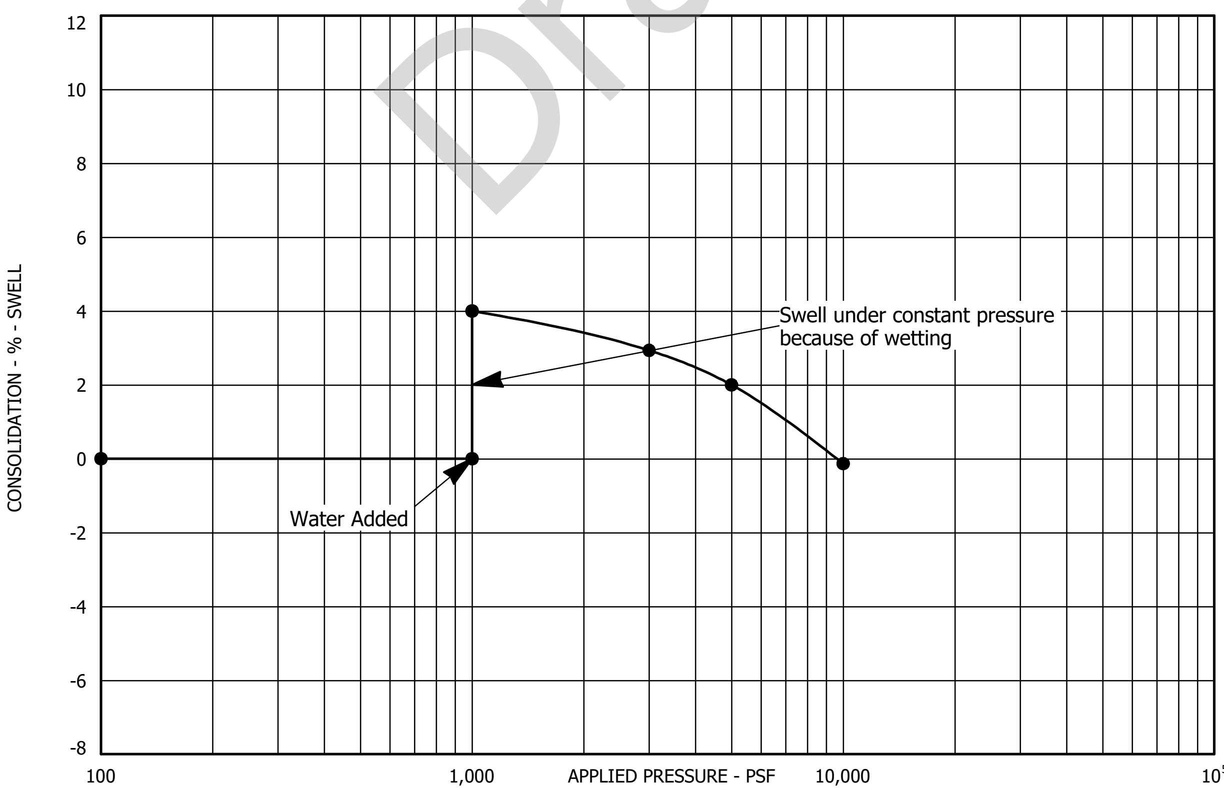
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-19

PROJECT NO. 202523



Sample Location	Test Boring No. 16 at a depth of 14 feet	Dry Unit Weight (pcf)	115
Sample Description	Clay, sandy	Moisture Content (%)	14

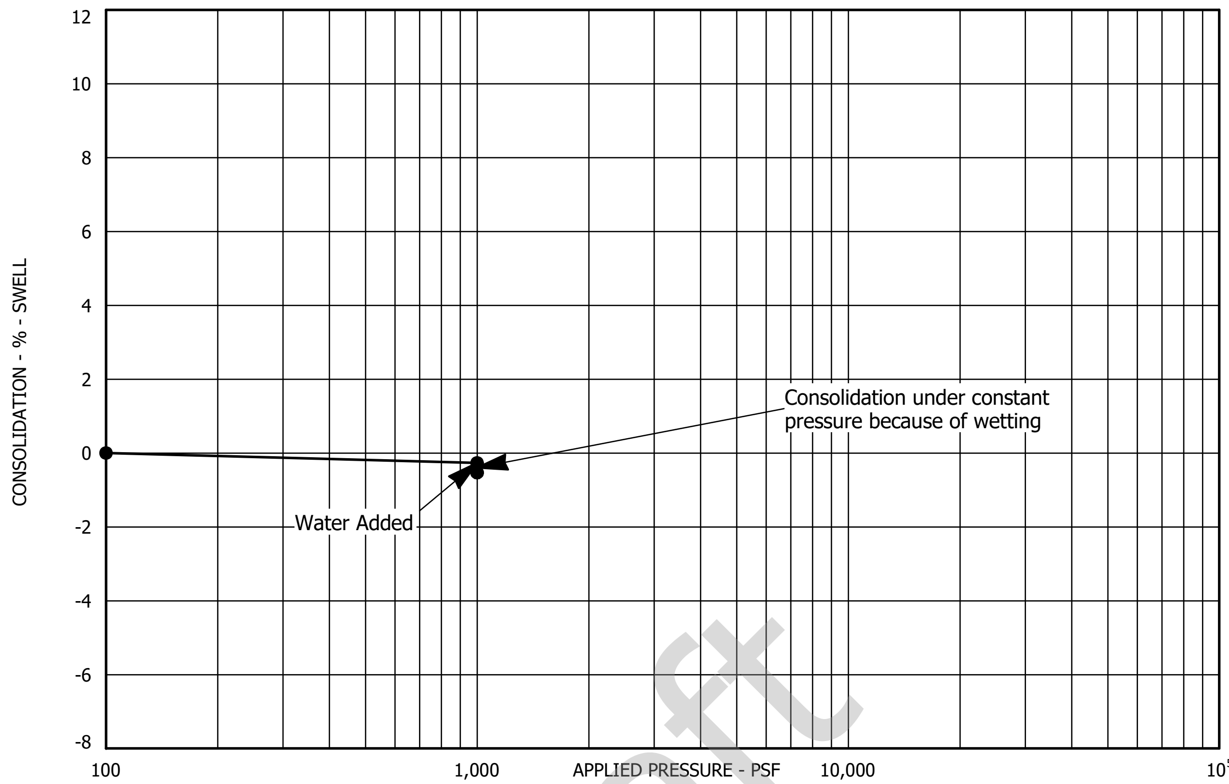


Sample Location	Test Boring No. 17 at a depth of 4 feet	Dry Unit Weight (pcf)	119
Sample Description	Clay, sandy	Moisture Content (%)	10

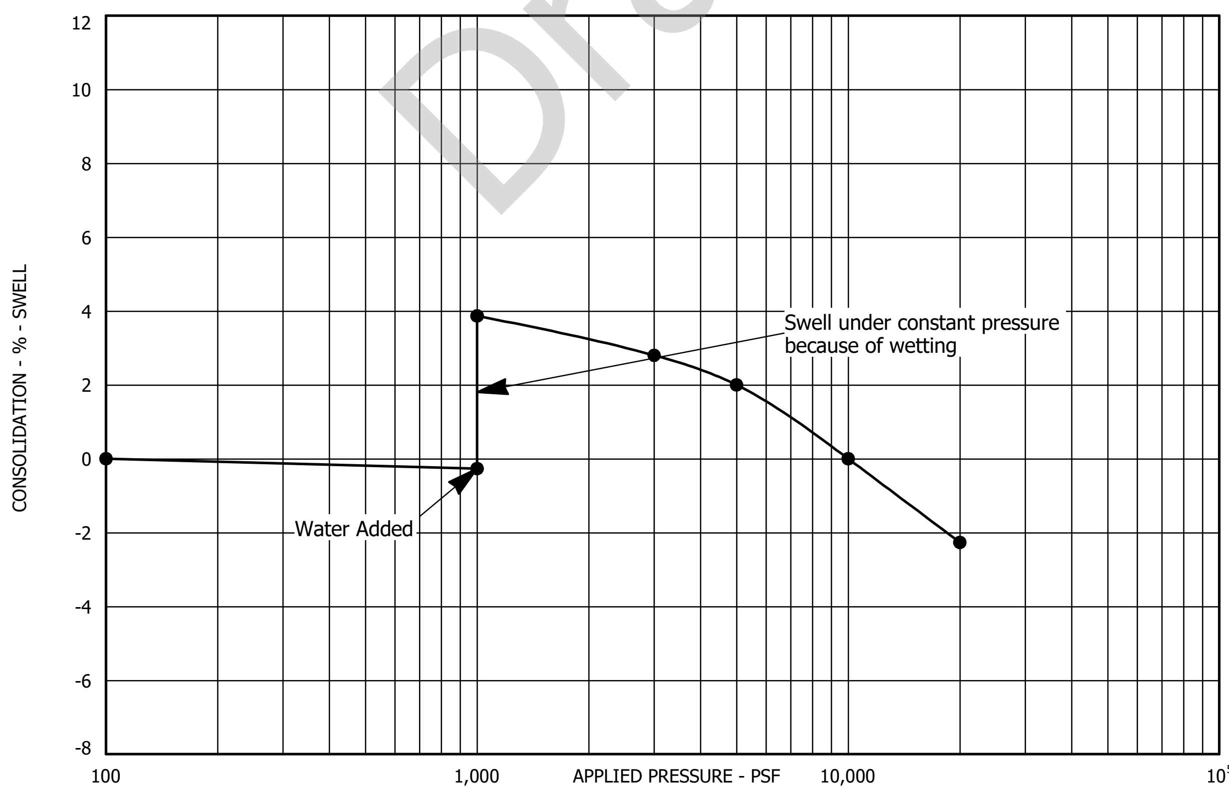
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-20

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 17 at a depth of 9 feet
Dry Unit Weight (pcf): 109
Sample Description: Clay, sandy
Moisture Content (%): 15

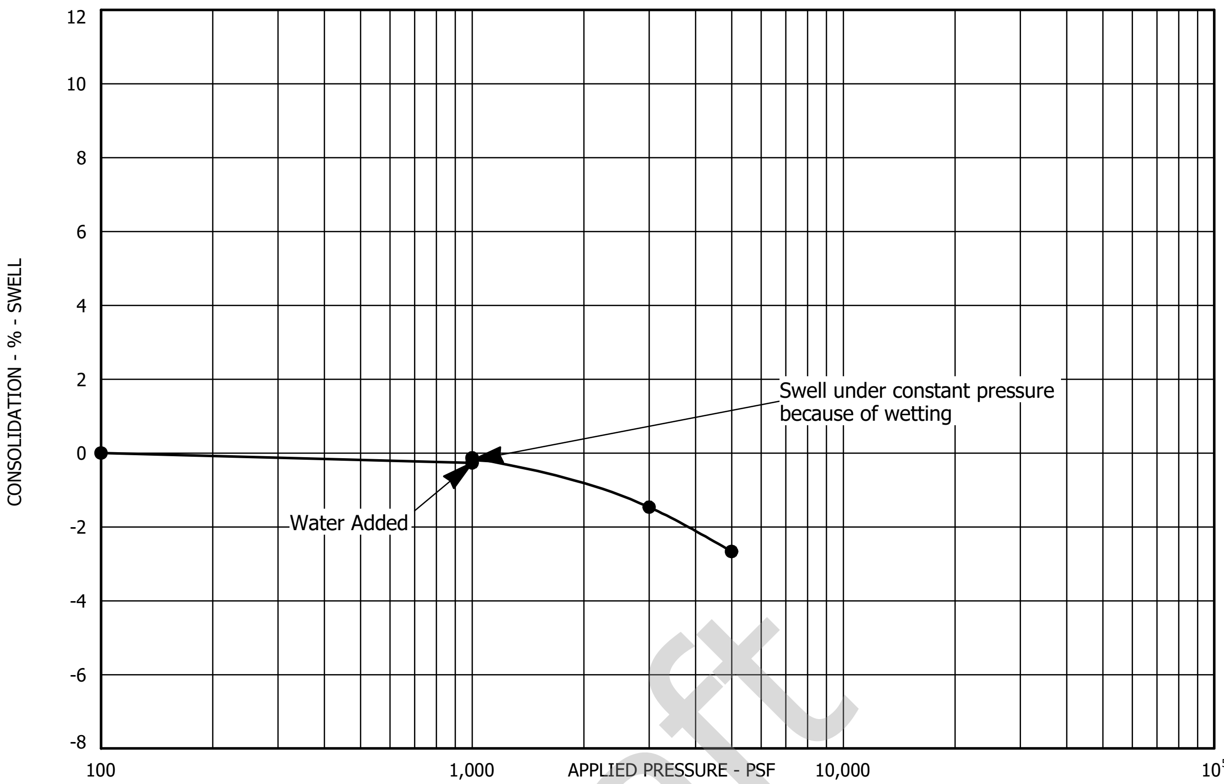


Sample Location: Test Boring No. 18 at a depth of 4 feet
Dry Unit Weight (pcf): 114
Sample Description: Clay, sandy
Moisture Content (%): 12

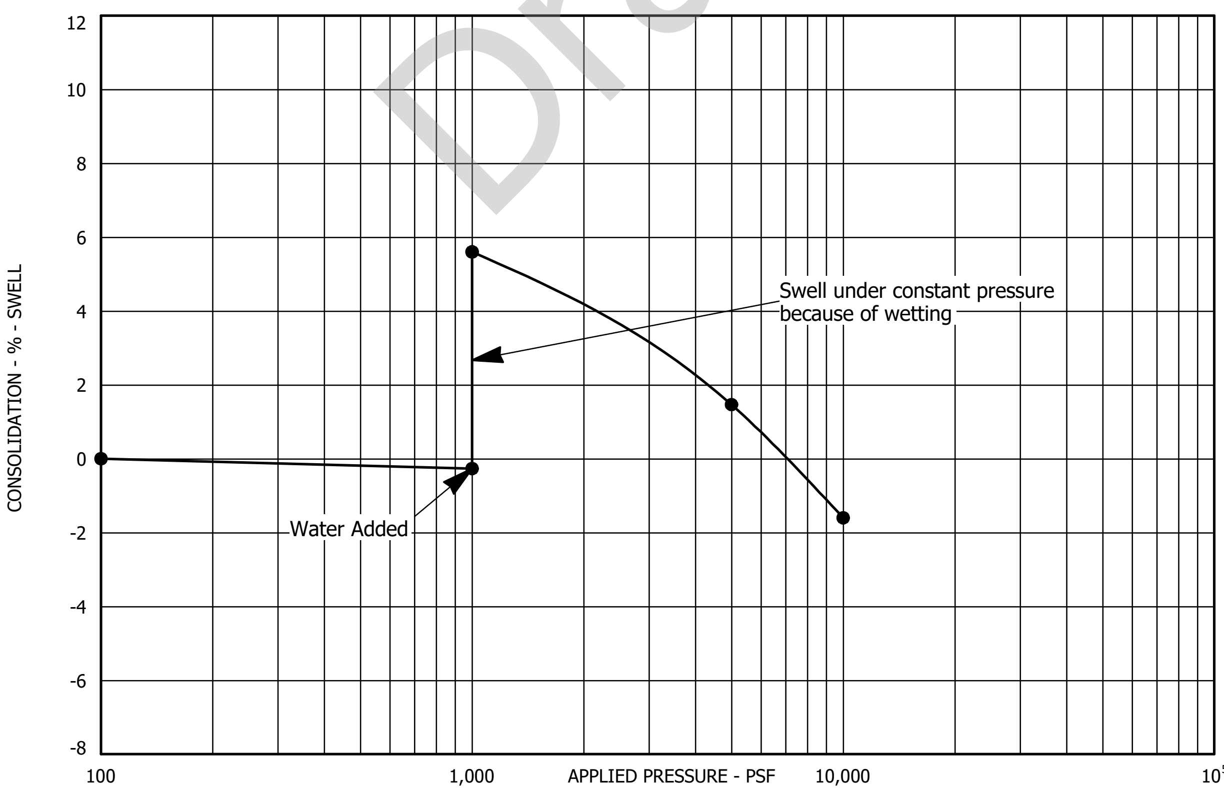
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-21

