Proposed TWTP PFAS Building

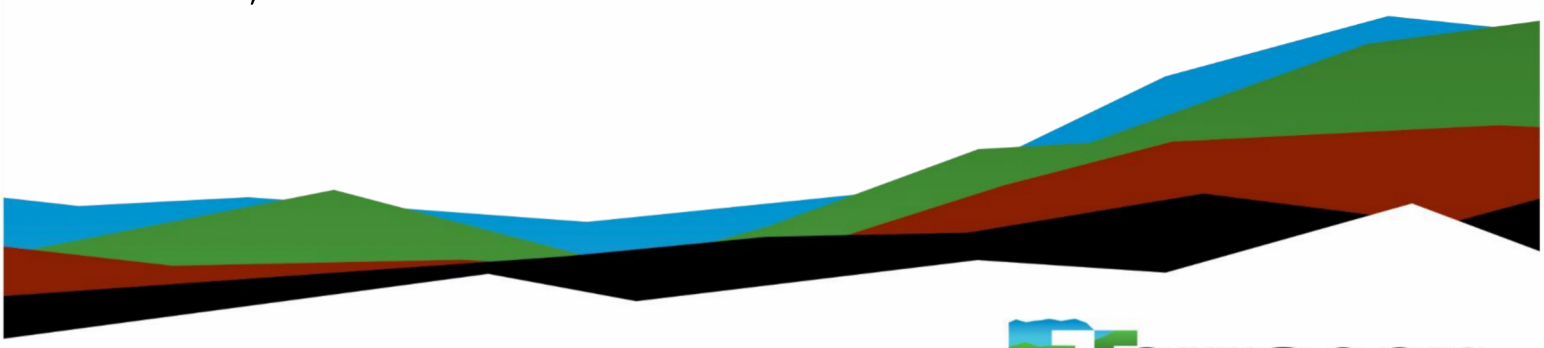
Geotechnical Engineering Report

920 Thornton Parkway | Thornton, Colorado

November 26, 2025 | Terracon Project No. 25245207

Prepared for:

Brown and Caldwell
1527 Cole Boulevard Ste. 300
Lakewood, Colorado 80401



Terracon
Explore with us

Nationwide
Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

10625 W. I-70 Frontage Rd N., Ste. 3
Wheat Ridge, Colorado 80033
P 303-423-3300
Terracon.com

November 26, 2025

Brown and Caldwell
1527 Cole Boulevard Ste. 300
Lakewood, Colorado 80401

Attn: Kathy Schlosser
P: (720) 712-2225
E: Kschlosser@BrwnCald.com

Re: Geotechnical Engineering Report
Proposed TWTP PFAS Building
920 Thornton Parkway
Thornton, Colorado
Terracon Project No. 25245207

Ms. Schlosser:

We have completed the scope of Geotechnical Engineering services for the project referenced above in general accordance with the Terracon Proposal No. P2524520, dated September 19, 2024 (Revised September 20, 2024), and our change order request dated May 8, 2025 (revised June 5, 2025). This report presents the findings of the subsurface exploration the results of our geotechnical engineering services.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon



Abbas A. Al Eyoon, P.E.
Project Engineer

Scott B. Myers, P.E.
Regional Senior Consultant

Table of Contents

Report Summary i
Introduction 1
Project Description 1
Site Conditions 4
Geotechnical Characterization 6
Subsurface Profile 6
Groundwater Conditions 7
Seismic Considerations 8
Corrosivity 8
Geotechnical Overview 9
Existing Fill Materials 9
Expansive Soils and Bedrock 10
Low Strength and Soft / Loose Soils 10
Difficult Excavations 10
Deep Backfill Zones 11
Existing Structures 11
Shoring 11
Temporary Dewatering 12
Permanent Dewatering 12
Distress of Existing Flatwork and Retaining Walls 13
Existing Flatwork 13
Existing Retaining Walls 13
Monitoring Program 13
Possible Conceptual Mitigations 14
Earthwork 16
Demolition 16
Site Preparation 16
Deep Backfill 17
Material Types 18
Compaction Requirements 20
Excavation 21
Dewatering 21
Grading and Drainage 21
Earthwork Construction Considerations 22
Utility Recommendations 23
Foundation Recommendations 24
Drilled Pier Recommendations 24
Interior Floors 27
Exterior Flatwork 28
Retaining Walls 29
Lateral Earth Pressures 29

Subsurface Drainage for Retaining and Below-Grade Walls 31
Below-Grade Structures 32
Pavements 33
Design Traffic 33
Subgrade Soils 33
Recommended Minimum Pavement Sections and Materials 34
Drainage Adjacent to Pavements 35
Pavement Maintenance 35
Pavement Construction Considerations 36
Aggregate-Surfaced Roadways 36
Subgrade Preparation 37
Design Recommendations 37
Aggregate-Surfaced Roadways Maintenance 38
General Comments 38

Figures

GeoModel

Attachments

Exploration and Testing Procedures
Site Location and Exploration Plans
Exploration and Laboratory Results
Supporting Information

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**. Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	We understand the proposed project consists of the design and construction of a new Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Treatment Facility at the Thornton Water Treatment Plant (TWTP). The PFAS treatment process will include gravity granular activated carbon (GAC) contactors with an anticipated treatment capacity of approximately 32 million gallons per day (mgd). The project will include the construction of a new tall single-story GAC building located west of the existing TWTP building. The proposed GAC building will have plan dimensions of approximately 88 by 200 feet with a below-grade level extending about 32 feet beneath the finished floor elevation at an elevation of 5378 feet. The building will have an FFE of 5405 feet. A new single-story influent pump station with a below grade level will be constructed adjacent to the east side of the existing TWTP building. The proposed pump station will have plan dimensions of approximately 35 by 101 feet, and will extend approximately 31 feet below the proposed FFE to an elevation of 5369.6 feet to accommodate the mechanical equipment and wetwell elevation. The FFE for the proposed influent pump station is planned to be 5400 feet. As part of the site development, two new retaining walls will be constructed: ■ The West Retaining Wall, located to the south of the proposed GAC building, will have a total length of approximately 250 feet and varying heights ranging from about 13 to 19.5 feet. ■ The East Retaining Wall, proposed as an extension of the existing south wall, will have a total length of approximately 260 feet and varying heights ranging from about 5.5 to 24.5 feet. The final length may be reduced pending the results of the structural evaluation of the existing wall. The project also includes installation of a new piping system consisting of four major pipelines connecting the GAC building and the influent pump station. The pipes will range in diameter

Topic [1]	Overview Statement [2]
	from 20 to 48 inches and will be installed at depths between 3 and 35 feet below finished grade. Maintenance and emergency drive access is planned around the GAC building and a semi-truck delivery and loading area is planned to the east of the building. We understand these areas may be paved with asphalt or concrete pavement or surfaced with aggregate. In addition to the design and construction of new structures, the project scope includes monitoring and evaluating existing distress observed in the flatwork and retaining walls associated with the existing TWTP building. The observed distress includes cracking and apparent movement. Conceptual mitigation recommendations will be provided following the completion of the ongoing monitoring program.
Geotechnical Characterization	Subsurface conditions encountered in the exploratory borings generally consisted of about 2 to 10 inches of asphalt or concrete pavements and topsoil underlain by existing fill materials consisting of lean to fat clay with varying amounts of sand, silt and gravel and sand with varying amounts of clay, silt, gravel and asphalt fragments to varying depths of about 13 to 36 feet below ground surface (bgs) or to the maximum depths explored in Boring Nos. BH-10 and BH-13 of 15 and 20 feet, respectively. The subsurface conditions below the fill materials consisted of claystone and sandstone bedrock to the maximum depths explored of 30 to 60 feet bgs. However, native gravel with varying amounts of sand was encountered below the fill materials in Boring No. BH-7 and extended to a depth of about 34 feet bgs. Groundwater was encountered at the time of our exploration in exploratory Boring Nos. BH-5 and BH-7 at depths of about 28 and 40 feet bgs, respectively. Groundwater was not encountered in the remaining borings to the maximum depths explored of about 15 to 60 bgs.
Expansive Soil and Bedrock	Based on the results of the laboratory testing, the existing fill materials are considered to have low expansive potential. Based on the laboratory results and our experience in the area, the claystone and sandstone bedrock are considered to have low to high expansive potential.

Topic [1]	Overview Statement [2]
Existing Fill	About 15 to 36 feet of fill materials were encountered within the footprint of the GAC building, and approximately 28 to 29 feet of fill materials were encountered within the footprint of the pump station building. Fill materials of varying depths, ranging from about 15 to 44.5 feet, were encountered in the vicinity of the existing retaining walls and flatwork areas (maximum depths explored in Boring Nos. BH-10 and BH-13). Based on field exploration and laboratory testing, the existing fill consists of soft to very stiff lean to fat clay and loose to medium dense sand with relatively high moisture contents. These materials exhibit low strength and variable compressibility, making them susceptible to consolidation / settlement. Structures or flatwork constructed on the existing fill materials will have a high qualitative risk of movement.
Earthwork	Exterior slabs-on-grade constructed on existing fill materials will have a high risk of movement. Mitigation measures to reduce the potential risk of movement are presented in the **Possible Conceptual Mitigations** subsection of **Distress of Existing Flatwork and Retaining Walls** section of this report. On-site soils are generally considered suitable for reuse as new engineered fill. Properly processed claystone and sandstone bedrock that meets the gradation and swell criteria for imported soil requirements is considered suitable for engineered fill below exterior flatwork areas.
Foundation Recommendations	Based upon the results of the field exploration and laboratory testing, and performance of the existing building and retaining walls, we recommend the proposed GAC and pump station buildings and the new retaining walls be constructed on drilled piers socketed into the underlying claystone and sandstone bedrock.
Interior Floors	Due to the presence of expansive bedrock at the below grade floor elevations, we recommend the use of a structural floor system, structurally supported independent of the subgrade soils for the proposed buildings.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.

Topic [1]	Overview Statement [2]

2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the Proposed TWTP PFAS Building to located at 920 Thornton Parkway in Thornton, Colorado. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification
- Distress of Existing Flatwork and Retaining Walls and conceptual mitigations
- Site preparation and earthwork
- Foundation design and construction
- Interior floors
- Exterior flatwork
- Lateral earth pressure
- Pavement design and construction
- Aggregate surfaced road

The original geotechnical engineering Scope of Services for this project included the advancement of thirteen (13) soil borings (designated as Boring Nos. BH-1 to BH-13) to depths of about 15 and 60 feet below ground surface (bgs). However, Boring No. BH-12 could not be drilled due to utility conflicts. Boring Nos. BH-1 to BH-5 were drilled within the footprint of the GAC building to depths of about 40 to 60 feet bgs. Boring Nos. BH-6 and BH-7 were drilled within the footprint of the pump station building to depths of about 30 to 40 feet bgs. Boring Nos. BH-8 to BH-13 were drilled within the vicinity of the existing flatwork and retaining walls areas.