PROJECT NO. 202523



Sample Location	Test Boring No. 18 at a depth of 9 feet	Dry Unit Weight (pcf)	116
Sample Description	Clay, sandy	Moisture Content (%)	13

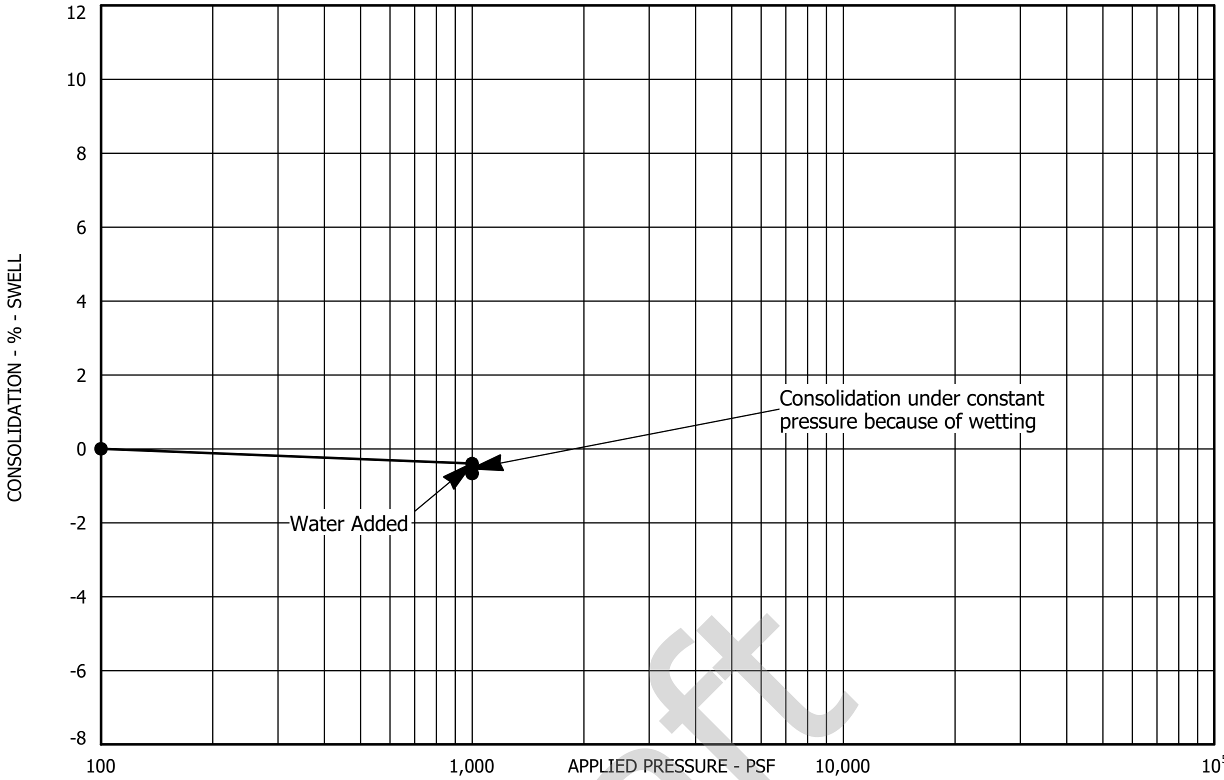


Sample Location	Test Boring No. 18 at a depth of 14 feet	Dry Unit Weight (pcf)	111
Sample Description	Claystone, slightly sandy	Moisture Content (%)	16

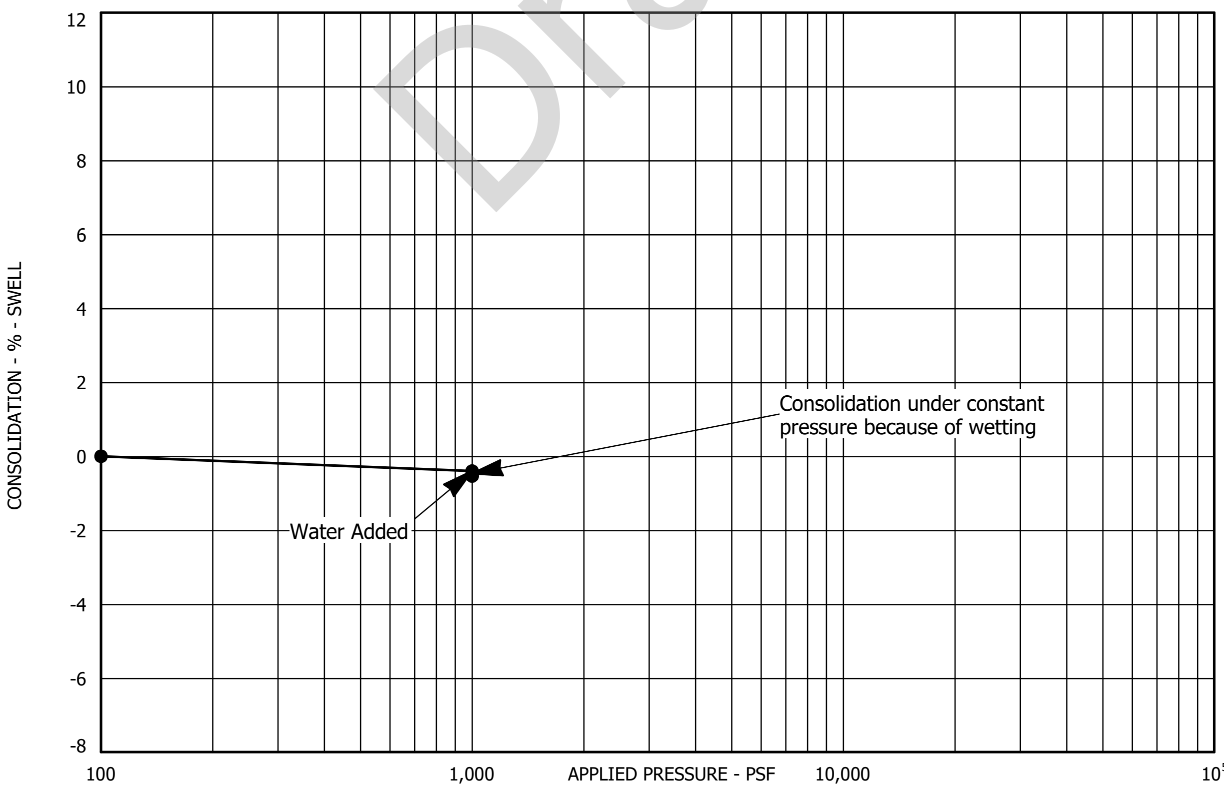
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-22

PROJECT NO. 202523



Sample Location: Test Boring No. 19 at a depth of 4 feet
Dry Unit Weight (pcf): 97
Sample Description: Clay, sandy
Moisture Content (%): 17



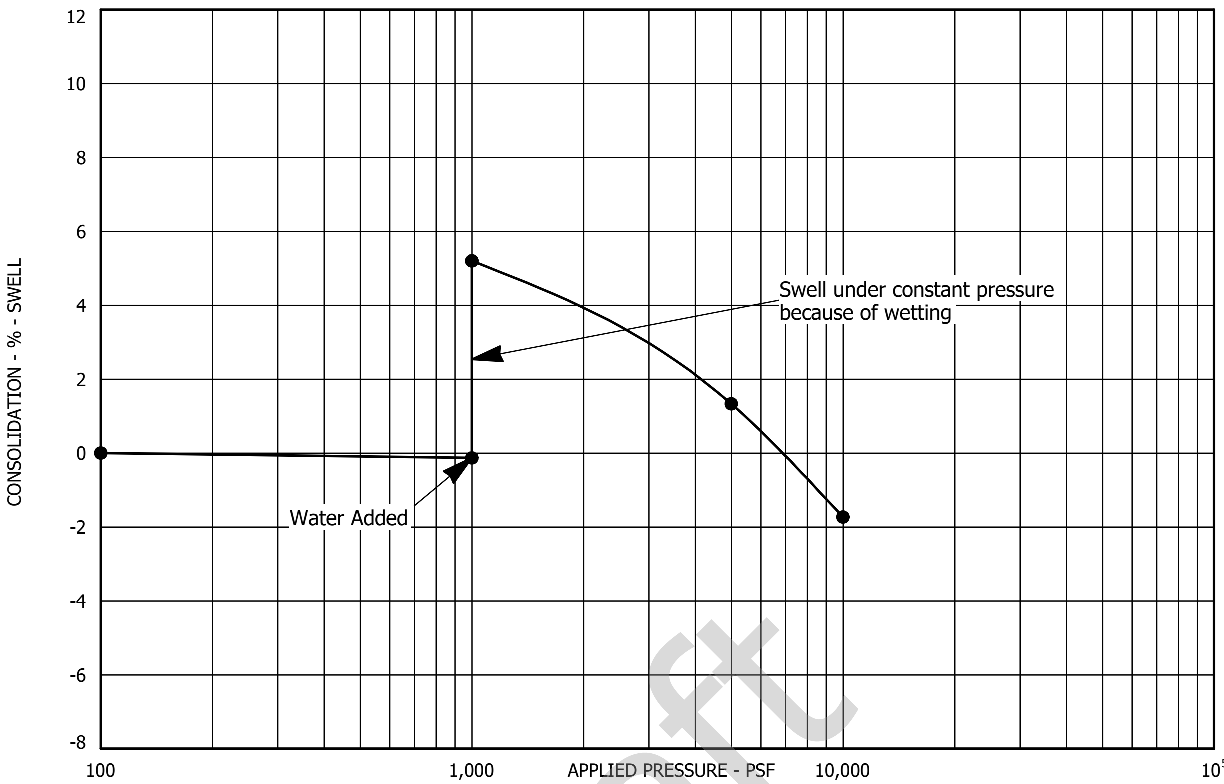
Sample Location: Test Boring No. 19 at a depth of 9 feet
Dry Unit Weight (pcf): 104
Sample Description: Clay, sandy
Moisture Content (%): 20

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-23

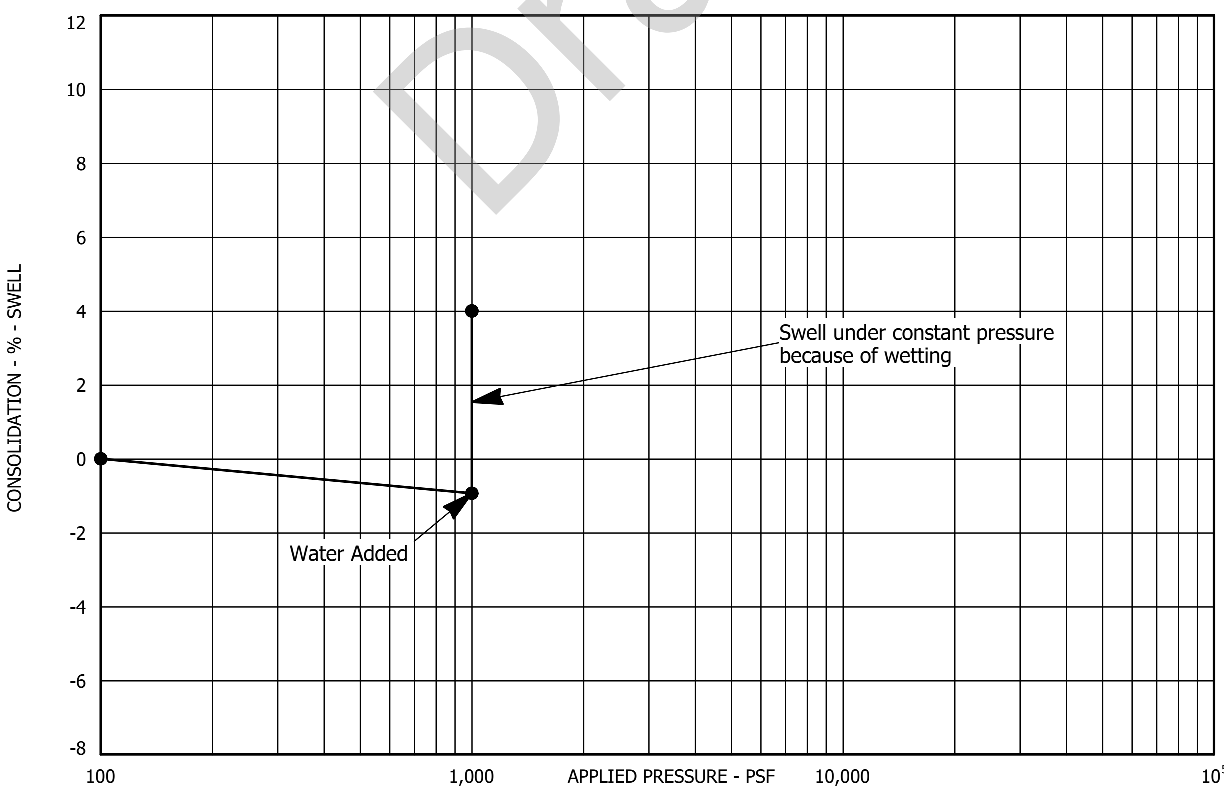
PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 19 at a depth of 14 feet — Dry Unit Weight (pcf): 104