Plans showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Brown and Caldwell on September 6, 2024. The request included the following documents: ■ 23-127-pfas-treatment-rfp-9-5-24-signed.pdf ■ exhibit-4---pfas-treatment-tt-trtmttechstudy_2024_0610.pdf ■ exhibit-5-23-127-pfas-treatment-cd-conceptualdsnrpt-2024-0719.pdf ■ exhibit-6---twtp_conforming-to-construction-drawings-final.pdf ■ exhibit-7---colorado-state-revolving-fund-required-specifications.pdf ■ TWTP PFAS overview.pdf
Project Description	We understand the proposed project consists of the design and construction of a new Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Treatment Facility at the Thornton Water Treatment Plant (TWTP). The PFAS treatment process will include gravity granular activated carbon (GAC) contactors with an anticipated treatment capacity of approximately 32 million gallons per day (mgd). The project will include the construction of a new tall single-story GAC building located west of the existing TWTP building. The proposed GAC building will have plan dimensions of approximately 88 by 200 feet with a below-grade level extending about 32 feet beneath the finished floor elevation at an elevation of 5378 feet. The building will have an FFE of 5405 feet. A new single-story influent pump station with a below grade level will be constructed adjacent to the east side of the existing TWTP building. The proposed pump station will have plan dimensions of approximately 35 by 101 feet, and will extend approximately 31 feet below the proposed FFE to an elevation of 5369.6 feet to accommodate the mechanical equipment and wetwell elevation. The FFE for the proposed influent pump station is planned to be 5400 feet. As part of the site development, two new retaining walls will be constructed: ■ The West Retaining Wall, located to the south of the proposed GAC building, will have a total length of

Item	Description
	approximately 250 feet and varying heights ranging from about 13 to 19.5 feet. ▪ The East Retaining Wall, proposed as an extension of the existing south wall, will have a total length of approximately 260 feet and varying heights ranging from about 5.5 to 24.5 feet. The final length may be reduced pending the results of the structural evaluation of the existing wall. The project also includes installation of a new piping system consisting of four major pipelines connecting the GAC building and the influent pump station. The pipes will range in diameter from 20 to 48 inches and will be installed at depths between 3 and 35 feet below finished grade. Maintenance and emergency drive access is planned around the GAC building and a semi-truck delivery and loading area is planned to the east of the building. We understand these areas may be paved with asphalt or concrete pavement or surfaced with aggregate. In addition to the design and construction of new structures, the project scope includes monitoring and evaluating existing distress observed in the flatwork and retaining walls associated with the existing TWTP building. The observed distress includes cracking and apparent movement. Conceptual mitigation recommendations will be provided following the completion of the ongoing monitoring program.
Building Construction	The GAC and pump station below grade levels walls and slabs will be constructed of cast-in-place concrete. The buildings above grade levels will be constructed of concrete masonry walls and steel framing. The buildings are anticipated to be constructed on drilled piers with structural floor systems.
Maximum Loads (Assumed)	Anticipated structural loads were not provided. Based on our experience with similar projects, we have assumed the following loads for the GAC and influent pump station buildings: ▪ Columns: 100 to 200 kips ▪ Walls: 5 to 10 kips per linear foot (klf) ▪ Slabs: 250 to 500 pounds per square foot (psf)
Anticipated Foundation System	Drilled piers

Item	Description
Excavation Depth	The GAC main floor elevation is 5,405 feet and the below grade level elevation is 5,373 feet, resulting in an estimated 34 feet of excavation for construction. The pump station building grade slab elevation is 5,400 feet, while wetwell elevation is 5,369.6 feet, resulting in an estimated 33 feet of excavation for construction. Excavations on the order of about 3 to 35 are anticipated for installation of the new piping systems.
Free-Standing Retaining Walls	Two new retaining walls will be constructed within the project site: ■ The West Retaining Wall, located to the south of the proposed GAC building, will have a total length of approximately 250 feet and varying heights ranging from about 13 to 19.5 feet. ■ The East Retaining Wall, proposed as an extension of the existing south wall, will have a total length of approximately 260 feet and varying heights ranging from about 5.5 to 24.5 feet. The final length may be reduced pending the results of the structural evaluation of the existing wall.
Pavements	We understand new pavements will be constructed as part of the improvements for the proposed facility. New pavements will consist of rigid or flexible pavements. Traffic loads were not available at the time of this report. We assumed traffic loads consistent with that of similar use. We understand aggregate could also be considered as a surface for this project.
Building Code	2021 IBC

Terracon should be notified if any of the above information is inconsistent with the planned construction as revised and/or additional geotechnical recommendations may be required.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Parcel Information	This project is located at 920 Thornton Parkway in Thornton, Colorado in Grand Junction, Colorado. Approximate latitude/longitude: 39.8701° N 104.9762° W See **Site Location**.
Existing Improvements	The project site currently consists of an existing Thornton Water Treatment Plant (TWTP) and associated retaining walls, parking areas, landscaping, and infrastructure. We understand the existing building consists of a single-story building with finished floor elevation of 5400 feet and has a below grade level that extends to an elevation of about 5368 feet. The existing building is constructed on drilled piers with a structural slab. A generator pad constructed on drilled piers is located to the west of the existing TWPT building and is situated behind three cantilever retaining walls to the north, west, and south. These walls are up to about 18.5 feet in height. Another retaining wall is located to the southwest of the existing building and to the north of the site stormwater detention pond. This retaining wall is a reinforced concrete cantilever wall with heights ranging from 10 to 26 feet. This wall was constructed on a shallow foundation system. We understand this wall was constructed adjacent to the existing clear well structure. The clear well structure is constructed on a drilled pier foundation system. Flatwork, concrete and asphalt pavement, landscaping and infrastructure utilities are also present at the project site. We understand the existing building and the associated improvements were constructed in 2021.
Current Ground Cover	Ground cover of the site consists of asphalt and concrete pavements, grass, weed, trees, and barren ground.
Existing Topography	The general site topography within the footprint of the GAC building is gently sloped to the south with elevation difference of about 5 to 8 feet. The location of the pump station is relatively flat. The general site topography within the footprint of the West Retaining Wall is sloped to the south with elevation difference of about 3 to 15 feet. The general site topography within the footprint of the East Retaining Wall is sloped to the south with elevation difference of up to about 15 feet.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Subsurface Profile

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Asphalt/Concrete /Topsoil	Asphalt; about 2 to 6 inches Concrete; about 8 to 10 inches Topsoil; about 4 to 6 inches
2	Fill	Fill material consisting of lean to fat clay with varying amounts of sand, silt and gravel and sand with varying amounts of clay, silt, gravel and asphalt fragments; various stiffnesses and densities
3	Native Gravel	Native gravel with varying amounts of clay; medium dense
4	Bedrock	Bedrock consisting of claystone and sandstone; soft to very hard

Stratification boundaries on the boring logs represent the approximate location of changes in soil and material types; in situ, the transition between materials may be gradual. Further details of the borings can be found on the boring logs in the **Exploration Results**.

Based on the results of the laboratory testing, the existing fill materials are considered to have low expansive and collapse potential. Based on the laboratory results and our experience in the area, the claystone and sandstone bedrock are considered to have low to high expansive potential. A summary of laboratory test results is included in the **Exploration Results**.

Groundwater Conditions

The borings were observed while drilling and upon completion of drilling for the presence and level of groundwater. The water levels encountered in the boreholes can be found on the boring logs in **Exploration Results** and are summarized below.

Boring No. [1]	Shallowest depth to groundwater encountered while or upon completion of drilling [2]
BH-1	None encountered to the maximum depth explored of 40 feet
BH-2	None encountered to the maximum depth explored of 50 feet
BH-3	None encountered to the maximum depth explored of 60 feet
BH-4	None encountered to the maximum depth explored of 40 feet
BH-5	About 38 feet
BH-6	None encountered to the maximum depth explored of 30 feet
BH-7	About 28 feet
BH-8	None encountered to the maximum depth explored of 30 feet
BH-9	None encountered to the maximum depth explored of 30 feet
BH-10	None encountered to the maximum depth explored of 15 feet
BH-11	None encountered to the maximum depth explored of 50 feet
BH-13	None encountered to the maximum depth explored of 20 feet

1. Boring Nos. BH-12 was unable to be drilled due to utility conflicts.
2. Due to safety concerns, borings were backfilled immediately after completion. Therefore, subsequent groundwater measurements were not obtained.

Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. The location and amount of perched water is dependent upon several factors, including hydrologic conditions, type of site development, irrigation demands on or adjacent to the site, fluctuations in water features, seasonal and weather conditions.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. Groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Seismic Considerations

The following table presents the seismic site classification based on the 2021 International Building Code (IBC), and the subsurface conditions encountered within the borings:

Code Used	Site Classification
2021 International Building Code (IBC) [1,2]	D

1. In general accordance with the 2021 International Building Code.
2. The 2021 International Building Code (IBC) requires a site subsurface profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100-foot subsurface profile determination. The deepest boring of this exploration extended to a maximum depth of about 60 feet and this seismic site class definition considers that similar subsurface conditions exist below the maximum depth of the subsurface exploration.

Corrosivity

The table below lists the results of laboratory pH, soluble sulfate, chlorides, electrical resistivity, and sulfides. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Boring	Sample Depth (feet)	pH	Soluble Sulfate (%)	Chlorides (mg/kg)	Electrical Resistivity (Ω-cm)	Sulfides
BH-3	0 - 5	8.05	<0.10	19	1,200	Present
BH-6	0 - 5	8.25	<0.10	51	1,600	Trace
BH-8	0 - 5	7.36	<0.10	60	610	Trace

Results of water-soluble sulfate testing indicate that samples of the on-site soils have an exposure class of S0 when classified in accordance with the American Concrete Institute (ACI) Design Manual. The results of the testing indicate ASTM Type I portland cement is suitable for project concrete in contact with on-site soils. However, if there is no (or minimal) cost differential, use of ASTM Type II portland cement is recommended for additional sulfate resistance of construction concrete. Concrete should be designed in accordance with the provisions of the ACI Design Manual.

Imported fill materials may have significantly different properties than the site materials noted above and should be evaluated if expected to be in contact with materials used for construction.

Geotechnical Overview

Based on subsurface conditions encountered in the borings, the site appears suitable for the proposed construction from a geotechnical point of view provided certain precautions and design and construction recommendations outlined in this report are followed. We have identified geotechnical conditions that could impact the design and construction of the proposed structures.