Sample Description: Claystone, slightly sandy — Moisture Content (%): 21

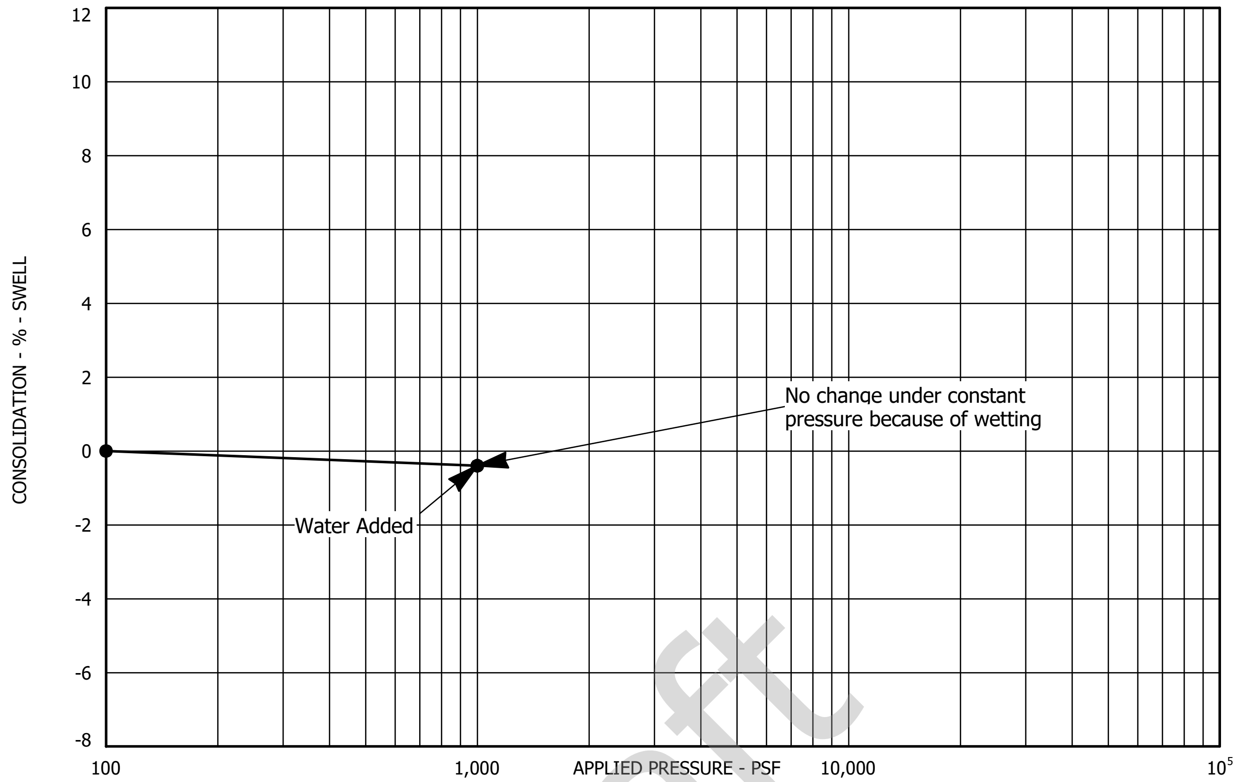


Sample Location: Test Boring No. 19 at a depth of 24 feet — Dry Unit Weight (pcf): 97

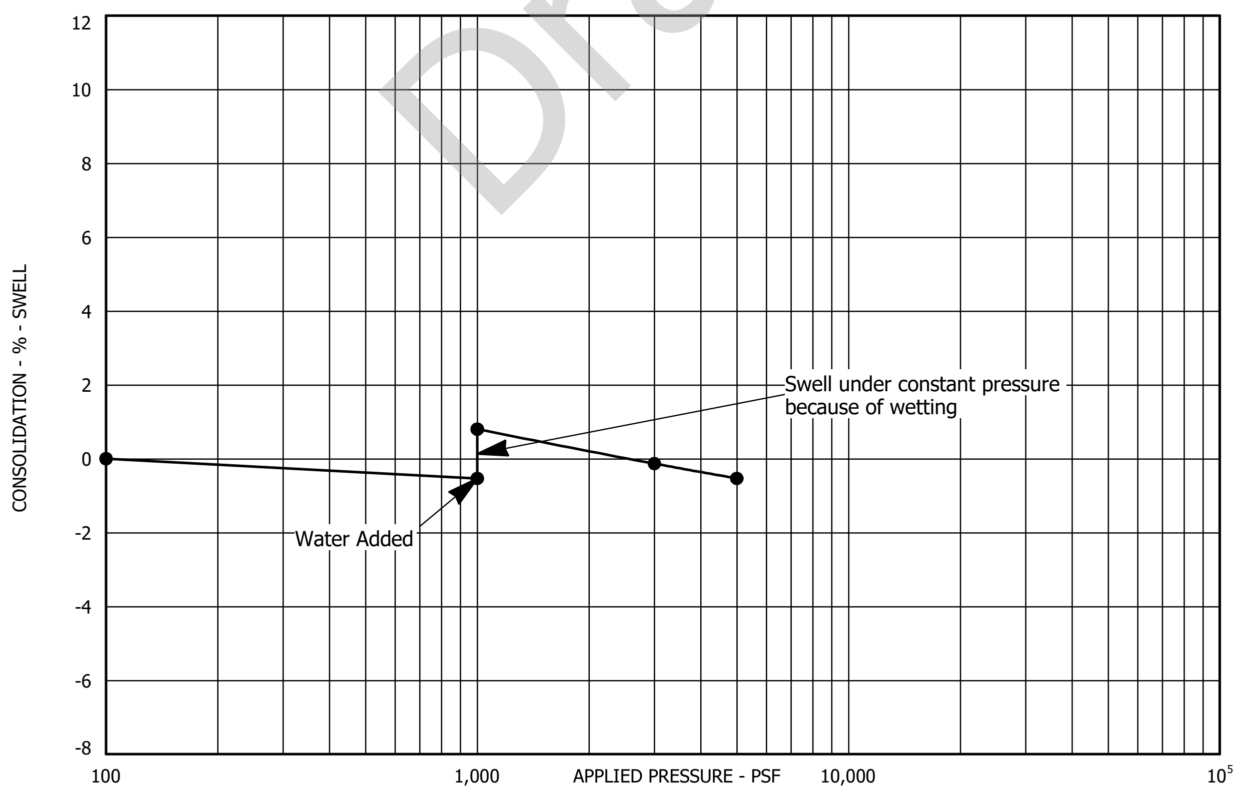
Sample Description: Lignite — Moisture Content (%): 23

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-24



Sample Location: Test Boring No. 20 at a depth of 4 feet
Dry Unit Weight (pcf): 95
Sample Description: Clay, sandy
Moisture Content (%): 12

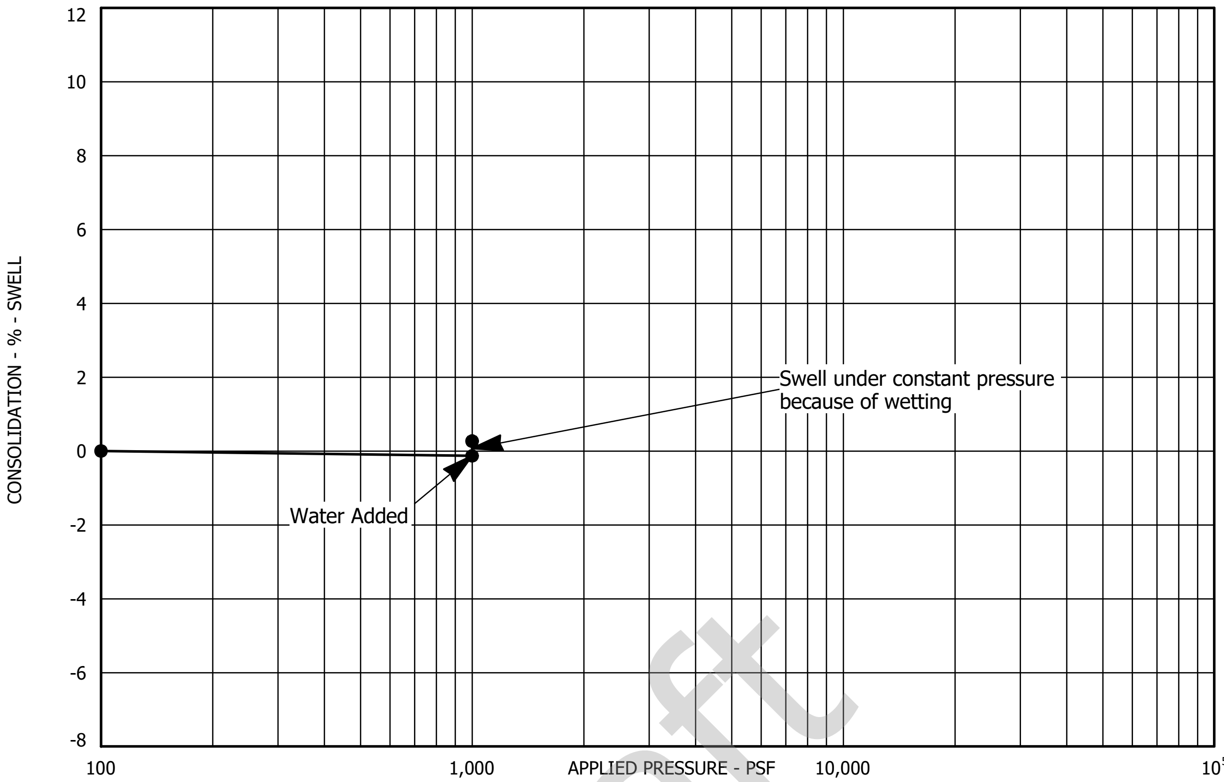


Sample Location: Test Boring No. 20 at a depth of 9 feet
Dry Unit Weight (pcf): 121
Sample Description: Clay, sandy
Moisture Content (%): 11

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-25

PROJECT NO. 202523

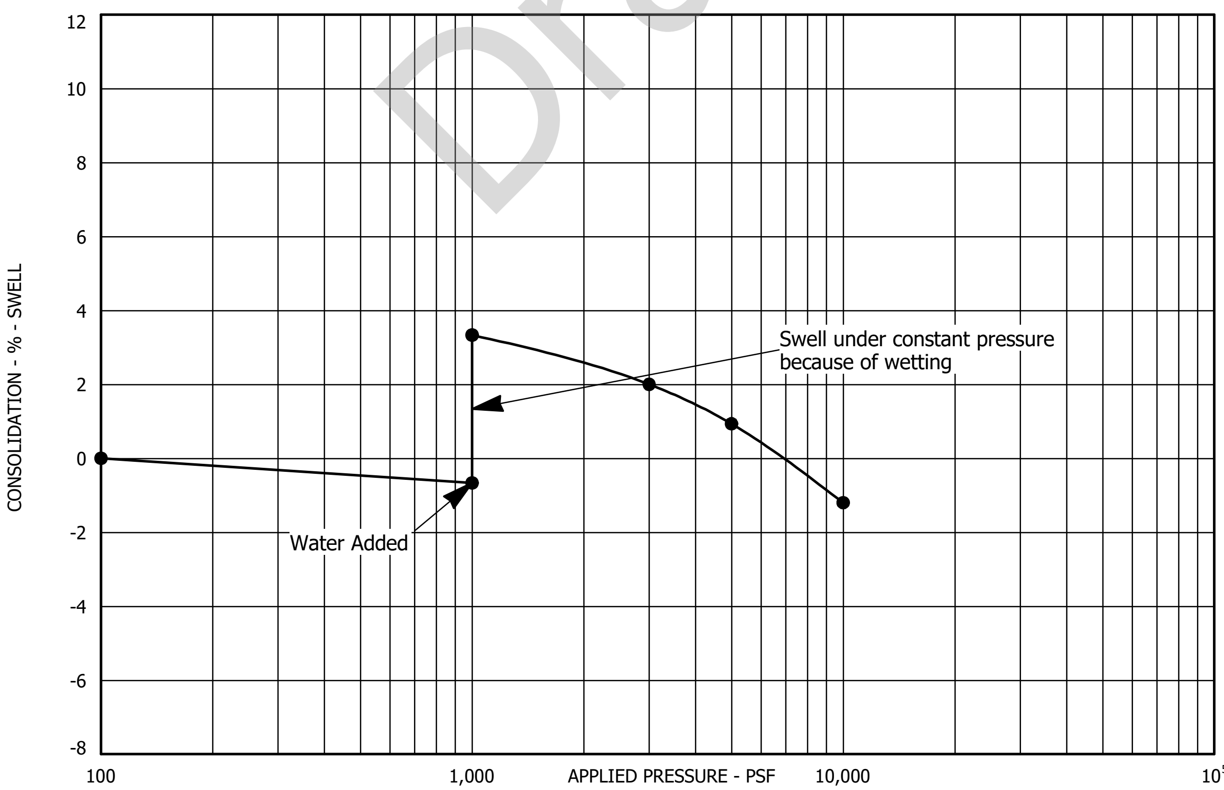


Sample Location Test Boring No. 21 at a depth of 4 feet

Sample Description Clay, sandy

Dry Unit Weight (pcf) 100

Moisture Content (%) 8



Sample Location Test Boring No. 21 at a depth of 9 feet

Sample Description Claystone, sandy

Dry Unit Weight (pcf) 117

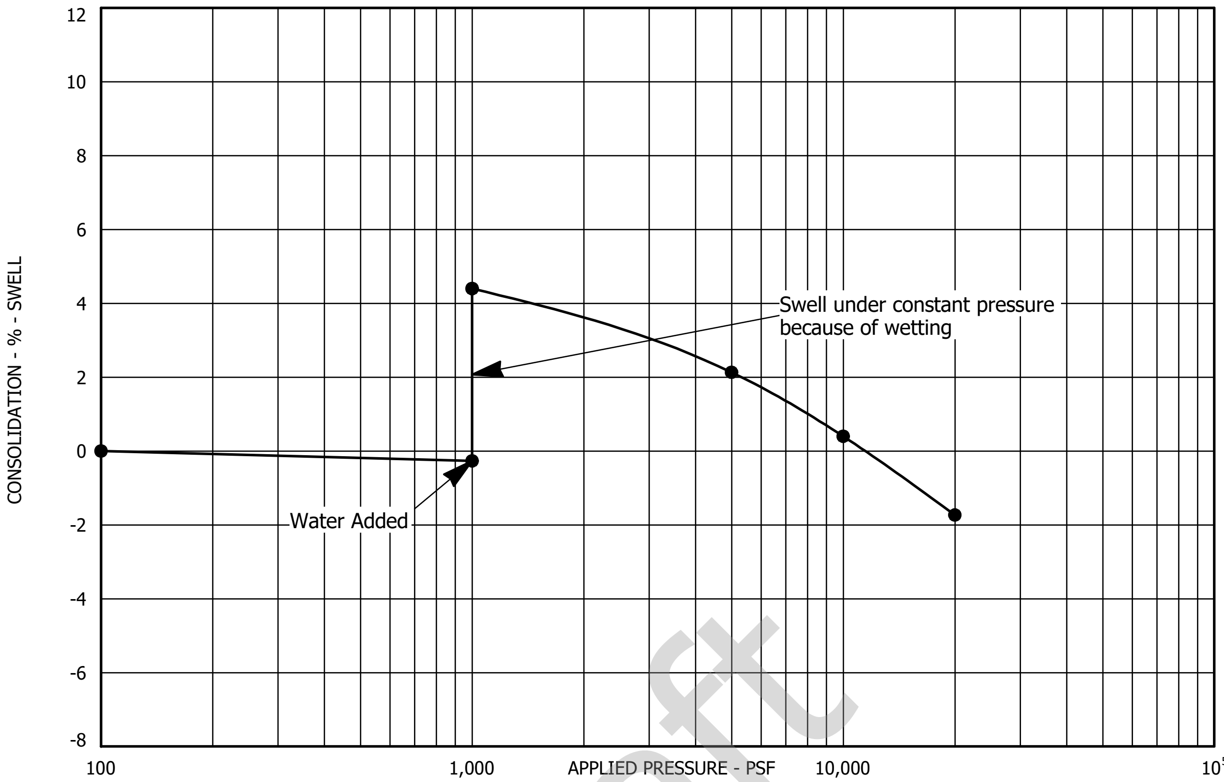
Moisture Content (%) 14

SWELL - CONSOLIDATION TEST RESULTS

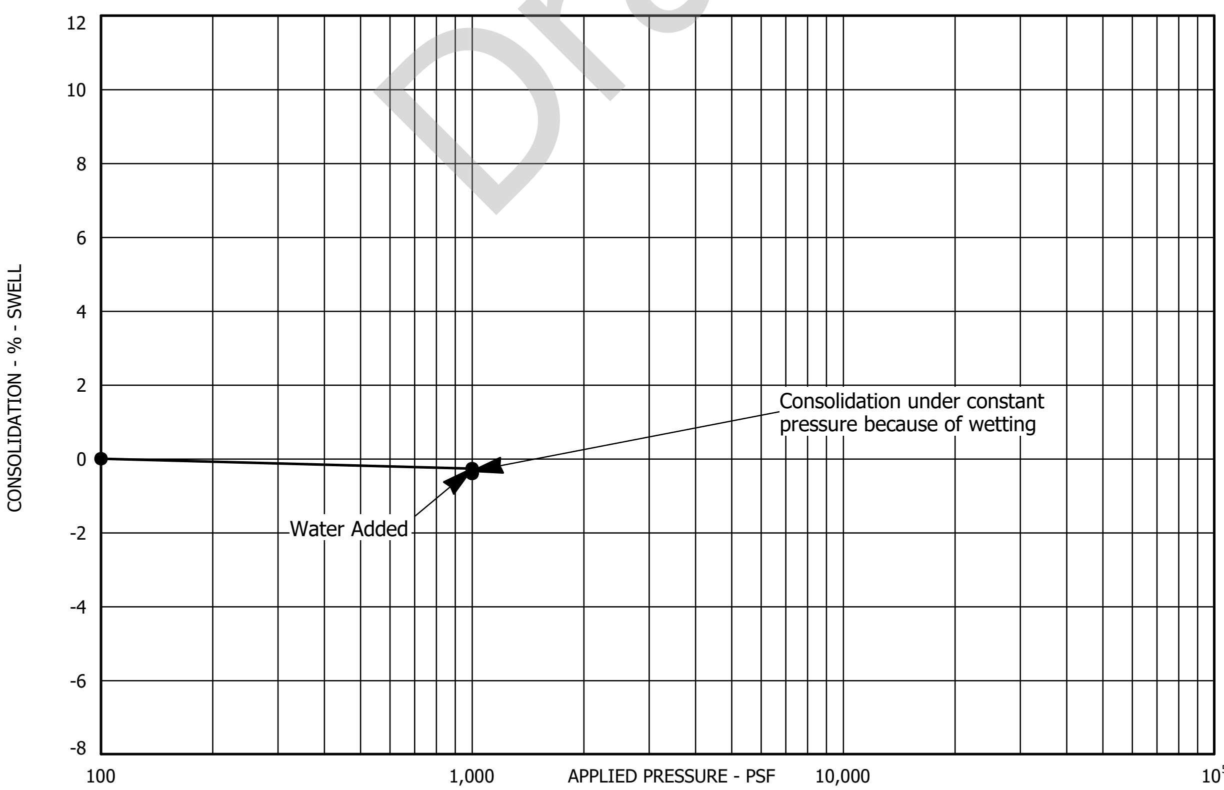
FIGURE A-26

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 22 at a depth of 4 feet
Sample Description: Clay, sandy
Dry Unit Weight (pcf): 120
Moisture Content (%): 12



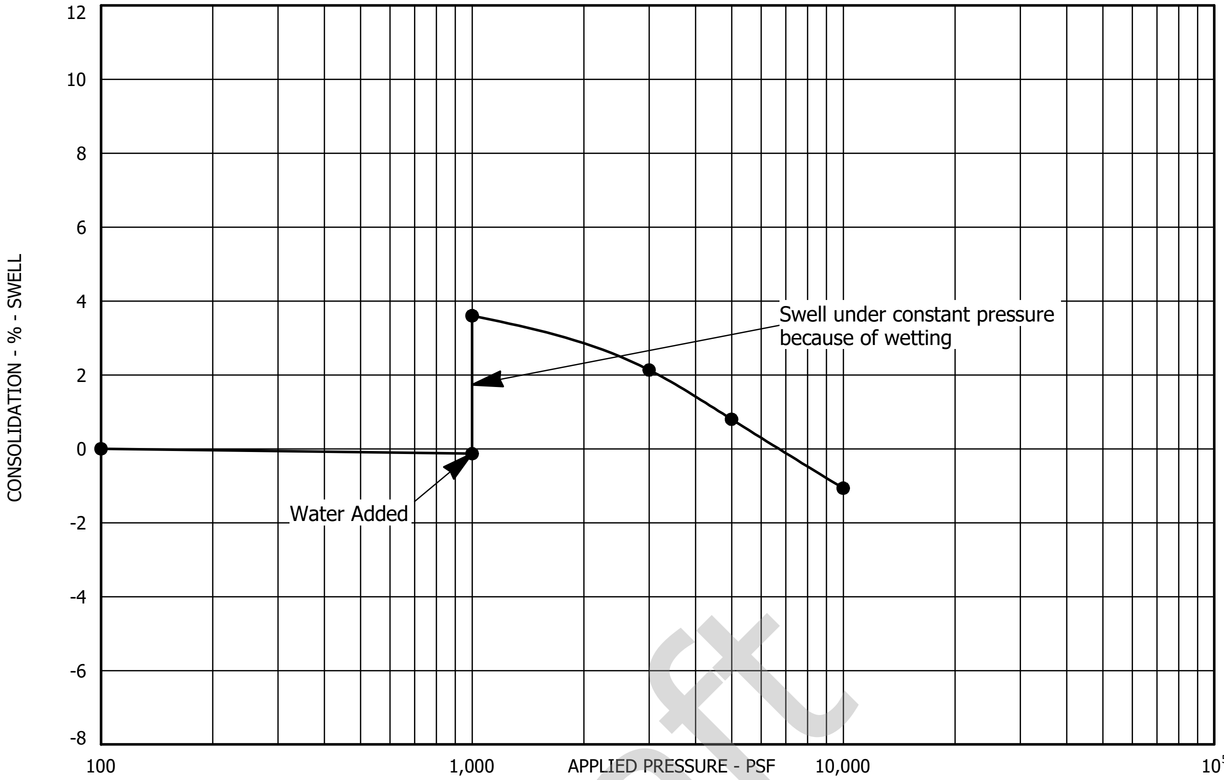
Sample Location: Test Boring No. 22 at a depth of 9 feet
Sample Description: Clay, sandy
Dry Unit Weight (pcf): 123
Moisture Content (%): 11

SWELL - CONSOLIDATION TEST RESULTS

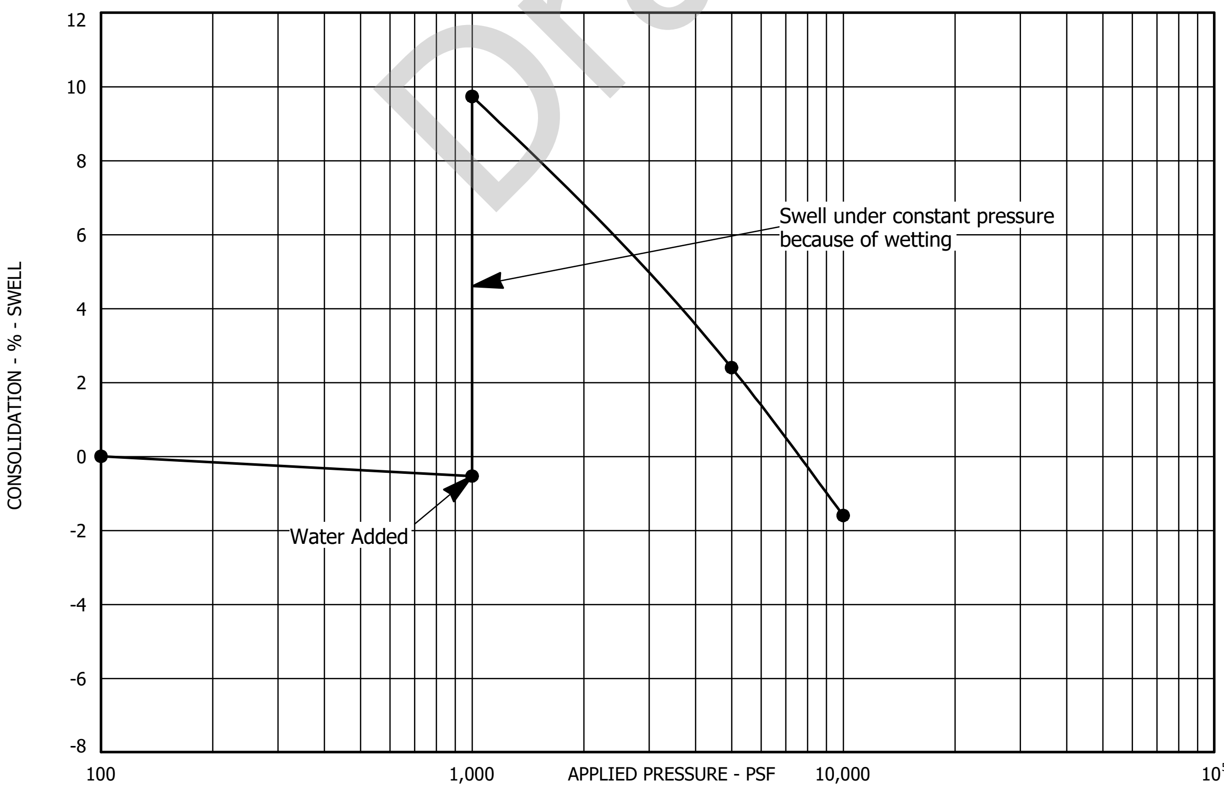
FIGURE A-27

PROJECT NO. 202523

A.G. WASSENAAR, INC.



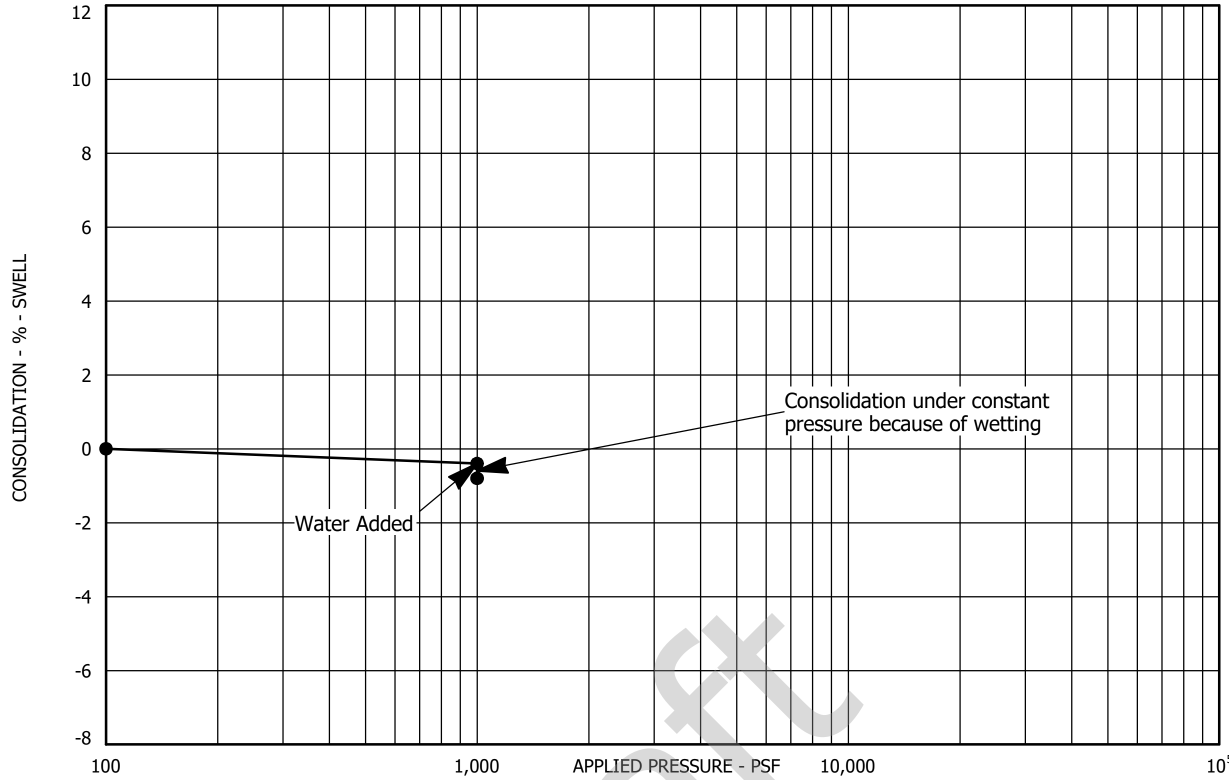
Sample Location: Test Boring No. 22 at a depth of 14 feet
Dry Unit Weight (pcf): 119
Sample Description: Claystone, sandy
Moisture Content (%): 14



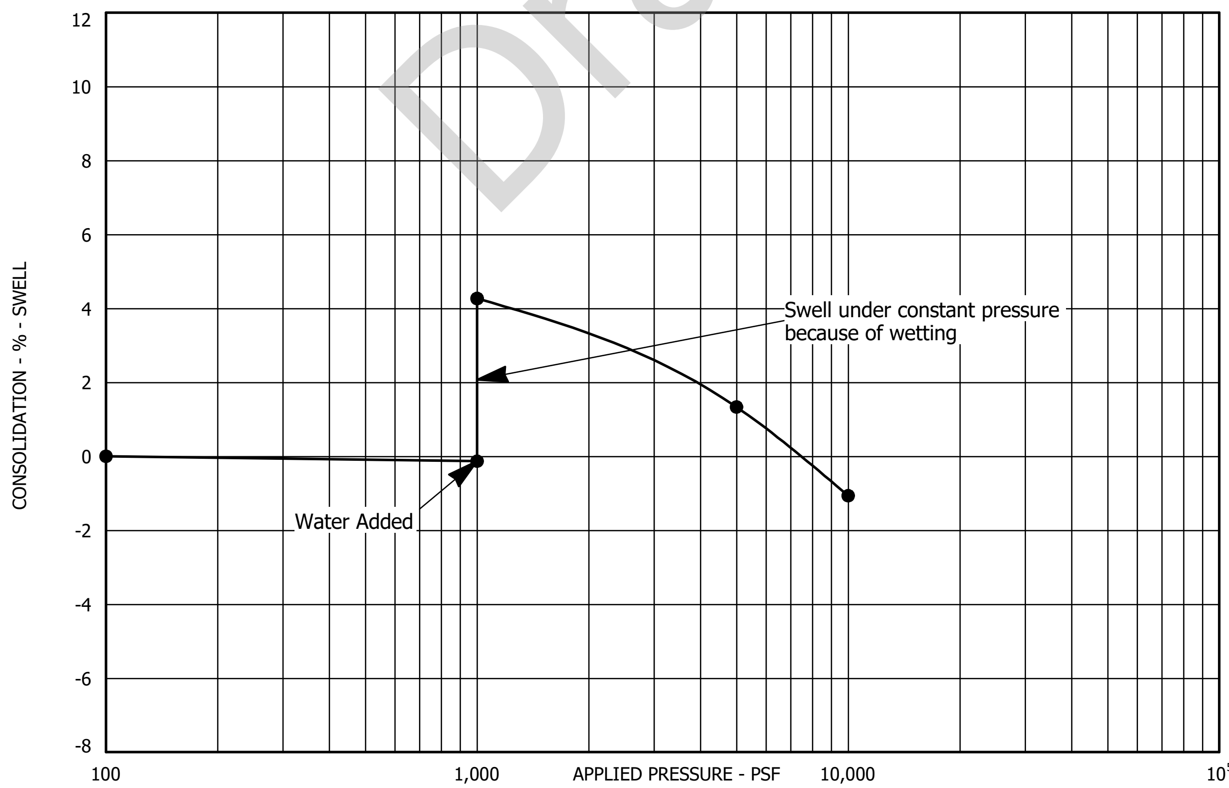
Sample Location: Test Boring No. 22 at a depth of 24 feet
Dry Unit Weight (pcf): 103
Sample Description: Claystone, slightly sandy
Moisture Content (%): 22