Existing Fill Materials

About 15 to 36 feet of fill materials were encountered within the footprint of the GAC building, and about 28 to 29 feet of fill materials were encountered within the footprint of the pump station building. Fill material of varying depths of 15 to 44.5 feet were encountered within the vicinity of the existing retaining walls and flatwork areas (maximum depths explored in Boring Nos. BH-10 and BH-13). It should be noted that fill depths presented in the boring logs are approximate and the depth, lateral extents, and composition of fill should be expected to vary. We believe the existing fill was placed as part of the development of the site and was likely controlled and documented. However, we do not possess any documentation that verifies the fill was placed in a controlled manner.

The fill materials consisted of soft to very stiff lean to fat clay and loose to medium dense sand with relatively high moisture contents. These materials exhibit low strength and variable compressibility, making them susceptible to consolidation/settlement.

Based on our field exploration and site observation, the pavements and flatwork constructed on existing fill and located to the west and at the southwest corner of the existing building are exhibiting distress in the form of cracking and differential movement. A downward movement of approximately 2 to 3 inches was observed between the flatwork and the southwest corner of the building, and about 4 to 5 inches of differential movement was observed between the flatwork and the generator pad west of the building.

Based on the subsurface conditions encountered in the borings and performance of the existing flatwork and pavements, it is our opinion, exterior slabs-on-grade constructed on existing fill material will have a high risk of movement. Mitigation measures to reduce the potential risk of movement are presented in the **Exterior Flatwork** section.

It should be noted that there exists the potential for construction debris and/or domestic trash to be encountered within the fill on some portions of the site. Based on existing fill materials encountered in the exploratory borings, it is our opinion, the potential for encountering construction debris or domestic trash is considered to be low. The fill materials should be observed for the presence of trash and debris during construction.

The existing fill can be reused as engineered fill below slabs-on-grade areas provided any deleterious materials are removed.

Expansive Soils and Bedrock

Based on the results of the laboratory testing, the existing fill materials are considered to have low expansive and collapse potential. Based on the laboratory results and our experience in the area, the claystone and sandstone bedrock are considered to have low to high expansive potential. A summary of laboratory test results is included in the **Exploration Results**.

This report provides recommendations to help mitigate the effects of soil and bedrock shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the pavements and flatwork should be anticipated. The severity of cracking and other damage such as uneven floor slabs will likely increase if any modification of the site results in excessive wetting or drying of the expansive soils and bedrock. Eliminating the risk of movement and distress is generally not feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. It is imperative the recommendations outlined in the **Grading and Drainage** subsection of **Earthwork** in this report be followed to reduce movement.

Low Strength and Soft / Loose Soils

Low strength and soft clay fill materials and loose to medium dense sand fill materials were encountered in all the exploratory borings to depths of about 15 to 44.5 feet below the ground surface. Excavations into low strength and soft/loose soils at this site will likely encounter unstable conditions which will require significant stabilization measures and difficult construction conditions. Unstable conditions may also develop due to precipitation or repetitive construction traffic. Extra time should be budgeted for addressing unstable conditions in excavations at this site.

Difficult Excavations

It is anticipated that excavations for the proposed improvements can be accomplished with conventional earthmoving equipment; however, specialized heavy-duty equipment capable of ripping or jack hammering may be required for bedrock excavation to

facilitate rock breakup and removal. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project.

Deep Backfill Zones

Excavations for the below-grade levels of the new GAC and pump station buildings and utilities will result in backfill thicknesses on the order of 35 feet or more. The magnitude of settlement of the deep backfill zones associated with the below-grade levels will be directly related to the type of fill material used, the degree of compaction, and the thickness of the fill zone. If the on-site clay and sand soils are used as the backfill material, the settlement of fill zones about 35 feet in thickness are estimated to be about 4 to 5 inches and would likely occur over an extended period. This assumes that the degree of compaction for fill zones is maintained in accordance with this report. Using gravel or flowable fill for backfill could reduce settlement; however, the upper 2 feet should consist of a clay cap to reduce infiltration of surface runoff. Structural exterior slabs could also be considered where movement must be held to a minimum.

Existing Structures

An existing building and associated retaining walls and utilities are currently occupying the subject site. We understand the existing building consists of a single-story building with finished floor elevation of 5400 feet and a below grade level that extends to an elevation of about 5368 feet. The existing building is constructed on drilled piers with a structural floor. We are not aware of reported issues with the performance of the existing building.

Excavations for the below grade level of the new pump station and associated piping system will likely extend at least 35 feet below finished grade adjacent to the existing building. Based on an elevation of 5369.6 feet for the below grade level of the pump station, we do not anticipate excavations for the pump station will extend below the existing building grade beams or structural floor. However, care should be used while excavating adjacent to the existing foundations or structural elements of the building and retaining walls to avoid undermining or otherwise disturbing these structural elements.

While not anticipated, if new construction extends below existing foundation elements or utilities, test pits, incremental excavation, or shoring will be needed to avoid undermining or disturbing the existing elements.

Shoring

Excavations on the order of about 35 feet are anticipated for the two buildings below grade levels and utilities. Due to the presence of existing structures, we anticipate some

shoring will be required to reach the planned excavation depths. The depths of excavation, groundwater, and subsurface soils will influence the type of shoring system that may be used. A qualified shoring contractor should be contacted to design and install the shoring system.

The lateral earth pressure parameters provided in this report may be used for temporary shoring design; however, the use of these parameters is at the discretion of the designer. It has been our experience that shoring designers have proprietary or various earth pressure diagrams to base the shoring design. It is up to the shoring designer to interpret the provided parameters.

We recommend shoring adjacent to the existing structures be monitored during construction for movement. We recommend the shoring contractor include a monitoring program in the design and construction of the shoring system.

Temporary Dewatering

Groundwater was measured at 38 and 28 feet below ground surface in Boring Nos. BH-5 and BH-7, respectively. Zones of perched and/or trapped groundwater are likely to be present in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. Based on the anticipated excavation depths for the below grade levels of the GAC and pump station buildings, and encountered groundwater depths, temporary dewatering will likely be necessary for constructing the below grade levels. We recommend a specialty dewatering contractor be contacted to consult on the most efficient temporary dewatering recommendations for the proposed project.

Permanent Dewatering

In addition to a temporary dewatering system used during construction, a permanent dewatering system will also be required for the proposed below grade levels of the GAC and pump station buildings. The permanent dewatering system may consist of a perimeter drain sloped to a vault where the water can be removed by pumping. As an alternative to designing and constructing a permanent dewatering system, the proposed below grade levels could be designed and constructed as a watertight structure. If the proposed below grade levels are designed as a watertight structure, below-grade elements should be designed to resist hydrostatic forces.

Distress of Existing Flatwork and Retaining Walls

Existing Flatwork

The existing concrete flatwork located to the west and at the southwest corner of the existing building is exhibiting distress in the form of cracking and differential movement. A downward movement of approximately 2 to 3 inches was observed between the flatwork and the southwest corner of the building, and about 4 to 5 inches of differential movement was observed between the flatwork and the generator pad west of the building. The flatwork was constructed when the existing building was constructed in 2021.

Existing Retaining Walls

We understand the existing site retaining walls around the generator pad consist of composite reinforced concrete and CMU (Concrete Masonry Units) cantilever retaining walls with a maximum height of about 18.5 feet. We understand the retaining walls around the generator pad were constructed on shallow foundations. Based on our observations, the south wall appears to have negative batter. A vertical crack of about ½ to ¾ inch in width was observed along the middle of the west wall. The crack appeared to penetrate through the wall.

Another retaining wall is located to the southwest of the existing building, adjacent to the clear well structure, and to the north of the site stormwater detention pond. This retaining wall is a reinforced concrete cantilever wall with heights ranging from 10 to 26 feet. We understand this wall was constructed on a shallow foundation system, while the clear well structure was constructed on a drilled pier foundation system. Based on our observations, the wall appears to have negative batter and has rotated outward around its toe. Differential lateral displacement of approximately 4 inches was observed at the junction between the wall and the clear well structure wall.

Monitoring Program

A survey monitoring program for the distressed flatwork, generator pad retaining walls, and the south retaining wall was initiated by a professional surveyor. The monitoring program included the establishment of horizontal and vertical controls based on the project's local coordinate system and datums. Monitoring monuments were installed within the distressed flatwork areas adjacent to the west and southwest corners of the existing building. Monuments were also installed along the tops of the generator pad retaining walls and the west section of the south retaining wall that is constructed on shallow foundations.

In addition to the survey monuments, crack gauges were installed at several locations to measure and monitor relative movements of the flatwork and retaining walls. The monitoring program was originally planned to continue for approximately two years, with monthly readings followed by quarterly readings. However, we understand the City of Thornton would like to make a decision regarding distress mitigation before the planned monitoring program is completed.

Possible Conceptual Mitigations

Existing Flatwork

Based on the subsurface conditions encountered in the exploratory borings and observations of the existing flatwork, we believe the primary cause of the observed flatwork distress is the ongoing consolidation of the deep fill materials placed during the original site development. It's common for fill materials placed adjacent to tall below grade walls to experience more consolidation/settlement than fills placed away from the structure. This is generally the result of the material receiving less compactive effort due to the proximity of the below grade wall.

These materials are expected to continue consolidating under their own weight over an extended period. The duration of consolidation is difficult to predict and may take several years to reach completion. Therefore, the ongoing monitoring program, including periodic survey monument and crack gauge readings, remains the most appropriate method to evaluate whether the observed movements are diminishing with time to determine if the remaining consolidation is acceptable.

Depending on the results of the monitoring and the extent of movement observed, the following conceptual mitigation options may be considered:

- If it is determined the remaining consolidation of the clay fill materials is acceptable, consideration could be given to "lifting" the slabs using mud jacking or foam injection. This technique can raise the slabs to roughly their original position, but it does not provide any substantial improvement of the underlying soils.
- To reduce the risk of future settlement immediately, the existing fill materials could be modified using a ground improvement method. A method of ground improvement that is commonly utilized in similar situations is compaction routing. The ground improvement technique needs to penetrate the existing fill materials and terminate into the underlying native soil or bedrock. As part of this technique, the upper 3 feet of existing fill materials will need to be replaced with a compacted granular fill, such as a CDOT Class 1.
- Reconstruction of the flatwork or pavement as structural slabs constructed on drilled piers or helical piles, designed to transfer loads to the underlying claystone

and sandstone bedrock and reduce settlement due to ongoing consolidation of the existing fill materials.

In the interim, sealing existing cracks to prevent surface water infiltration is recommended to reduce further movement and help preserve the integrity of the affected areas.

Existing Retaining Walls

The following factors are likely contributed to the observed cracking within the generator pad south wall, and the outward rotation of the south retaining wall:

- Infiltration of surface water into the existing fill materials and increasing lateral earth pressures on the walls. Relatively high moisture contents were noted in the existing fill materials encountered in the exploratory borings.
- Consolidation or settlement of the bearing soil below the wall foundation.