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-28



Sample Location	Test Boring No. 23 at a depth of 9 feet	Dry Unit Weight (pcf)	99
Sample Description	Clay, sandy	Moisture Content (%)	19

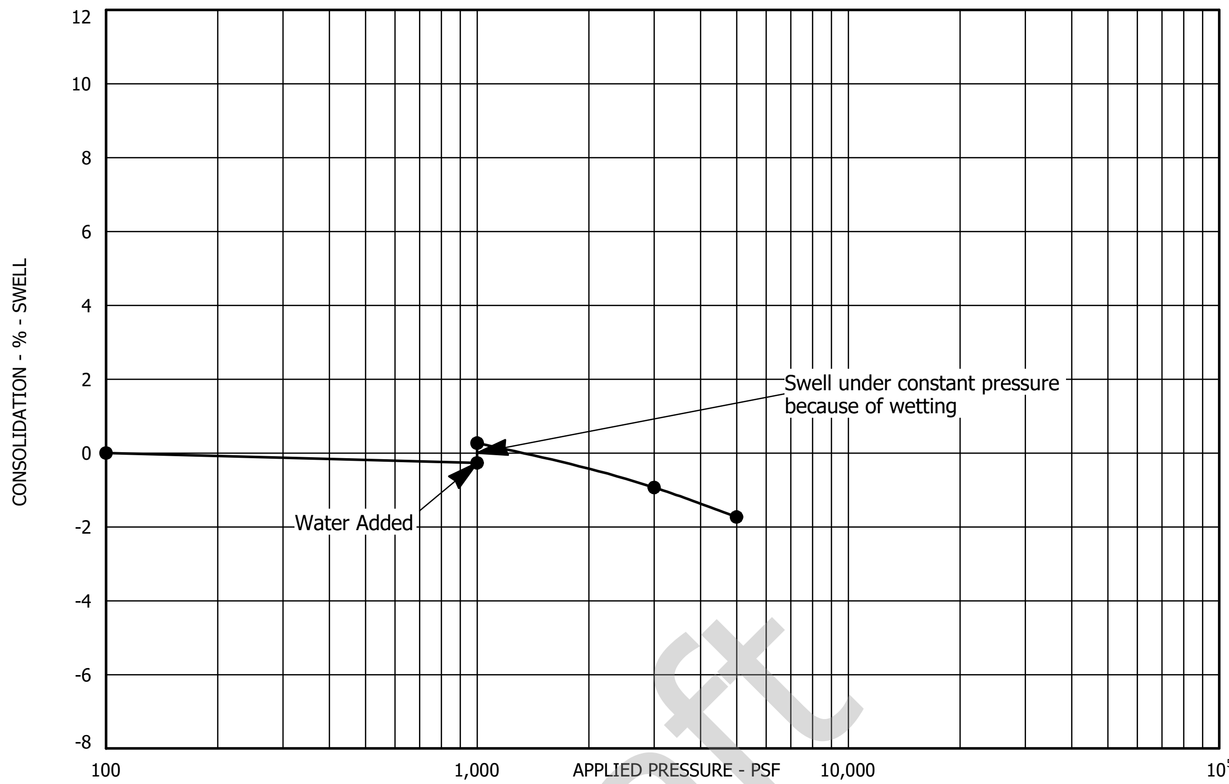


Sample Location	Test Boring No. 24 at a depth of 4 feet	Dry Unit Weight (pcf)	120
Sample Description	Clay, sandy	Moisture Content (%)	10

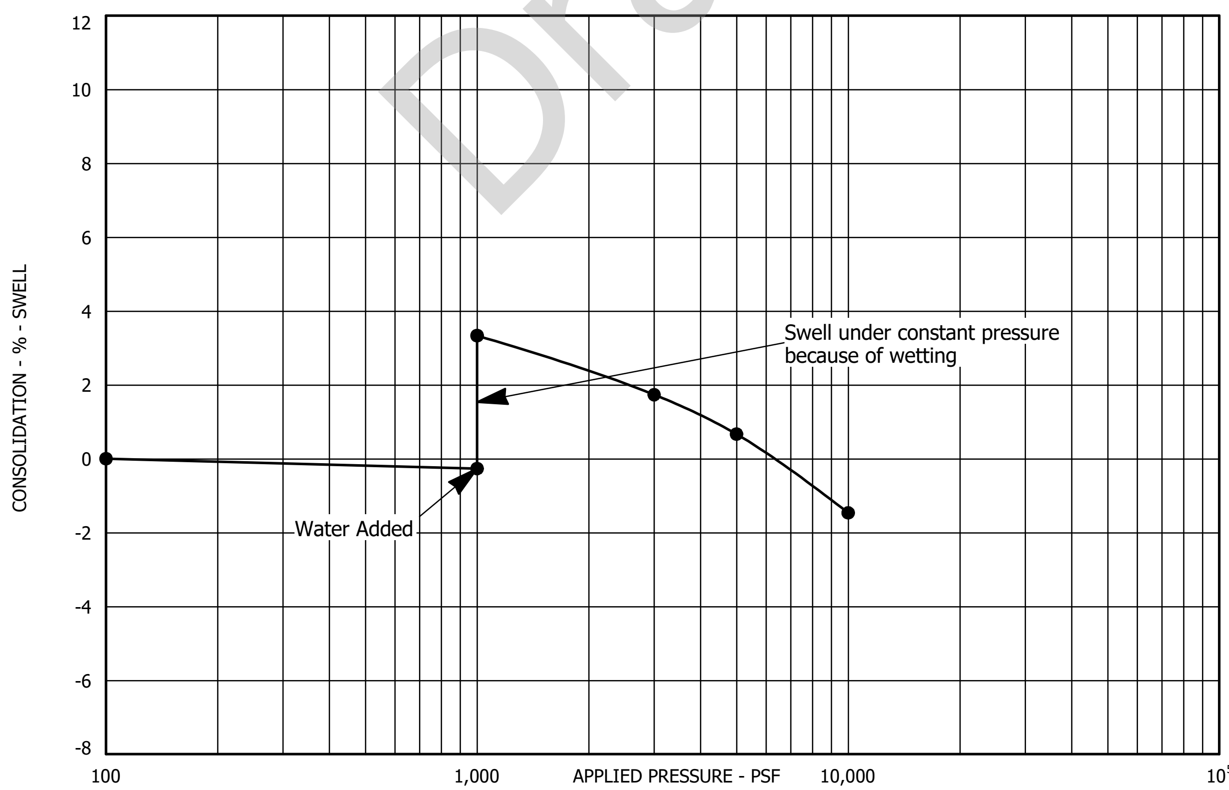
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-29

PROJECT NO. 202523



Sample Location: Test Boring No. 24 at a depth of 9 feet
Dry Unit Weight (pcf): 119
Sample Description: Clay, sandy
Moisture Content (%): 10

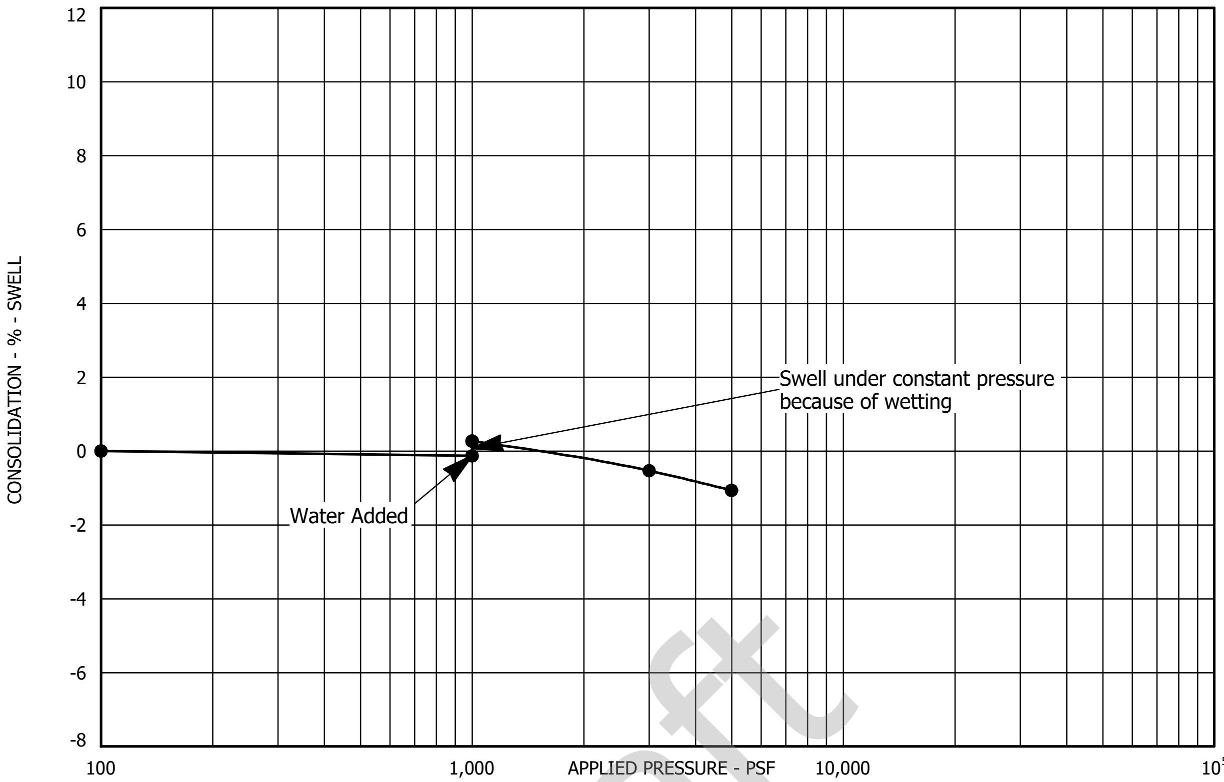


Sample Location: Test Boring No. 25 at a depth of 4 feet
Dry Unit Weight (pcf): 118
Sample Description: Clay, sandy
Moisture Content (%): 8

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-30

PROJECT NO. 202523

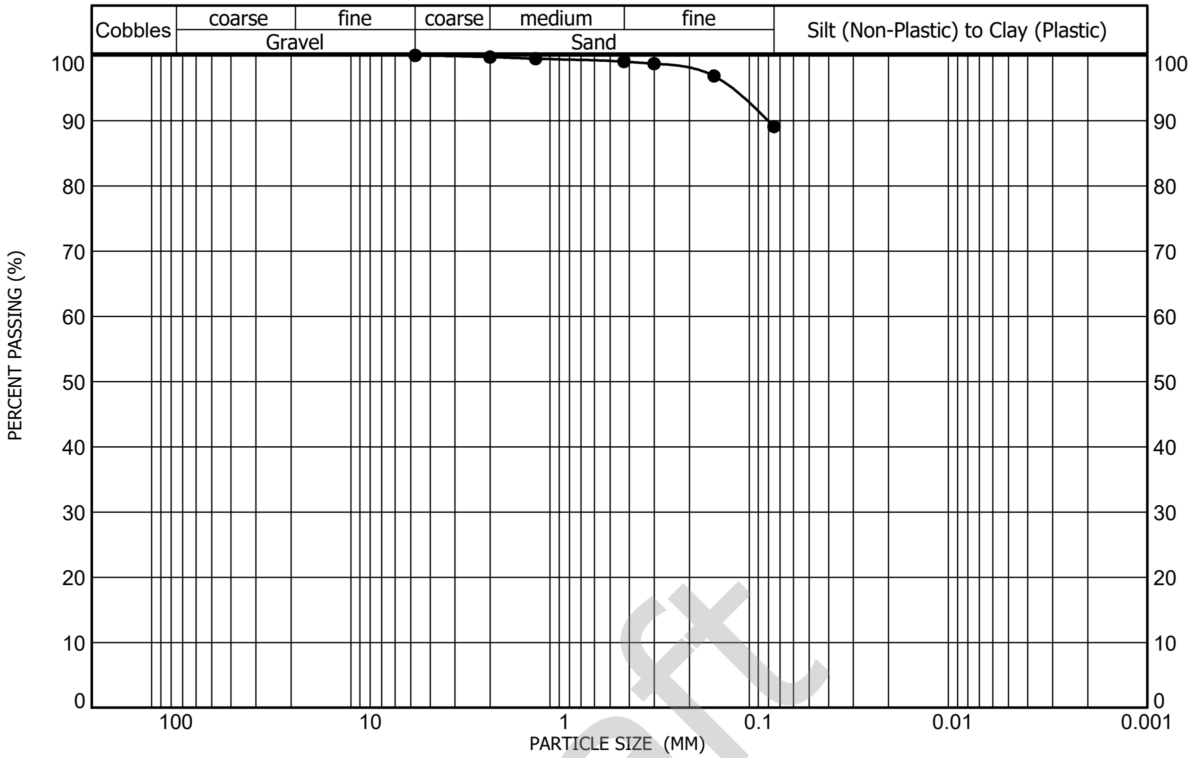


Sample Location	Test Boring No. 25 at a depth of 9 feet	Dry Unit Weight (pcf)	116
Sample Description	Sandstone, very clayey	Moisture Content (%)	11