Based on the results of the ongoing monitoring program, if the measured movements continue or show progressive trends, conceptual mitigation measures may include the following:

- Installation of tiebacks to provide additional lateral resistance by transferring loads to deeper, more competent soils or bedrock. The feasibility of this option may be limited by existing utilities and adjacent structures such as the generator pad.
- Localized underpinning of the wall base foundation to provide increased load carrying capacity.
- Selective wall reconstruction, incorporating improved drainage systems and granular backfill materials to reduce lateral pressures.
- Reconstruction of the distressed retaining walls using a deep foundation system such as drilled piers.

Results of the ongoing monitoring program, including survey locations and readings, and crack monitor locations and data, as well as a discussion of the probable causes of the observed flatwork and retaining wall movements, will be provided in a separate addendum letter upon completion of the current monitoring program. The addendum letter will also include additional discussion of the conceptual mitigation options for both the flatwork and retaining walls based on the observed performance trends and movement rates.

Earthwork

The following sections present recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fills for new constructions for the project. All earthwork on the project should be observed and evaluated by Terracon.

Demolition

We understand the existing pavements and flatwork located to the south and east of the existing building as well as the existing parking area and several utilities are planned to be demolished as part of the proposed site improvements. The west section of the south retaining wall that is constructed on shallow foundations could also be demolished based on the final structural evaluation.

Existing shallow foundations, pavements, floor slabs, and utilities within the proposed new retaining wall areas should be completely removed, including any associated backfill materials. Abandoned utilities should be properly removed, grouted, or capped to prevent future voids or water infiltration. Resulting excavations should be cleaned of debris and backfilled with approved engineered fill placed and compacted in controlled lifts.

Demolition activities should also comply with applicable environmental regulations, and any hazardous materials (such as asbestos, lead-based paint, or contaminated soils) should be identified and properly abated in accordance with local, state, and federal requirements.

Site Preparation

Strip and remove existing pavements, vegetation, unsuitable fills, organics, and other deleterious materials from the proposed construction areas. All exposed surfaces should be free of mounds and depressions that could prevent uniform compaction.

Stripped materials consisting of vegetation, unsuitable fills, and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

Where possible, the site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath the proposed building and improvement areas. All exposed areas that will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, conditioned to near optimum moisture content, and compacted. It is imperative the moisture content of prepared materials be protected from moisture loss.

Although evidence of underground facilities, outside of the existing buried utilities, was not observed during our exploration, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

The stability of subgrade soils may be affected by precipitation, repetitive construction traffic, or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by overexcavation of wet zones and mixing these soils with crushed gravel. Use of geotextiles could also be considered as a stabilization technique. Lightweight excavation equipment may be required to reduce subgrade pumping.

Deep Backfill

Excavation for the below-grade levels of the new GAC and pump station buildings and the piping system will result in backfills of up to about 35 feet in thickness. Backfill in front of the proposed retaining walls could be up to about 25 feet.

To reduce settlement of structures and utilities constructed over deep backfill, the following measures could be considered:

- Use of gravel or similar free-draining materials as backfill. This should only be used if there is a foundation or below grade drain at the base of the backfill.
- Using Controlled Low-Strength Material (CLSM) as backfill material.
- Place backfill in thin lifts (about 4 inches max) and compact, as recommended in this report.
- Provide full-time backfill observation and testing during placement.
- Delay construction of elements over deep backfill as long as practical.

Settlement will occur in new engineered fills due to the self-weight of the newly placed engineered fill materials. The following table presents various fill heights and the estimated settlement due to the self-weight of properly moisture conditioned and compacted fill:

Maximum Fill Height	Estimated Settlement of On-Site Soils [1]	Estimated Settlement of CLSM	Estimated Settlement of Crushed Rock or Gravel [2]
About 10 feet	About 1 to 2 inches	Less than 1 inch	Less than 1 inch
About 20 feet	About 2 to 3 inches	About 1 inch	Less than 1 inch
About 30 feet	About 3 to 4 inches	More than 1 inch	About 1 inch

Maximum Fill Height	Estimated Settlement of On-Site Soils [1]	Estimated Settlement of CLSM	Estimated Settlement of Crushed Rock or Gravel [2]
About 35 feet	About 4 to 5 inches	More than 1 inch	About 1 inch

1. Assumes on-site soils are used as new engineered fill as recommended in the **Earthwork** section of this report.
2. Gravel and crushed rock may only be used in the backfill zone if a drain is constructed at the base of these materials.
3. Additional settlement will occur if the backfill materials are not moisture conditioned and compacted to the levels recommended in this report.
4. Utilities buried into the deep fill zone could experience differential settlement of about 50% to 75% of the total settlement over a span of about 40 feet

All new engineered fills should be moisture conditioned and compacted, as recommended in the **Compaction Requirements** subsection in the **Earthwork** section of this report.

Maintaining uniform backfill thickness or using gravel or flowable fill for backfill could reduce the differential settlement; however, due to the presence of expansive soil and bedrock, the gravel or crushed rock fill, if used, it should be properly drained. The drain system may consist of collector and lateral pipes beneath the entire structural fill zone sloped to a positive gravity or sump pit where water can be removed by pumping.

Material Types

Fill for this project should consist of engineered fill. Engineered fill is fill that meets the criteria presented in this report and has been properly documented.

Engineered fill should meet the following material property requirements:

Fill Type [1,2]	USCS Classification	Acceptable location for placement
On-site clay soils	CL, CH	On-site clay soils are considered suitable for reuse as engineered fill below exterior slabs-on-grade, pavements and as general fill for this project.
On-site sand and gravel soils	SC, GC	On-site sand soils are considered suitable for reuse as engineered fill below exterior slabs-on-grade, pavements and as general fill for this project.
Processed claystone and sandstone bedrock [3]	N/A	Properly processed on-site claystone and sandstone bedrock that meets the imported soil requirements is considered suitable for engineered

Fill Type [1,2]	USCS Classification	Acceptable location for placement
		fill below exterior slabs-on-grade and pavement areas and as general fill for this project.
CDOT Class 1 [4]	Varies	Imported soils meeting the gradation of a CDOT Class 1 can be considered acceptable for use as engineered fill below foundation, slabs-on-grade, pavement areas, and as structural fill within the reinforced zone for mechanically stabilized wall systems.
Imported soils	Varies	Imported soils meeting the gradation outlined herein can be considered acceptable for use as engineered fill beneath foundation areas and as general fill for this project.

1. Engineered fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation.
2. Care should be taken during the fill placement process to avoid zones of dis-similar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.
3. On-site claystone and sandstone bedrock materials should be staged separately from excavated soil. The onsite claystone and sandstone bedrock should be processed to a soil-like consistency with a maximum particle size of 1 inch. The processed claystone and sandstone bedrock must meet the imported soil requirements.
4. CDOT Class 1 Structural Fill (or equivalent) may only be used in the backfill zone if a drain is constructed at the base of these materials. The drain system may conceptually consist of collector and lateral pipes beneath the entire structural fill zone sloped to a sump pit where water can be removed by pumping. The subgrade below the structural fill should be sloped to the collector at a minimum of 2 percent. Layout and details of the drain system will be determined in collaboration with the design team.

Imported soils for engineered fill (if required) should meet the following material property requirements:

Gradation	Percent finer by weight (ASTM C136)
1”	90-100
¾”	50-100
No. 4 Sieve	50-100
No. 200 Sieve	30-75

- Liquid Limit..... 40 (max)

- Plasticity Index.....20 (max)
- Maximum Expansive Potential (%).....1.0*

  *Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at optimum water content. The sample is confined under a 200-psf surcharge and submerged.

Compaction Requirements

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift.

Item	Description
Fill lift thickness	8-inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6-inches in loose thickness when hand-guided equipment (i.e. jumping jack, plate compactor) is used
Compaction requirements [1,2]	Minimum of 95% of the material's standard Proctor maximum dry density (ASTM D698) for clay soils and a minimum of 98% of the material's standard Proctor maximum dry density for sand and gravel soils. Minimum of 100% of the material's standard Proctor maximum dry density (ASTM D698) for fills below a depth of 10 feet from finished grade.
Moisture content cohesive soils (clay soils) [3]	+1 to +4% of the optimum moisture content
Moisture content cohesionless soils (sand and gravel soils)	-2 to +2% of the optimum moisture content

1. We recommend that engineered fill be tested for water content and compaction during placement. Should the results of the in-place density tests indicate the specified water or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified water and compaction requirements are achieved.
2. Water levels should be maintained low enough to allow for satisfactory compaction to be achieved without the compacted fill material pumping when proofrolled.
3. Moisture conditioned clay soils should not be allowed to dry out. A loss of moisture within these materials could result in an increase in the materials expansive potential. Subsequent wetting of these materials could result in undesirable movement.

Excavation

Excavations into the subsurface soils and bedrock will encounter a variety of conditions. The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards.

Soils and bedrock penetrated by the proposed excavations may vary significantly across the site. The soil classifications are based solely on the materials encountered in the exploratory borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Dewatering

Groundwater was measured at 38 and 28 feet below ground surface in Boring Nos. BH-5 and BH-7, respectively. Zones of perched and/or trapped groundwater are likely to be present in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials.

In addition to temporary dewatering, a permanent system should be considered for the below-grade structures. This may consist of a perimeter drain leading to a sump and pump, or the structures may be designed as watertight structures to resist hydrostatic forces. A specialty dewatering contractor should be consulted to assist in the design of the temporary and permanent dewatering systems.

Grading and Drainage

All grades must be adjusted to provide positive drainage away from the proposed structures during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Water permitted to pond near or adjacent to the perimeter of the structures (either during or post-construction) can result in significantly higher soil movements than those discussed in this report. As a result, any estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

Permanent grades of the subgrade soils below any surface gravel should be sloped at a minimum of 10 percent grade for at least 10 feet beyond the perimeter of the structures. Backfill against foundations and in utility trenches should be compacted in

accordance with recommendations in this report and free of all construction debris to reduce the possibility of water infiltration. After construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved.

Where paving or flatwork abuts the structures, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Landscape or xeriscape areas within 10 feet of the foundation systems shall not be hindered by landscape edging, grade variations, or vegetation. In addition, consideration should be given to snow removal practices that will minimize the stockpiling of snow in planter and landscaped areas adjacent to structural improvements.

Sprinkler mains and spray heads should be located a minimum of 10 feet away from the building lines. Where drip line irrigation is located near the buildings, we recommend that drip line irrigation systems be located at least 5 feet from the outside edge of the foundations. Roof drains should discharge on pavements or be extended away from the structures a minimum of 10 feet through the use of splash blocks or downspout extensions.

Earthwork Construction Considerations

Upon completion of grading operations, care should be taken to maintain the moisture content of the subgrade prior to construction of the structures. Construction traffic over prepared subgrade should be minimized and avoided to the extent practical.

The site should also be graded to prevent ponding of surface water on prepared subgrade or in excavations. In areas where water is allowed to pond over a period of time, the affected area should be removed and allowed to dry out. If constraints do not allow for moisture conditioning of affected soils as recommended in this report, the affected area should be overexcavated and replaced with engineered fill. As an alternative, geotextiles could also be considered as a stabilization technique.

The Geotechnical Engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during overexcavation operations, excavations, subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction.

Utility Recommendations

Utilities constructed within deep backfill zones of the on-site soils will be at high risk of movement. Refer to **Deep Backfill** subsection of the **Earthwork** section for additional discussion. To reduce the risk of future settlement immediately, the newly placed engineered fill / existing fill materials could be modified using a ground improvement method. A method of ground improvement that is commonly utilized in similar situations is compaction grouting. The ground improvement technique needs to penetrate the newly placed engineered fill / existing fill materials and terminate into the underlying native soil or bedrock.

Utilities sensitive to movement could also be constructed on deep foundation systems such as drilled pier or helical piles. Drilled piers for the utilities may be designed and constructed in accordance with the recommendations in the **Foundation Recommendations** section of this report. Helical piles are designed and constructed by a specialty contractor. If helical piles are used for the proposed utilities, the top helice must extend through the fill materials

The onsite soil is expected to be used as backfill for buried utilities. Based on the Bureau of Reclamation suggested modules of soil reaction (E') values, we recommend a modulus of soil reaction of 50 psi for on-site clay and 200 for on-site sand when compacted to the recommendations presented in this report.

Because water can pond within granular bedding materials, we do not recommend granular material be used as bedding for utilities underlain by existing fill. The existing clay fill is prone to long-term softening when subjected to ponded water over an extended period. Where utilities must be installed within the clay fill, we recommend using a bedding material containing more than 50 percent fines or using a low permeable controlled low-strength material (CLSM) as bedding material.

All underground piping within 10 feet of the proposed structures should be designed with flexible couplings, so deviations in alignment do not result in breakage or distress. Utility knockouts in foundation walls should be oversized to accommodate differential movements. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of on-site clay soil to reduce the infiltration and conveyance of surface water through the trench backfill.

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structures should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective clay "trench plug" that extends at least 10 feet out from the structures exteriors. The clay plug material should consist of on-site clay compacted in accordance with the recommendations presented in the **Compaction Requirements** subsection of **Earthwork**. The clay fill should completely surround the

utility line and be properly placed and compacted in accordance with recommendations in this report.

Foundation Recommendations

Based upon the results of the field exploration and laboratory testing program for this exploration, the following foundation systems were evaluated for the proposed GAC and pump station buildings, the proposed retaining walls, and utilities sensitive to movement:

- Straight-shaft, cast-in-place piers constructed in bedrock.
- Spread footing on new engineered fill.

Based upon the results of the field exploration and laboratory testing, and performance of the existing building and retaining walls, we recommend the proposed GAC and pump station buildings, the new retaining walls, and utilities sensitive to movement be constructed on drilled piers socketed into the underlying claystone and sandstone bedrock.

If the owner is willing to accept a higher risk of movement, the proposed retaining walls could be constructed on spread footings, over a zone of new engineered fill. If the owner chooses to construct the retaining walls on spread footings, we should be contacted to provide shallow foundation design and construction recommendations and the risks associated with constructing on existing and new fills.

Drilled Pier Recommendations

Design recommendations for a drilled pier foundation system are presented in the following paragraphs:

Description	Value
Minimum Pier Length [1]	35 feet
Minimum Bedrock Embedment [2,3,4]	15 feet
Maximum Allowable End-Bearing Pressure [5]	25,000 psf
Maximum Allowable Skin Friction [6]	2,000 psf
Uplift Force (Tension due to Soil/Bedrock Uplift, kips)	80 x Pier diameter (ft.)
Minimum Dead Load (kips)	None
Minimum Pier Diameter	18 inches or length/diameter < 30

Description	Value
Shear Rings	3 inches high by 3 inches deep at 16 inches on center within bottom 15 feet of shaft
Void Thickness [7]	12 inches

1. The required minimum length is from the bottom of grade beams or pier caps.
2. The required minimum bedrock embedment considers the uplift force from soil/bedrock uplift only.
3. Drilled shafts should be embedded into firm or harder bedrock materials.
4. The portion of the drilled piers that can resist the uplift force must be (a) embedded in firm or harder bedrock and (b) be at least 15 feet below the top of the drilled pier.
5. In accordance with IBC Section 1806.1, if design of the pier foundations is completed using allowable stress design (ASD) methods, the vertical bearing resistance may be increased by 1/3 where used with the alternative basic load combinations that include wind or seismic loads that are described in IBC Section 1605.2(2021). This 1/3 increase does not apply if design is completed using load and resistance factor design (LRFD) methods. Increases also do not apply to the resistance of uplift loads, nor to the soil properties provided in this report for modeling the pier response to lateral loads, nor the resulting lateral pier deflection vs. applied load graph.
6. Skin friction should not be applied in fill or overburden soils, or the upper 3 feet of the drilled pier, whichever is deepest.
7. The void space below grade beams (between the piers) and pier caps should be periodically maintained and re-established, as necessary.
8. Movement on the order of less than ½ inch should be anticipated for the drilled piers, provided the piers and properly designed and constructed. Skin friction capacity provided may be used for compression and tension loading.

Piers should be considered to work in group action if the center-to-center horizontal spacing is less than three pier diameters. A minimum practical center-to-center horizontal spacing between piers of at least three diameters should be maintained, and adjacent piers should bottom at the same elevation. The capacity of individual piers must be reduced when considering the effects of group action. Capacity reduction is a function of pier spacing and the number of piers within a group. The following table presents capacity reductions for closely spaced piers.

Description	Value		
Drilled Pier Spacing (Center-to-Center)	>3 diameters	>2 to 3 diameters	1 to 2 diameters
Pier Capacity Reduction	None	30 percent	50 percent

1. End bearing values do not need to be reduced for closely spaced piers if bottom of piers are at the same elevation.

To satisfy forces in the horizontal direction using the computer program LPile©, piers may be designed for the following lateral load criteria:

Soil Type	Curve Model (p-y)	Unit Weight (pcf)	Undrained Shear Strength (psf)	Angle of Internal Friction, Φ (degrees)	Coeff. of Subgrade Reaction, k (pci)	Strain, ε_{50} (%)
Clay	Stiff clay w/out free water	105	500	--	Allow LPile program to choose values based on the other parameters in this table.	
Sand	Reese	110	--	30		
Claystone / Sandstone	Stiff clay w/out free water	120	2,500	--		

Lateral analysis should account for the center-to-center spacing and P-Y multiplier values per the following table:

Pier Center-to-Center Spacing (In Direction of Loading)	P-multiplier, P_M Row 1	P-multiplier, P_M Row 2	P-multiplier, P_M Row 3 and Higher
3 x diameter	0.8	0.4	0.3
5 x diameter	1.0	0.85	0.7

The structural engineer should determine the reinforcement necessary for the piers. At a minimum, all piers should be reinforced full depth for the applied axial, lateral, and uplift stresses imposed. We recommend a minimum reinforcement of at least 1 percent of the cross-sectional area of the pier.

Drilling to design depth should be possible with conventional single-flight power augers; however, very hard and potentially cemented bedrock layers could require the use of heavy-duty equipment.

Pier casing will likely be required. Casing should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or caving soils or the creation of voids in pier concrete. Pier concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Pier concrete with slump in the range of 5 to 7 inches is recommended for uncased piers. For cased piers, a slump in the range of 7 to 9 inches is recommended.

Groundwater should be removed from each pier hole prior to concrete placement. Pier concrete should be placed immediately after completion of drilling and cleaning. If pier

concrete cannot be placed in dry conditions, a tremie should be used for concrete placement. Free-fall concrete placement in piers will only be acceptable if provisions are taken to avoid striking the concrete on the sides of the hole or reinforcing steel. The use of a bottom-dump hopper, or an elephant's trunk discharging near the bottom of the hole where concrete segregation will be reduced, is recommended.

Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes. Pier-bearing surfaces must be cleaned prior to concrete placement. A Terracon representative should observe the bearing surface and shaft configuration.

The top of the piers should be cylindrical in shape. Forms may be necessary at the top of the piers in order to minimize the disturbance of the soils and to maintain a cylindrical shape. Failure to provide this shape (i.e., allowing mushrooming of pier tops) may result in additional uplift forces and unanticipated movement.

Interior Floors

Due to the presence of expansive bedrock at the below grade floor elevations, we recommend the use of a structural floor system, structurally supported independent of the subgrade soils for the proposed buildings.

Structurally supported floors should be constructed with a minimum 12-inch void space between the low point for any element of the floor system and the ground surface. Carton type void forms, such as SureVoid or an approved equivalent, may be used to provide the minimum void space of 12 inches. The void form manufacturer’s installation recommendations must be followed during construction of the structurally supported floor.

Larger void space/crawlspace areas may be necessary to allow for safe access, inspection, and maintenance. Trenches excavated below slabs-on-void may act as conduits for water transmission and should be avoided. If used, they must be sloped to a drain, sump pit, or other appropriate outfall and must be periodically inspected and maintained.

Utilities below structural floors should be limited to crawlspace areas, independent of the subgrade, and maintain a minimum of 12-inches space between the utility and subgrade soils. Where possible, utilities should not be constructed below slabs-on-void.

The design team should account for control of humidity within crawlspaces. We recommend a firm specializing in the design and construction of air quality control systems be consulted.

Exterior Flatwork

Based on the subsurface conditions encountered in the exploratory borings and observations of the existing flatwork, exterior slabs-on-grade constructed on existing fill materials will have a high risk of movement. A lower risk alternative for exterior flatwork is complete removal of existing fill and replacement with moisture conditioned properly compacted fill. However, this could be cost prohibitive.

Alternative options to reduce the risk of movement of exterior flatwork are presented in the **Possible Conceptual Mitigations** subsection of **Distress of Existing Flatwork and Retaining Walls** section of this report. However, implementation of these options may also be cost prohibitive.

If the owner is willing to accept a higher risk of movement for exterior flatwork, estimated to be on the order of about 1-1/2 to 3 inches, consideration could be given to overexcavating a portion of the existing fill materials below these elements, then processing, moisture conditioning and compacting the materials back to subgrade elevation. At a minimum, we recommend the subgrade materials below exterior slabs-on-grade and flatwork be overexcavated to a depth of at least 3 feet, moisture conditioned, and recompacted to grade.

New fill materials beneath flatwork should be placed and compacted as outlined in the **Earthwork** section of this report.

For structural design of exterior concrete slabs-on-grade, a modulus of subgrade reaction of 90 pci may be used for point or limited area loads for exterior slabs-on-grade at this site.