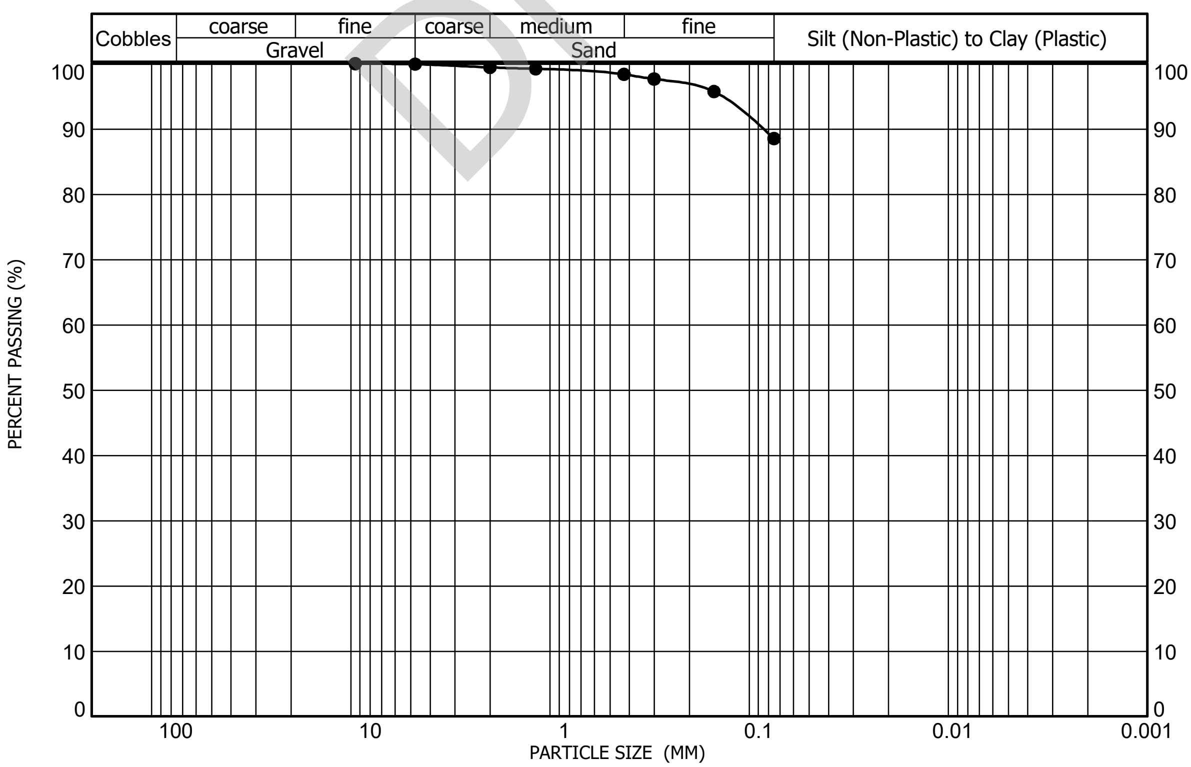
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-31

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 3 at a depth of 4 feet	Gravel (%) 0	Liquid Limit 58
Sample Description: Clay, slightly sandy	Sand (%) 11	Plasticity Index 38
Classification: A-7-6(36), FAT CLAY(CH)	Clay/Silt (%) 89	

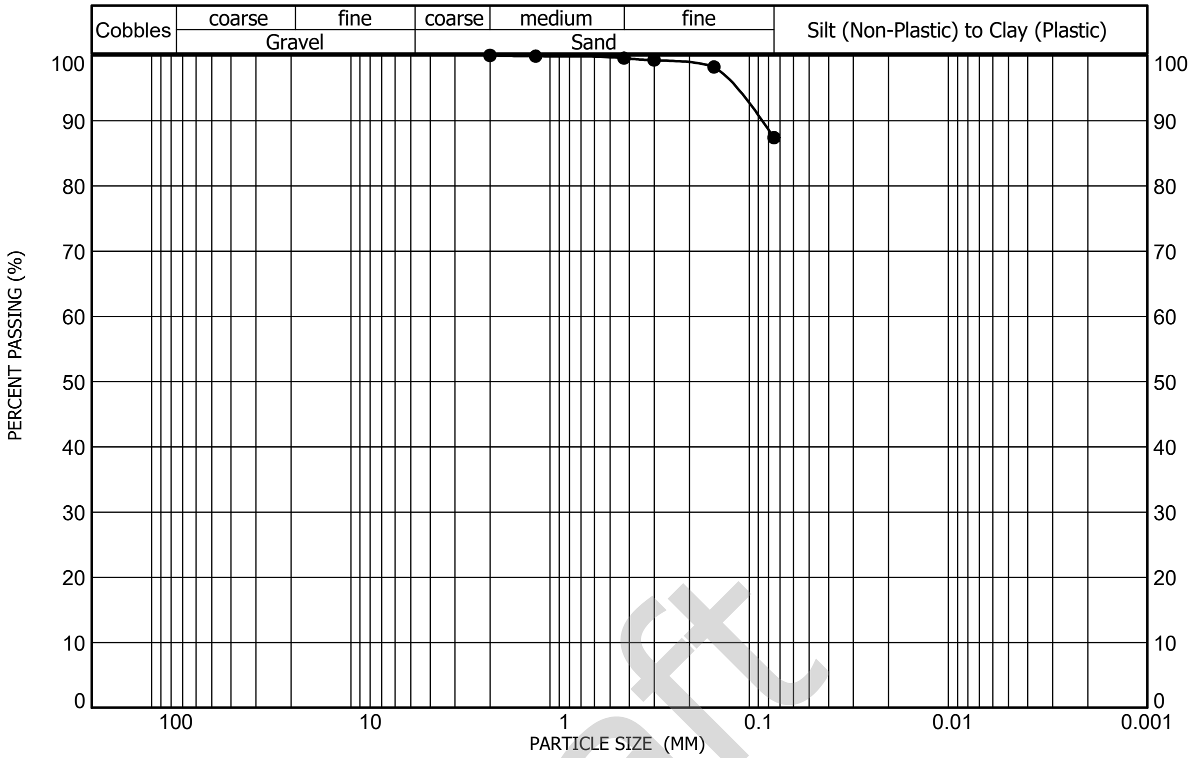


Sample Location: Test Boring No. 4 at a depth of 14 feet	Gravel (%) 0	Liquid Limit 55
Sample Description: Claystone, slightly sandy	Sand (%) 11	Plasticity Index 36
Classification: A-7-6(34), FAT CLAY(CH)	Clay/Silt (%) 89	

GRADATION AND ATTERBERG TEST RESULTS

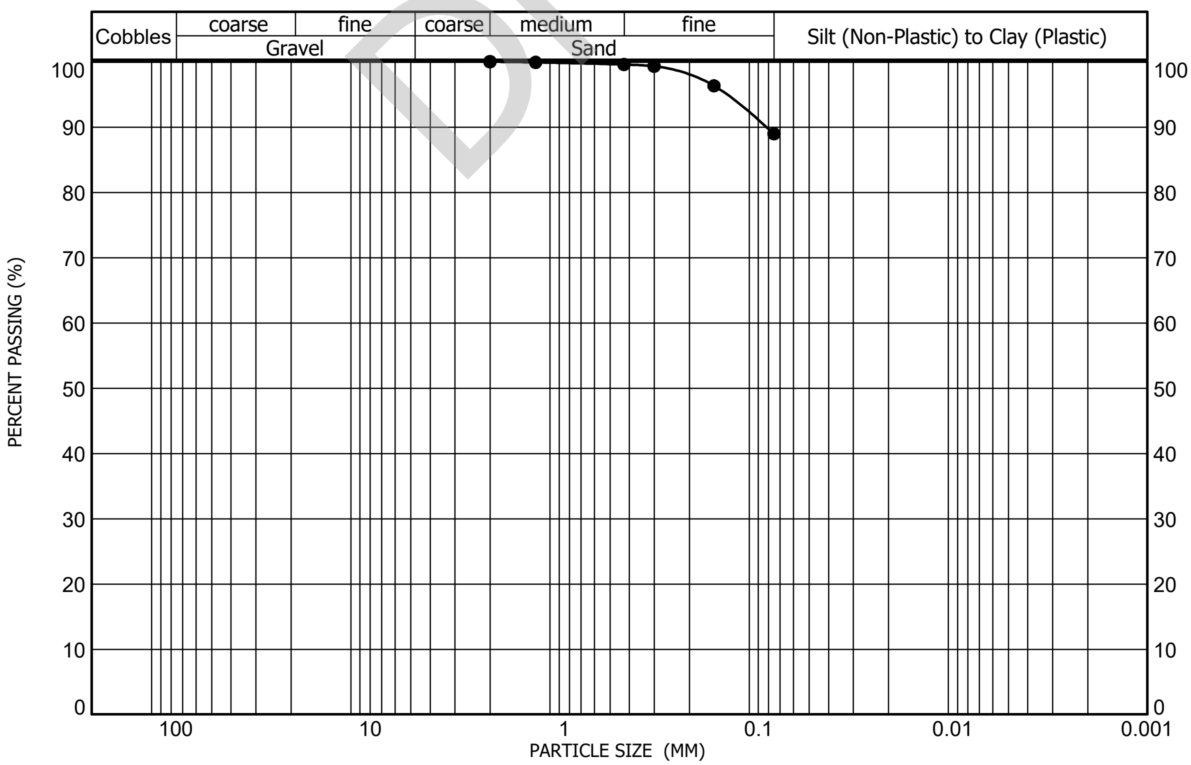
FIGURE A-32

PROJECT NO. 202523



Sample Location: Test Boring No. 6 at a depth of 9 feet
Sample Description: Claystone/Sandstone, silty
Classification: A-6(9), LEAN CLAY(CL)

Gravel (%): 0
Sand (%): 13
Clay/Silt (%): 87
Liquid Limit: 30
Plasticity Index: 11



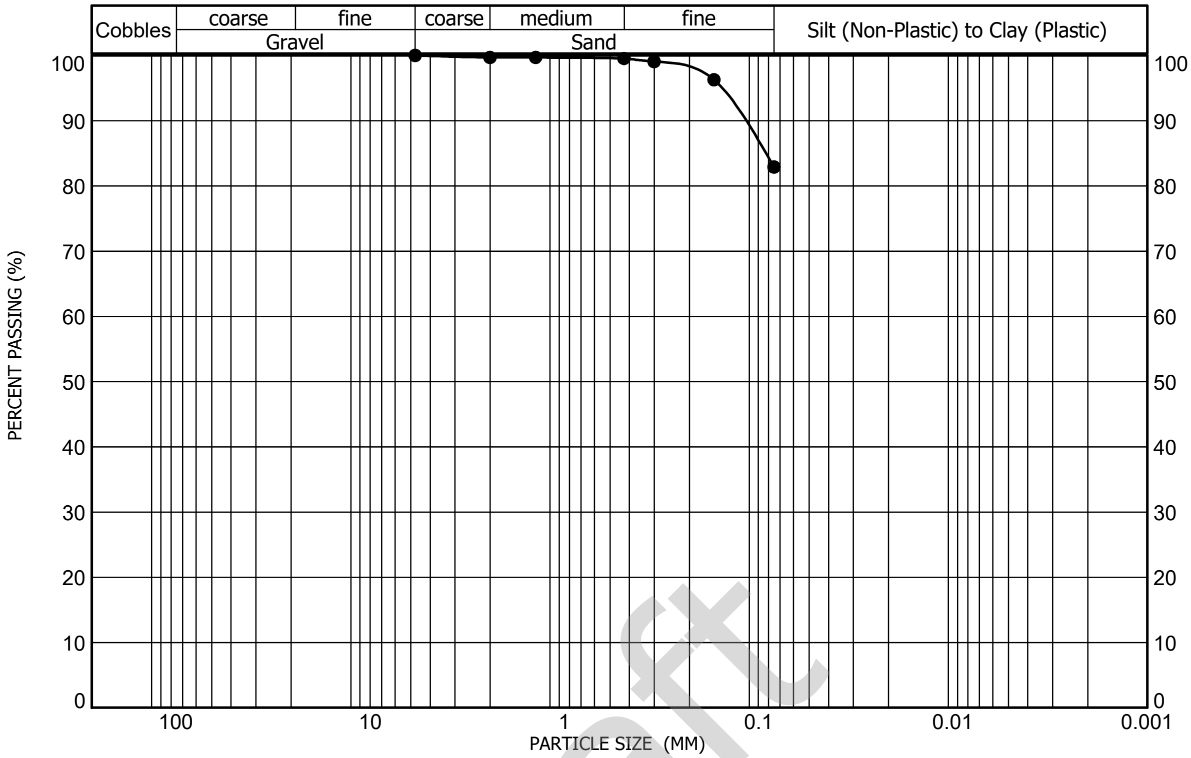
Sample Location: Test Boring No. 9 at a depth of 4 feet
Sample Description: Claystone, slightly sandy
Classification: A-6(19), LEAN CLAY(CL)

Gravel (%): 0
Sand (%): 11
Clay/Silt (%): 89
Liquid Limit: 39
Plasticity Index: 22

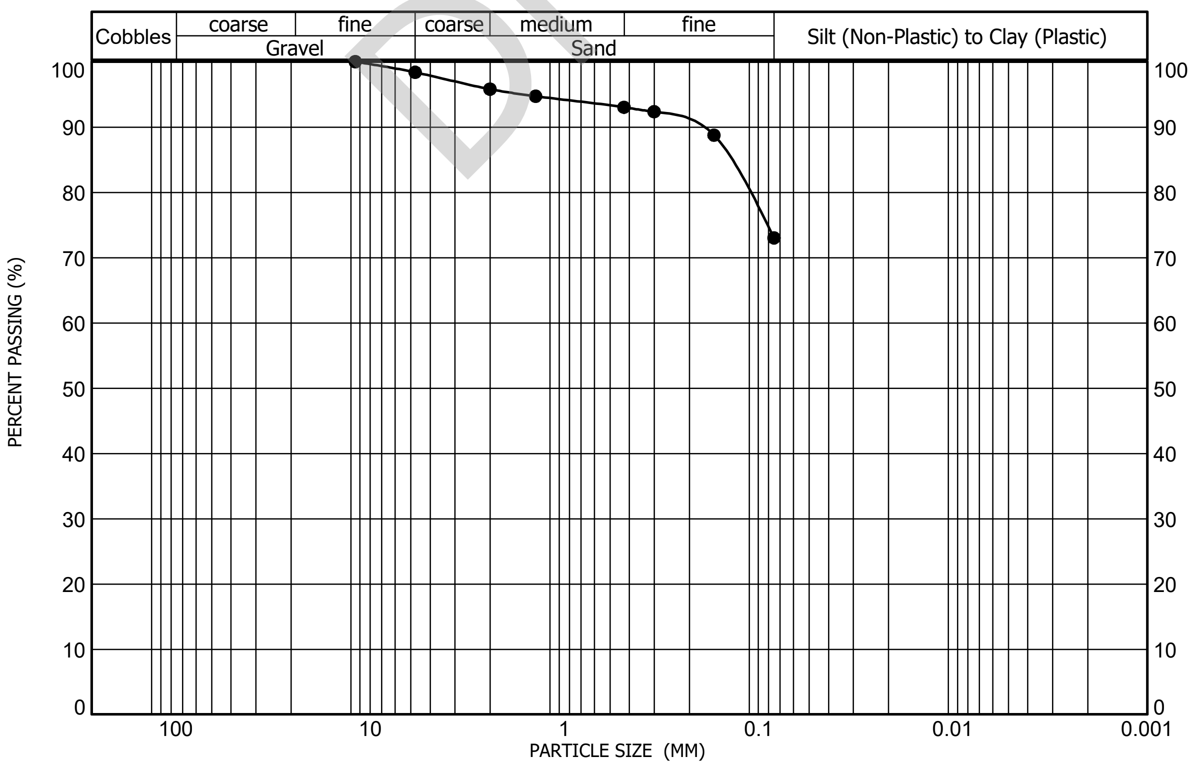
GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-33