Additional slab design and construction recommendations are as follows:

- Minimizing moisture increases in the backfill.
- Controlling moisture-density during placement of backfill.
- Positive separations and/or isolation joints should be provided between exterior slabs and structures to allow independent movement.
- Control joints should be provided in slabs to control the location and extent of cracking.
- Exterior slabs should not be constructed on frozen subgrade
- Other design and construction considerations, as outlined in Section 302.1R of the ACI Design Manual, are recommended.

Movements of exterior slabs-on-grade using the above technique will likely be reduced and tend to be more uniform. Additional movement could occur should the subsurface soils become wetted to significant depths, which could result in potential excessive movement causing uneven exterior slabs and severe cracking. This could be due to over

watering of landscaping, poor drainage, and/or broken utility lines. Therefore, it is imperative that the recommendations outlined in the **Grading and Drainage** subsection of **Earthwork** be followed.

Retaining Walls

We understand two new retaining walls will be constructed within the project site. The West Retaining Wall, located to the south of the proposed GAC building, will have a total length of approximately 250 feet and varying heights ranging from about 13 to 19.5 feet. The East Retaining Wall, proposed as an extension of the existing south wall, will have a total length of approximately 260 feet and varying heights ranging from about 5.5 to 24.5 feet. The final length may be reduced pending the results of the structural evaluation of the existing wall.

Rigid retaining walls, such as cantilever, or gravity type concrete walls may be designed using the lateral earth pressures provided in the following section. Foundations for rigid retaining walls may be designed and constructed in accordance with the recommendations in the **Foundation Recommendations** section of this report. If the owner is willing to accept a higher risk of movement, the proposed retaining walls could be constructed on spread footings, over a zone of new engineered fill. If the owner chooses to construct the retaining walls on spread footings, we should be contacted to provide shallow foundation design and construction recommendations and risk associated with constructing on existing and new fill.

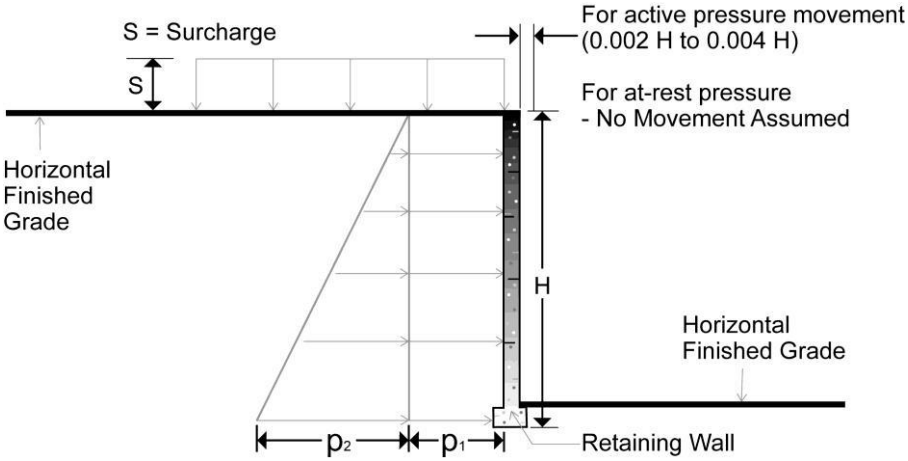
The wall designer should perform standard wall design practices including analysis for overturning, sliding, bearing capacity, and global stability, and results of these analyses should be provided for our review.

Lateral Earth Pressures

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Shoring systems may also be designed using the earth pressures presented in this section. However, the use of these parameters is at the discretion of the designer. It has been our experience that shoring designers have proprietary or various earth pressure diagrams to base the shoring design. It is up to the shoring designer to interpret the provided parameters.

Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall

movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Earth Pressure Conditions	Lateral Earth Pressure Coefficient	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (Ka)	0.59	65	(0.59)S	(65)H
At-Rest (Ko)	0.74	85	(0.74)S	(85)H
Passive (Kp)	1.7	180	---	---

Applicable conditions to the above include:

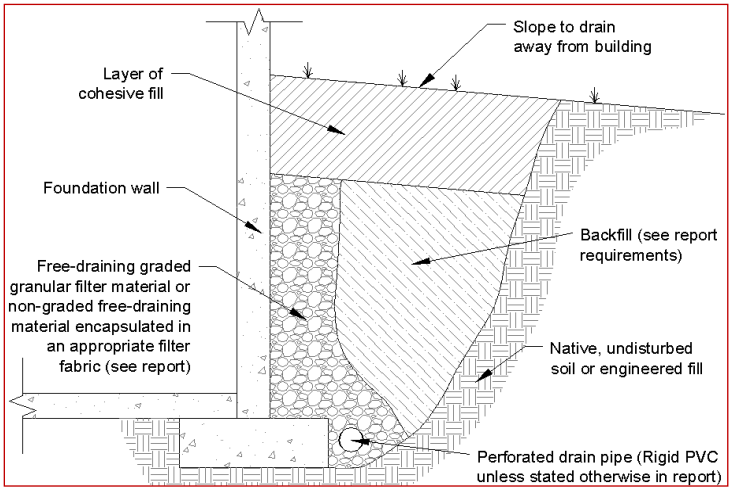
- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted to at least 95 percent of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters

To control hydrostatic pressure behind earth-retaining walls we recommend that a drain be installed below the foundation of the wall with a collection pipe leading to a reliable

discharge. If this is not possible, then combined hydrostatic and lateral earth pressures should be calculated for lean clay backfill using an equivalent fluid weighing 90 and 100 pcf for active and at-rest conditions, respectively. For granular backfill, an equivalent fluid weighing 85 and 90 pcf should be used for active and at-rest conditions, respectively. These pressures do not include the influence of surcharge, equipment, or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

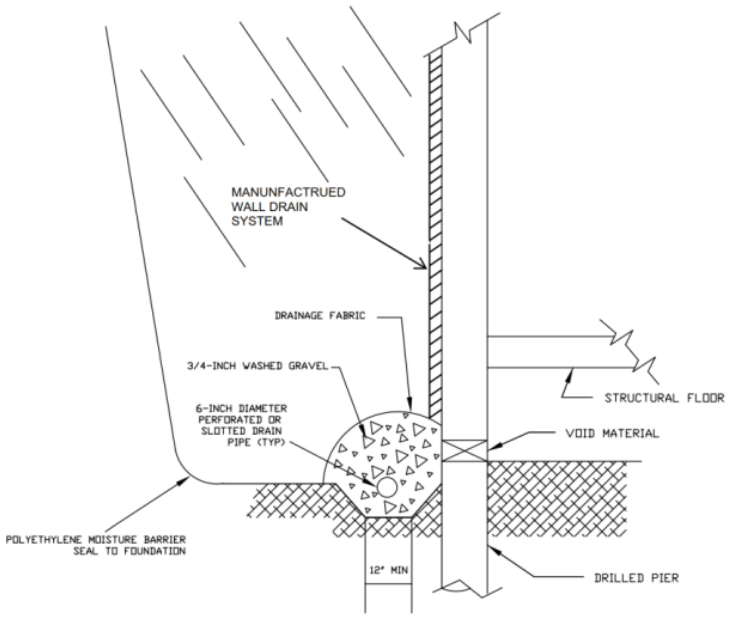
Subsurface Drainage for Retaining and Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends belowadjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system. The detail figure below could be use as a refrence inthe design of the drainage system behind retaining walls.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

The detail figure below could be used as a reference in the design of the drainage system behind the below grade foundation walls constructed on drilled piers.



Below-Grade Structures

Groundwater was measured at 38 and 28 feet below ground surface in Boring Nos. BH-5 and BH-7, respectively. Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. Based on the anticipated excavation depths of up to about 35 feet bgs and the potential for seasonal groundwater level variation, a temporary dewatering system should be anticipated for construction. We recommend a qualified dewatering contractor be consulted to design the temporary dewatering system for the project.

Based on the groundwater measurements obtained at the site, groundwater will influence the design of the structure. The below-grade level of the proposed structure should be designed as water-tight structure and/or be designed with permanent dewatering system. It has been our experience that permanent dewatering systems may require on-site treatment systems and on-going monitoring and water testing for the duration of project's life. A qualified dewatering contractor should be consulted to design the permanent dewatering system for the proposed structure if a dewatering system is elected for design of the project.

If the below-grade level for the proposed building is designed as water-tight structure, it should be designed to resist uplift forces from buoyancy. Due to the clayey nature of the

on-site soils, hydrostatic forces resulting from water at finished grade should be considered in the design.

Pavements

Maintenance and emergency drive access is planned around the GAC building and a semi-truck delivery and loading area is planned to the east of the building. New pavements may consist of rigid or flexible pavements. Traffic loads were not available at the time of this report. We assumed traffic loads consistent with that of similar use.

Design of privately maintained pavements for the project has been based on the procedures outlined by the Asphalt Institute (AI) and the American Concrete Institute (ACI).

Design Traffic

We assumed the following design parameters for Asphalt Institute flexible pavement thickness design:

- Maintenance and Emergency Drive Access - Traffic Class II
  - Access lanes with a maximum of 10 trucks per day
- Semi-Truck Delivery and Loading Area- Traffic Class III
  - Access lanes with a maximum of 25 trucks per day
- Subgrade Soil Characteristics
  - USCS Classification – CL, CH, SC (poor to medium subgrade)

We assumed the following design parameters for ACI rigid pavement thickness design based upon the average daily truck traffic (ADTT):

- Maintenance and Emergency Drive Access
  - ACI Category A with an ADTT of 10 over 20 years
- Semi-Truck Delivery and Loading Area
  - ACI Category B with an ADTT of 25 over 20 years
- Subgrade Soil Characteristics
  - USCS Classification – CL, CH, SC (low to medium support)
- Concrete modulus of rupture value of 500 psi

We should be contacted to confirm and/or modify the recommendations contained herein if actual traffic volumes differ from the assumed values shown above.

Subgrade Soils

Based on the subsurface conditions encountered in the exploratory borings and observations of the existing flatwork, pavements constructed on existing fill materials

will have a high risk of movement. A lower risk alternative for pavements is complete removal of existing fill and replacement with moisture conditioned, properly compacted fill. However, this could be cost prohibitive.

Alternative options to reduce the risk of movement of pavements constructed on existing fill materials are presented in the **Possible Conceptual Mitigations** subsection of **Distress of Existing Flatwork and Retaining Walls** section of this report. However, implementation of these options may also be cost prohibitive.

If the owner is willing to accept a higher risk of movement for pavements, estimated to be on the order of about 1-1/2 to 3 inches, consideration could be given to overexcavating a portion of the existing fill materials below these elements, then processing, moisture conditioning and compacting the materials back to subgrade elevation. At a minimum, we recommend the subgrade materials below pavements be overexcavated to a depth of at least 3 feet, moisture conditioned, and recompacted to grade.