PROJECT NO. 202523



Sample Location: Test Boring No. 13 at a depth of 4 feet
Sample Description: Clay, sandy
Classification: A-6(11), LEAN CLAY with SAND(CL)
Gravel (%): 0
Sand (%): 17
Clay/Silt (%): 83
Liquid Limit: 34
Plasticity Index: 14



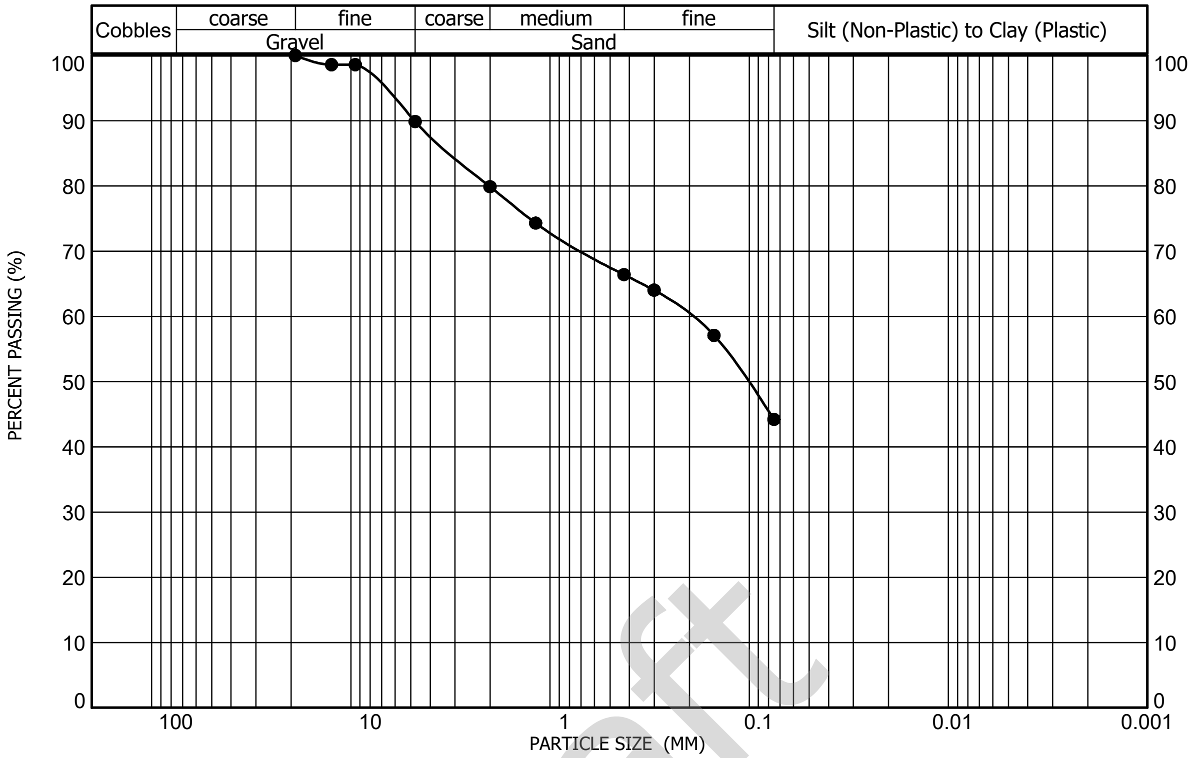
Sample Location: Test Boring No. 15 at a depth of 9 feet
Sample Description: Claystone, sandy, trace gravel
Classification: A-6(13), LEAN CLAY with SAND(CL)
Gravel (%): 2
Sand (%): 25
Clay/Silt (%): 73
Liquid Limit: 36
Plasticity Index: 20

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-34

PROJECT NO. 202523

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 17 at a depth of 19 feet

Sample Description: Sandstone, very clayey, slightly gravelly

Classification: A-4(1), CLAYEY SAND(SC)

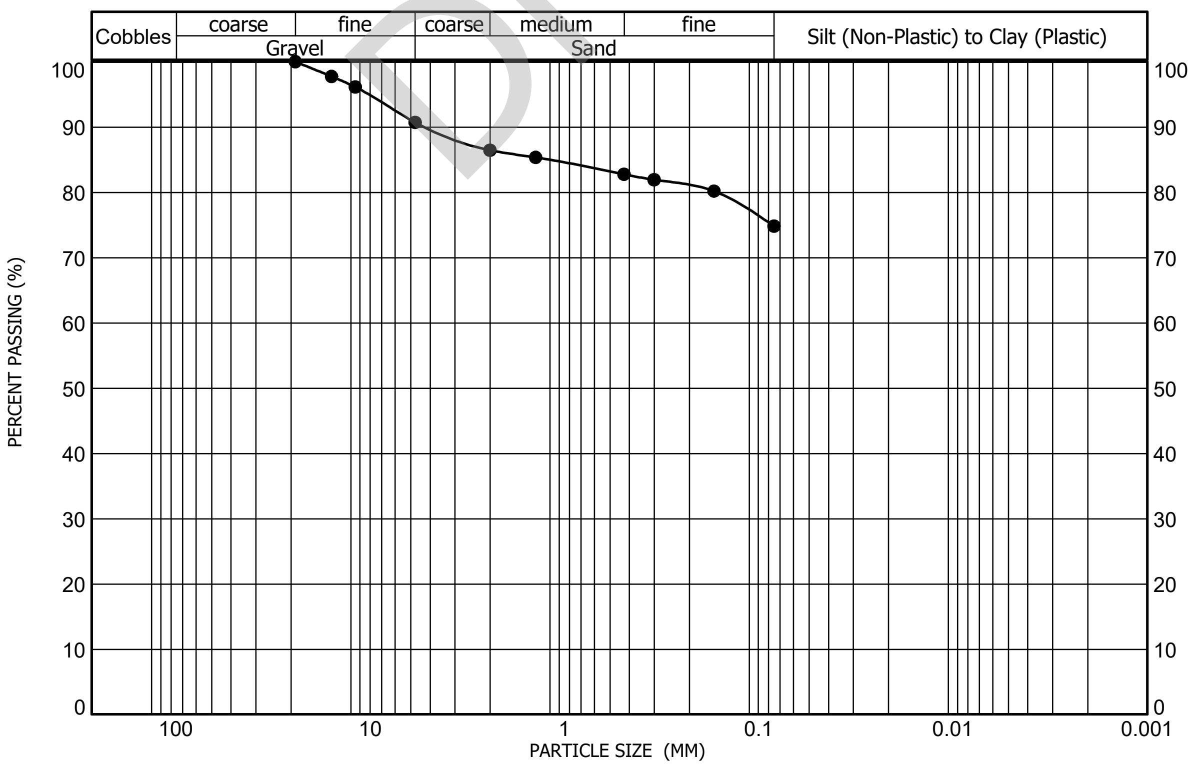
Gravel (%): 10

Sand (%): 46

Clay/Silt (%): 44

Liquid Limit: 27

Plasticity Index: 8



Sample Location: Test Boring No. 20 at a depth of 19 feet

Sample Description: Claystone, sandy, slightly gravelly

Classification: A-6(11), LEAN CLAY with SAND(CL)

Gravel (%): 9

Sand (%): 16

Clay/Silt (%): 75

Liquid Limit: 35

Plasticity Index: 17

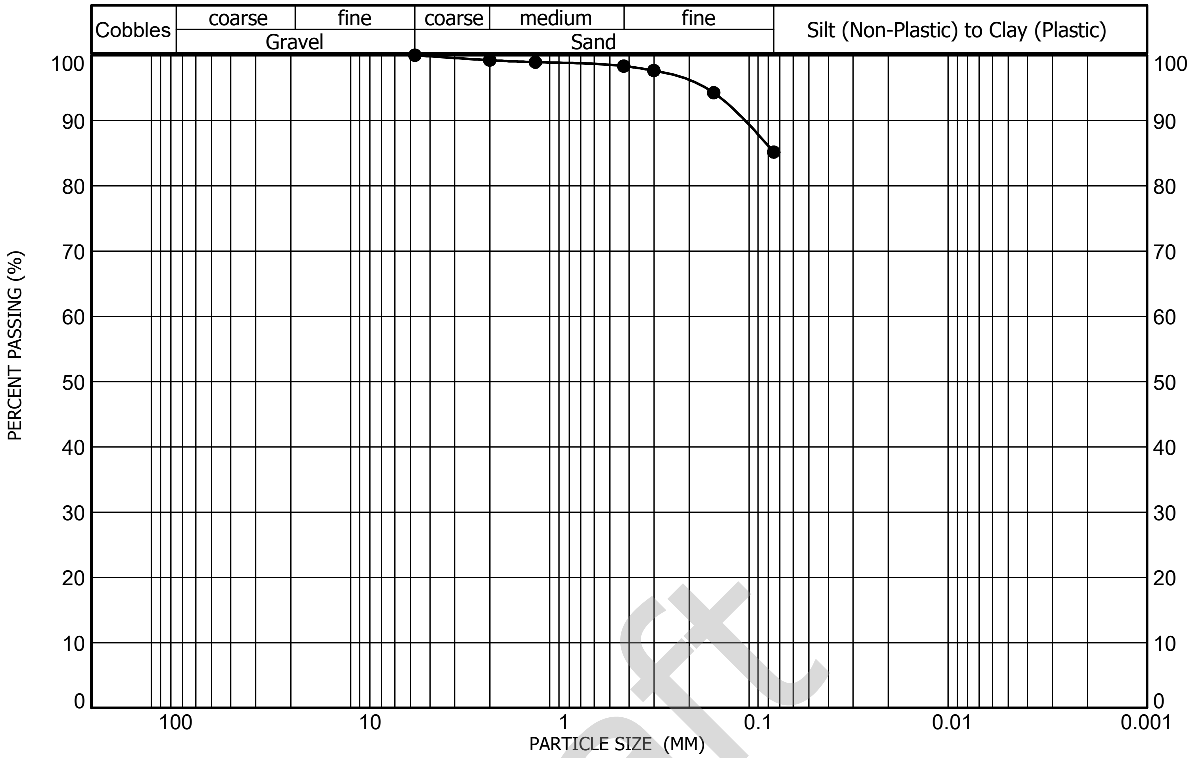
GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-35

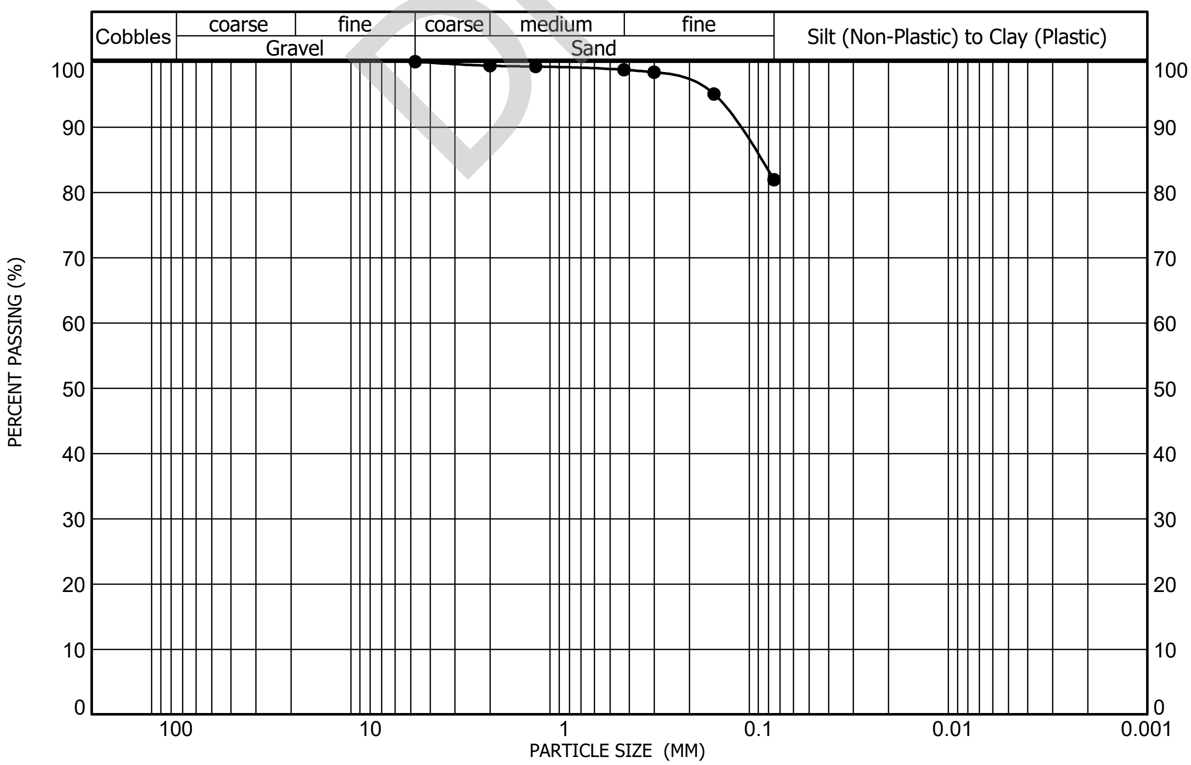
PROJECT NO. 202523

AGW

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 21 at a depth of 9 feet	Gravel (%)	0	Liquid Limit	42
Sample Description	Claystone, sandy	Sand (%)	15	Plasticity Index	24
Classification	A-7-6(20), LEAN CLAY(CL)	Clay/Silt (%)	85		

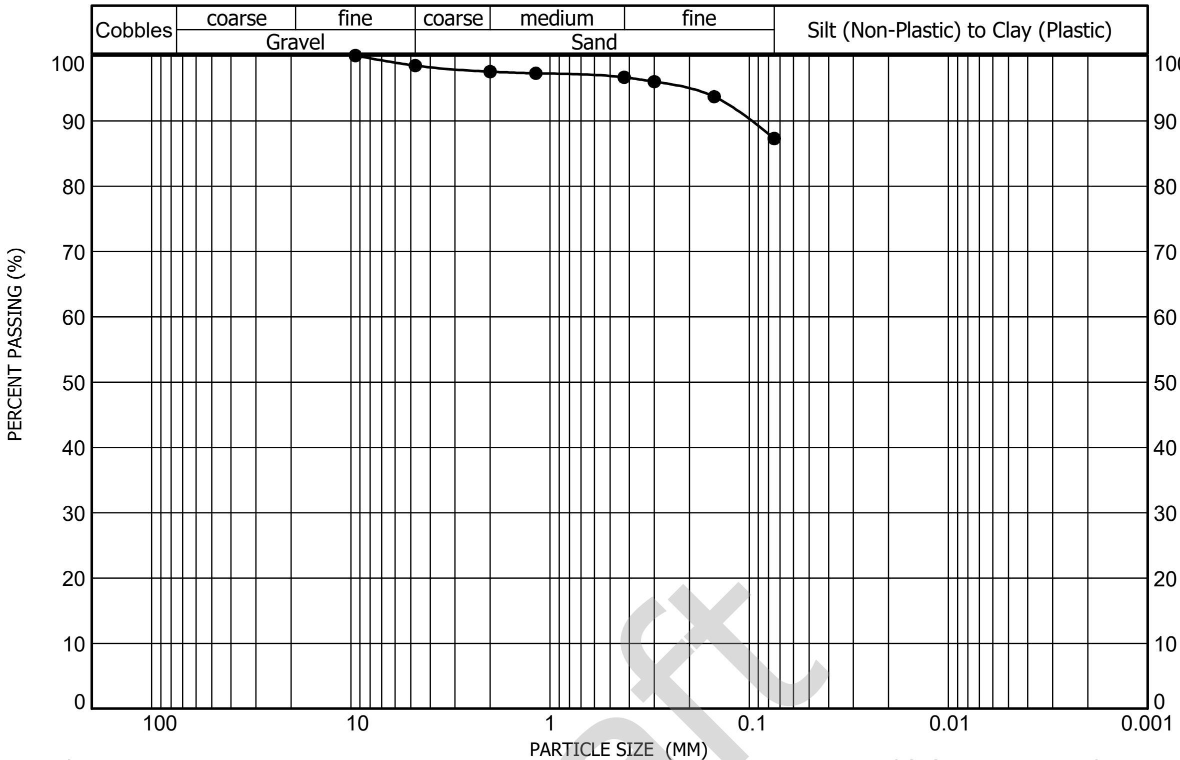


Sample Location	Test Boring No. 25 at a depth of 4 feet	Gravel (%)	0	Liquid Limit	34
Sample Description	Clay, sandy	Sand (%)	18	Plasticity Index	16
Classification	A-6(12), LEAN CLAY with SAND(CL)	Clay/Silt (%)	82		