Recommended Minimum Pavement Sections and Materials

Recommended alternatives for flexible and rigid pavements are summarized for each traffic area as follows:

Traffic Area	Alternative	Preliminary Pavement Thickness (Inches)			
		Asphalt Concrete Surface	Aggregate Base Course	Portland Cement Concrete	Total
Maintenance and Emergency Drive Access (AI Class II and ACI Category A)	A	6	--	--	6
	B	5	6	--	11
	C [1]	--	--	6	6
Semi-Truck Delivery and Loading Area (AI Class III and ACI Category B)	A	7	--	--	7
	B	6	6	--	12
	C [1]	--	--	7	7

1. The minimum pavement section thickness per ACI

Each alternative should be investigated with respect to current material availability and economic conditions. A minimum 7-inch thickness of rigid reinforced concrete pavement is recommended at the location of dumpsters where trash trucks park and load, and in areas of tight turning radius.

Concrete pavement joint spacing and reinforcement should be in accordance with specifications in the ACI Design Manual.

For analysis of pavement costs, the following specifications should be considered for each pavement component:

Pavement Component	Colorado Department of Transportation Criteria
Asphalt Concrete Surface	Grading S or SX
Aggregate Base Course	Class 6
Portland Cement Concrete	Class P

Drainage Adjacent to Pavements

Subgrade materials will expand and/or lose stability with increases in moisture content. To reduce pavement distress due to wetting of the subgrade in areas of water intensive landscaping or other nearby water sources (or if aggregate base course is used) located adjacent to pavements, edge drains should be considered.

Pavement Maintenance

Future performance of pavements constructed at this site will be dependent upon several factors, including:

- Maintaining stable moisture content of the subgrade soils both before and after pavement construction.
- Providing for a planned program of preventative maintenance.

The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be implemented:

- Site grading at a minimum 2 percent grade onto or away from the pavements.
- Water should not be allowed to pond behind curbs.
- Compaction of any utility trenches for landscaped areas to the same criteria as the pavement subgrade.
- Sealing all landscaped areas in or adjacent to pavements or providing drains to reduce the risk of moisture migration to subgrade soils.
- Placing compacted backfill against the exterior side of curb and gutter.
- Placing curb, gutter, and/or sidewalk directly on subgrade soils without the use of base course materials.

Preventative maintenance should be planned and provided for an ongoing pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program.

Pavement Construction Considerations

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction and corrective action will be required. The subgrade should be carefully evaluated at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture conditioned, and properly compacted to the recommendations in this report immediately prior to paving.

We recommend the pavement areas be rough graded and then thoroughly proofrolled with a loaded tandem axle dump truck prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.

The placement of a partial pavement thickness for use during construction is not recommended without a detailed pavement analysis incorporating construction traffic. In addition, if the actual traffic varies from the assumptions outlined above, we should be contacted to confirm and/or modify the pavement thickness recommendations outlined above.

Aggregate-Surfaced Roadways

We understand an aggregate-surfaced road is also being considered for the project. Aggregate surfaced roads can accommodate moderate soil movement without significant distress, providing a flexible surface compared to rigid or conventional flexible pavement. An aggregate surface provides a cost-effective, easily repairable option that can tolerate ongoing minor movements in the underlying soils. However, aggregate surfaced roads generally require more maintenance than conventional pavements

Subgrade Preparation

The subgrade should be prepared in accordance with the Compaction Requirements presented in the **Earthwork** section of this report. We recommend the subgrade be thoroughly proof rolled with a loaded tandem-axle dump truck prior to final grading. All aggregate-surfaced roadway subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the aggregate surfacing.

Design Recommendations

Design of aggregate-surfaced roadways for the project has been based in general accordance with the "Aggregate-Surfaced Road Design Catalog" subsection of the 1993 AASHTO "Guide for the Design of Pavement Structures" and based on subsurface conditions encountered at the site, laboratory test results and an assumed CBR value of 2.0 based on soil classification. Recommended minimum pavement sections are provided in the table below.

Traffic Area	Relative Quality of Roadway Subgrade	Traffic Level	U.S. Climate Region	Aggregate-Surfacing Material Thickness, in.
Maintenance and Emergency Drive Access	Low [1]	Low	VI	6
Semi-Truck Delivery and Loading Area		Moderate		7

1. AASHTO low volume subgrade support characteristics for fat clay soils.

Quality roadway surfacing materials should consist of a blend of gravel, sand, and fines (clay and silt). We believe the maximum size particle should not exceed 1 inch in diameter and the gravel should be crushed with angular edges (not rounded). The blend of materials should be selected to allow for easy compaction resulting in a firm, low permeable surface promoting surface drainage off of the roadway surface. Aggregate base course should be placed in lifts not exceeding 6 inches and compacted to a minimum of 95 percent of the maximum dry unit weight as determined by ASTM D1557.

A quality roadway surfacing material should also contain approximately 10 to 25 percent fines (silt and clay-sized particles passing the No. 200 sieve). The fines should exhibit low to moderate plasticity (plastic index less than 15) and will act as a binder to help reduce risk for wash boarding. If the fines content of a roadway surfacing material is comprised mostly of silt, the fines will be non-plastic and the surfacing materials will not have the benefit of the binder or cohesive aspects.

In order to reduce dust, reclaimed asphalt pavement (RAP) may be used as the upper 2 to 4 inches of the aggregate-surfacing. The RAP should be graded to the specified limits for CDOT Class 6 aggregate base course but modified to contain 10 to 25 percent fines and properly compacted. Periodic (1 to 2 times a year following maintenance grading) spraying of the surface with magnesium chloride or other dust suppressant may also be considered to reduce dust and wash boarding.

Aggregate-surfaced roadways performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of aggregate-surfaced roadways:

- Site grades should slope a minimum of 10 percent away from the roadways;
- The subgrade and the aggregate-surfaced roadways have a minimum 10 percent slope to promote proper surface drainage;
- Consider appropriate edge drainage; and
- Install pavement drainage in surrounding areas anticipated for frequent wetting.

Aggregate-Surfaced Roadways Maintenance

Preventative maintenance should be planned and provided for an ongoing aggregate-surfaced roadways management program in order to enhance future roadway performance. Preventative maintenance is usually the first priority when implementing a planned maintenance program and provides the highest return on investment for aggregate-surfaced roadways.

Periodic maintenance extends the service life of the aggregate-surfaced roadways and should include re-grading and replacement of aggregate base course in any deteriorated areas. Also, thicker aggregated base course sections could be used to reduce the required maintenance and extend the service life of the aggregate-surfaced roadways. Design alternatives which could reduce the risk of subgrade saturation and improve long-term performance include installing surface drains next to any areas where surface water could pond. Properly designed and constructed subsurface drainage will reduce the time subgrade soils are saturated and can also improve subgrade strength and performance.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become

evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

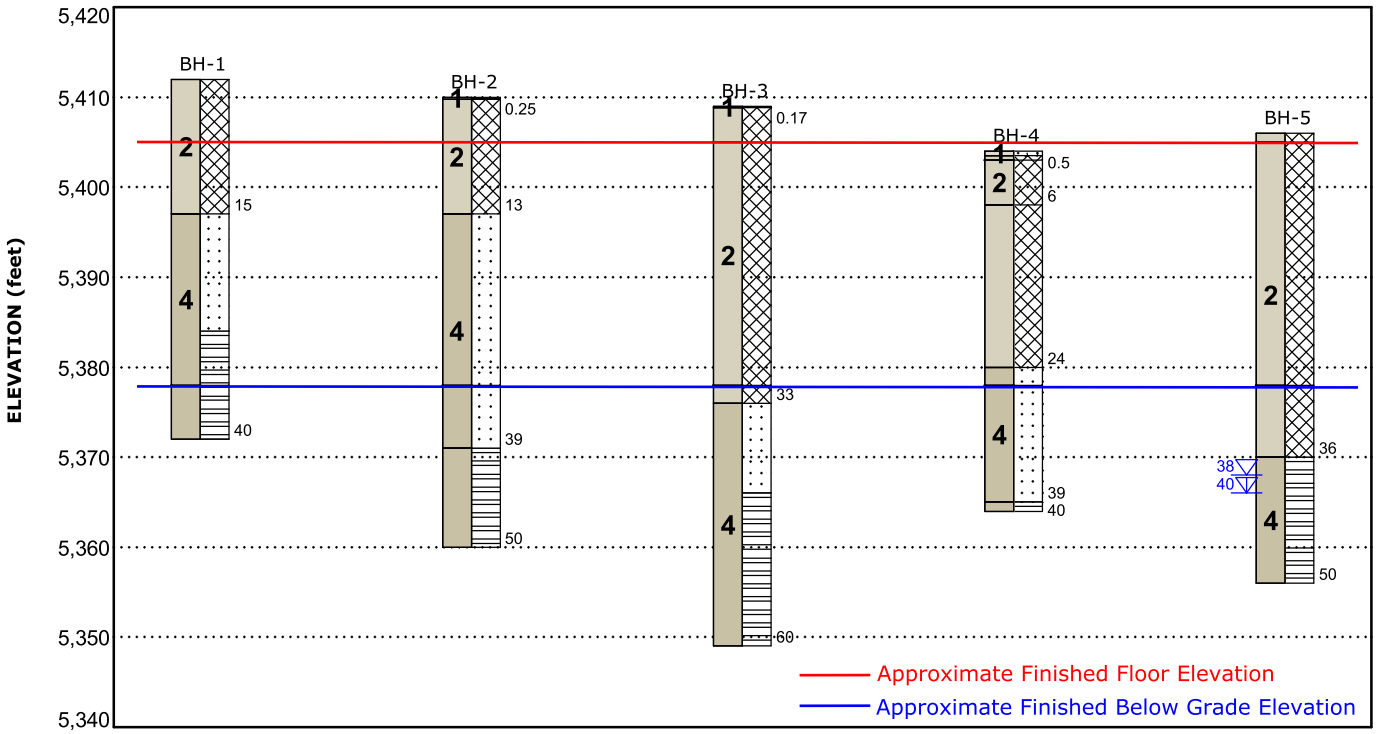
Contents:

GeoModel (3 pages)

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N
Ste 3
Wheat Ridge, CO

GeoModel - GAC Building



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Asphalt/Concrete/Topsoil	Asphalt; about 2 to 6 inches Topsoil; about 4 to 6 inches Concrete; about 8 to 10 inches
2	Fill	Fill material consisting of lean to fat clay with varying amounts of sand, silt and gravel and sand with varying amounts of clay, silt, gravel and asphalt fragments; various stiffnesses and densities
3	Native Gravel	Native gravel with varying amounts of clay; medium dense
4	Bedrock	Bedrock consisting of claystone and sandstone; soft to very hard