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-36

PROJECT NO. 202523



Sample Location	Blended Bulk Sample from Test Borings	Gravel (%)	2	Liquid Limit	37
Sample Description	Clay, slightly sandy, trace gravel	Sand (%)	11	Plasticity Index	19
Classification	A-6(16), LEAN CLAY(CL)	Clay/Silt (%)	87		

GRADATION AND ATTERBERG TEST RESULTS

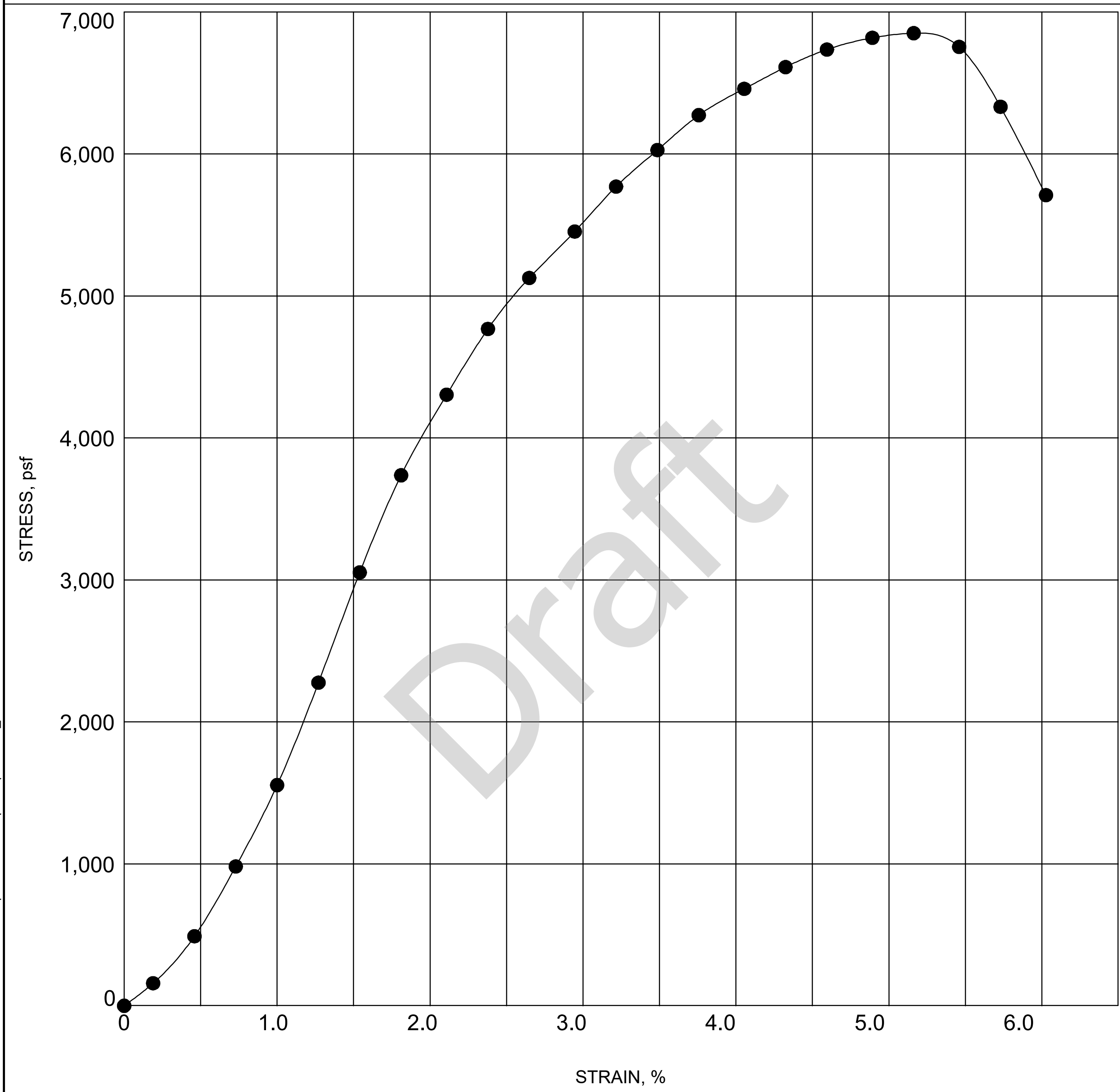
FIGURE A-37

UNCONFINED COMPRESSION TEST

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc. **PROJECT NAME** Colliers Hill, Filing 4G

PROJECT NUMBER 202523 **PROJECT LOCATION** Erie, Colorado



	BOREHOLE	DEPTH	Classification	γ_d	MC%
●	**23**	**4.0**	**Clay, sandy**	**110**	**15**

FIGURE A-38

U:\PROJECT FILES\2 - GEOTECHNICAL\202523 COLLIERS HILL F4G RICHMOND SD KAN\TO BE SAVED\GINT\202523S_GT2020-11-04 COLLIERS HILL F4G SD.GPJ

MOISTURE-DENSITY RELATIONSHIP

A.G. WASSENAAR, INC.

CLIENT Richmond American Homes of Colorado, Inc.
PROJECT NAME Colliers Hill, Filing 4G
PROJECT NUMBER 202523
PROJECT LOCATION Erie, Colorado

TEST RESULTS

Maximum Dry Density	**104.5**	**PCF**
Optimum Water Content	**19.2**	**%**

Sample Location	Blended Bulk Sample from Test Borings
Sample Source	
AGW Description	Clay, slightly sandy, trace gravel
USCS Classification	LEAN CLAY(CL)
AASHTO Classification	A-6(16)
Test Method	D698A

Gravel (%)	2
Sand (%)	12
Silt/Clay (%)	87
Liquid Limit	37
Plasticity Index	19

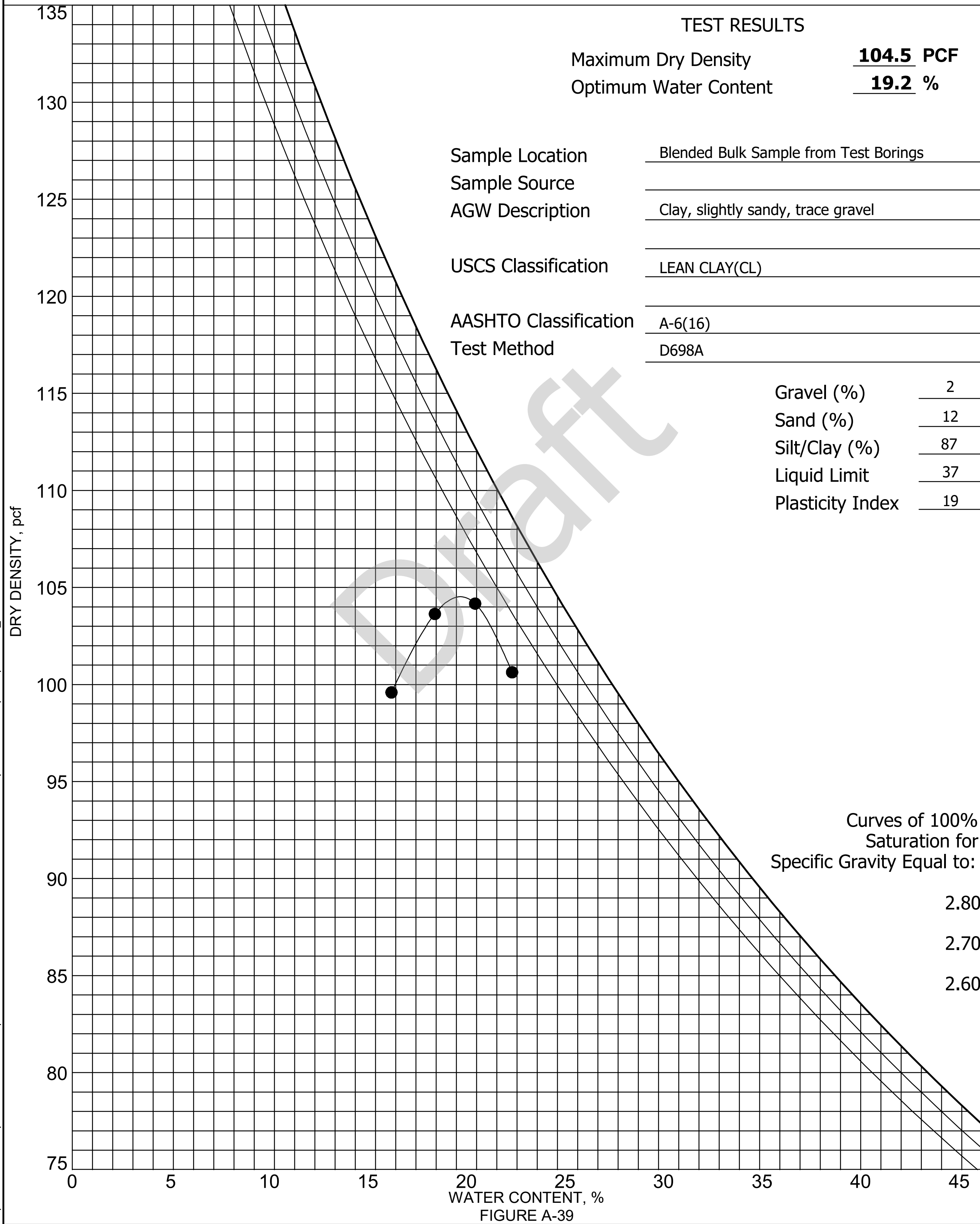


FIGURE A-39

APPENDIX B
SPECIFICATIONS FOR PLACEMENT OF FILL

APPENDIX B
SPECIFICATIONS FOR PLACEMENT OF FILL

General
AGW, as the Client's representative, should observe fill placement and conduct tests to determine if the materials placed, methods of placement, and compaction are in reasonable conformance with these specifications. Specifications presented in this Appendix are general in nature. They should be used for construction except where specifically superseded by those presented in the attendant geotechnical study.

For the purpose of this specification, structural areas include those areas that will support constructed appurtenances (e.g., foundations, slabs, flatwork, pavements, etc.) and fill embankments or slopes that support significant fills or constructed appurtenances. Structural areas will be as defined by AGW.

Fill Material
Fill material should consist of on or off-site soils which are relatively free of vegetable matter and rubble. Off-site materials should be evaluated by AGW prior to importation. No organic, frozen, perishable, rock greater than 6 inches, or other unsuitable material should be placed in the fill. For the purpose of this specification, cohesive soil is defined as a mixture of clay, sand, and silt with more than 35% passing a U. S. Standard #200 sieve and a Plasticity Index of at least 11. These materials will classify as an A-6 or A-7 by the AASHTO Classification system. Granular soils are all materials which do not classify as cohesive.

Preparation of Fill Subgrade
Vegetation, organic topsoil, any existing fill, and any other deleterious materials should be removed from the fill area. The area to be filled should then be scarified, moistened or dried as necessary, and compacted to the moisture content and compaction level specified below prior to placement of subsequent layers of fill.

Placement of Fill Material
The materials should be delivered to the fill in a manner which will permit a well and uniformly compacted fill. Before compacting, the fill material should be properly broken down, mixed, and spread in approximately horizontal layers not greater than 8 inches in loose thickness.

Moisture Control
The material must contain uniformly distributed moisture for proper compaction. The Contractor will be required to add moisture to the materials if, in the opinion of AGW, sufficient and uniform moisture is not present in the fill. If the fill materials are too wet for proper compaction, aerating and/or mixing with drier materials will be required.

Moisture content should be controlled as a percentage deviation from optimum. Optimum moisture content is defined as the moisture content corresponding to the maximum density of a laboratory compacted sample performed according to ASTM D698 for cohesive soils or ASTM D1557 for granular soils. The moisture content specifications for the various areas are as follows:

		Cohesive Soils	Granular Soils
1.	Beneath Structural Areas:	0 to +4%	−2 to +2%
2.	Beneath Non-Structural Areas:	−3 to +3%	−3 to +3%
3.	Moisture Treated Fill:	0 to +4%	−2 to +2%

Compaction

When the moisture content and conditions of each layer spread are satisfactory, the fill should be compacted. Laboratory moisture-density tests should be performed on typical fill materials to determine the maximum density. Field density tests must then be made to determine fill compaction. The compaction standard to be utilized in determining the maximum density is ASTM D698 for cohesive soils or ASTM D1557 for granular soils. The following compaction specifications should be followed for each area:

1.	Beneath Structural Areas:	95% of Maximum Dry Density
2.	Beneath Non-Structural Areas:	90% of Maximum Dry Density
3.	Moisture Treated Fill:	95% of Maximum Dry Density

If the fill contains less than 10% passing the No. 200 sieve, it may be necessary to control compaction based on relative density (ASTM D2049). If this is the case, then compaction around the structures and beneath walkway or other slabs should be to at least 70% relative density, and compaction beneath foundations and vehicle supporting should be to at least 80% relative density.

Deep Fills

In areas where fill depths exceed 20 feet beneath structural areas, additional compaction considerations will be required to reduce fill settlement. Fill placed within 20 feet of final overlot grade should be compacted as required above. Deeper fills should be compacted to 100% of maximum dry density at a moisture content of ±2% of optimum moisture content. Relative density of at least 85% will be required when necessary.

Responsibility

Any mention of essentially full-time testing and observation does not mean AGW will accept responsibility for future fill performance. AGW shall not be responsible for constant or exhaustive inspection of the work, the means and methods of construction or the safety procedures employed by Client's contractor. Performance of construction observation services does not constitute a warranty or guarantee of any type, since even with diligent observation, some construction defects, deficiencies or omissions in the Contractor's work may occur undetected. Client shall hold its contractor solely responsible for the quality and completion of the project, including construction in accordance with the construction documents. Any duty hereunder is for the sole benefit of the Client and not for any third party, including the contractor or any subcontractor.