Legend

Fill
Sandstone
Claystone
Asphalt
Topsoil

▽ First Water Observation
▽ Second Water Observation

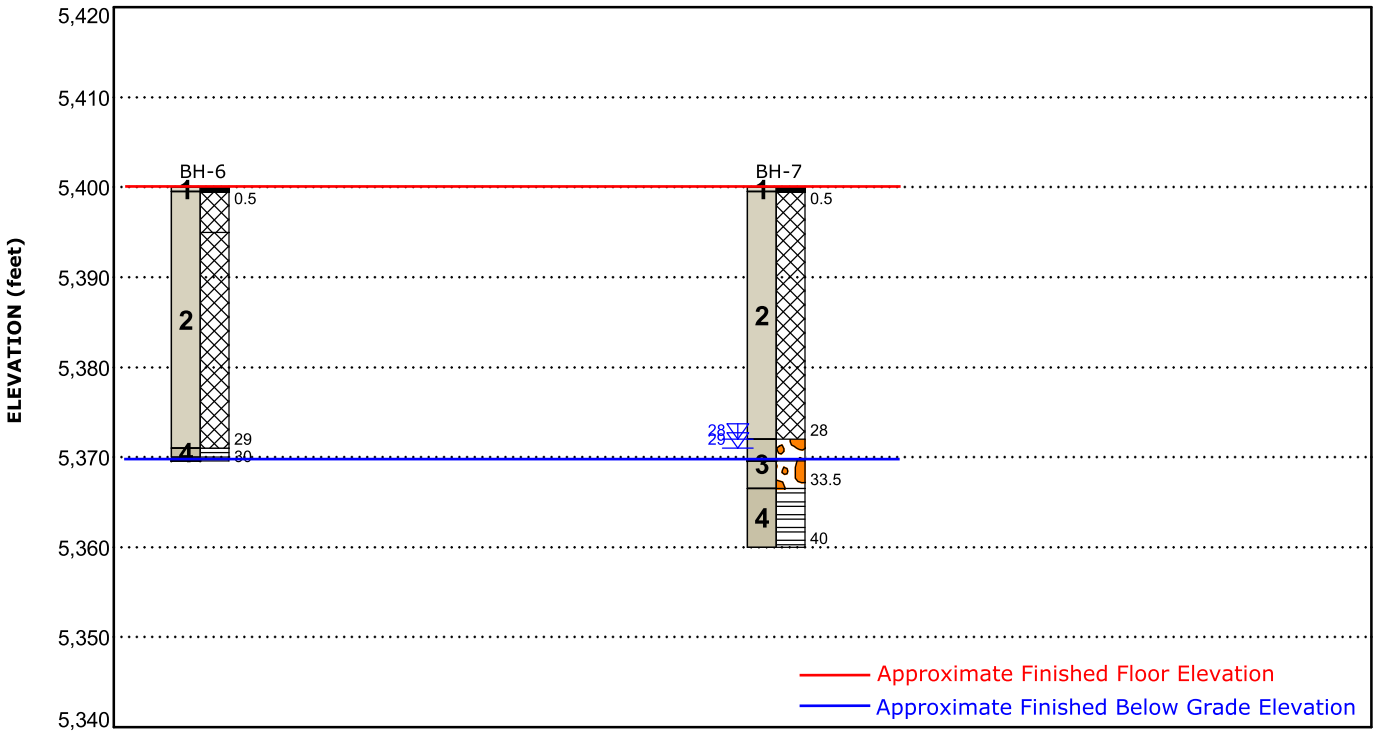
Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N
Ste 3
Wheat Ridge, CO

GeoModel - Influent Pump Station



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Asphalt/Concrete/Topsoil	Asphalt; about 2 to 6 inches Topsoil; about 4 to 6 inches Concrete; about 8 to 10 inches
2	Fill	Fill material consisting of lean to fat clay with varying amounts of sand, silt and gravel and sand with varying amounts of clay, silt, gravel and asphalt fragments; various stiffnesses and densities
3	Native Gravel	Native gravel with varying amounts of clay; medium dense
4	Bedrock	Bedrock consisting of claystone and sandstone; soft to very hard

Legend

Asphalt
Fill
Claystone
Poorly-graded Gravel

▽ First Water Observation
▽ Second Water Observation

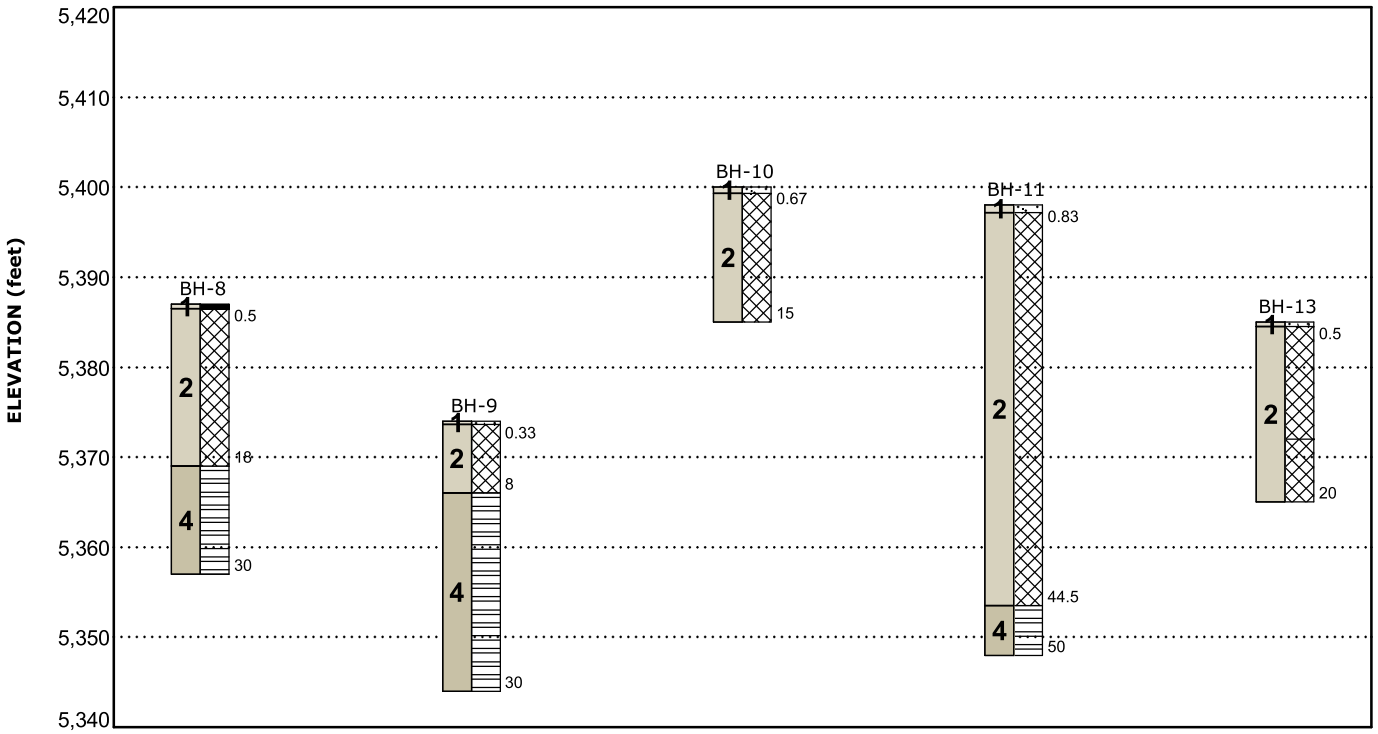
Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N
Ste 3
Wheat Ridge, CO

GeoModel - Retaining Walls and Flatwork



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Asphalt/Concrete/Topsoil	Asphalt; about 2 to 6 inches Topsoil; about 4 to 6 inches Concrete; about 8 to 10 inches
2	Fill	Fill material consisting of lean to fat clay with varying amounts of sand, silt and gravel and sand with varying amounts of clay, silt, gravel and asphalt fragments; various stiffnesses and densities
3	Native Gravel	Native gravel with varying amounts of clay; medium dense
4	Bedrock	Bedrock consisting of claystone and sandstone; soft to very hard

Legend

Asphalt
Fill
Claystone
Topsoil
Concrete

▽ First Water Observation
▽ Second Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Boring Layout and Elevations: The locations of the borings are presented in the **Site Location and Exploration Plans**. The borings locations were staked and marked by Topographic Land Surveyors. Approximate ground surface elevations were provided by Topographic Land Surveyors.

Subsurface Exploration Procedures: The borings were drilled using a CME-55/300 and a Mobile B-57 track-mounted all-terrain rotary drill rigs with solid-stem augers. During the drilling operations, lithologic logs of the borings were recorded by the field engineer. Relatively undisturbed samples were obtained at selected intervals utilizing a 2½-inch outside diameter modified California barrel sampler. Bulk samples were obtained from auger cuttings. Penetration resistance values were recorded in a manner similar to the standard penetration test (SPT). This test consists of driving the sampler into the ground with a 140-pound hammer free falling through a distance of 30 inches. The number of blows required to advance the barrel sampler 12 inches (18 inches for standard split-spoon samplers, final 12 inches are recorded) or the interval indicated is recorded and can be correlated to the standard penetration resistance value (N-value). The blow count values are indicated on the boring logs at the respective sample depths, barrel sampler blow counts are not considered N-values.

An automatic hammer was used to advance the samplers in the borings performed on this site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The standard penetration test provides a reasonable indication of the in-place density of sandy type materials, but only provides an indication of the relative stiffness of cohesive materials since the blow count in these soils may be affected by the soil moisture content. In addition, considerable care should be exercised in interpreting the N-values in gravelly soils, particularly where the size of the gravel particle exceeds the inside diameter of the sampler.

Groundwater measurements were obtained in the borings at the time of drilling. Due to safety concerns, the borings were backfilled with auger cuttings after drilling. Some settlement of the backfill may occur and should be repaired as soon as possible.

Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for observation by the Geotechnical Engineer and were classified in general accordance with the Unified Soil Classification System presented in the **Supporting Information**.

At this time, an applicable laboratory-testing program was formulated to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary, and the boring logs were prepared. The boring logs are included in the **Exploration Results**.

Laboratory test results are included in the **Exploration Results**. These results were used for the geotechnical engineering analyses and the development of foundation and earthwork recommendations. All laboratory tests were performed in general accordance with the applicable local or other accepted standards.

Selected soil samples were tested for the following engineering properties:

- Water content
- Dry density
- Grain size distribution
- Atterberg limits
- Moisture-density relationship (Proctor)
- Unconfined compressions
- Direct shear test
- pH
- Water-soluble sulfate content
- Chlorides
- Sulfides
- Electrical resistivity

Site Location and Exploration Plans

Contents:

Site Location Plan
Exploration Plan with Aerial Image
Exploration Plan with Project Overlay

Note: All attachments are one page unless noted above.

Site Location



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan with Aerial Image



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan with Project Overlay

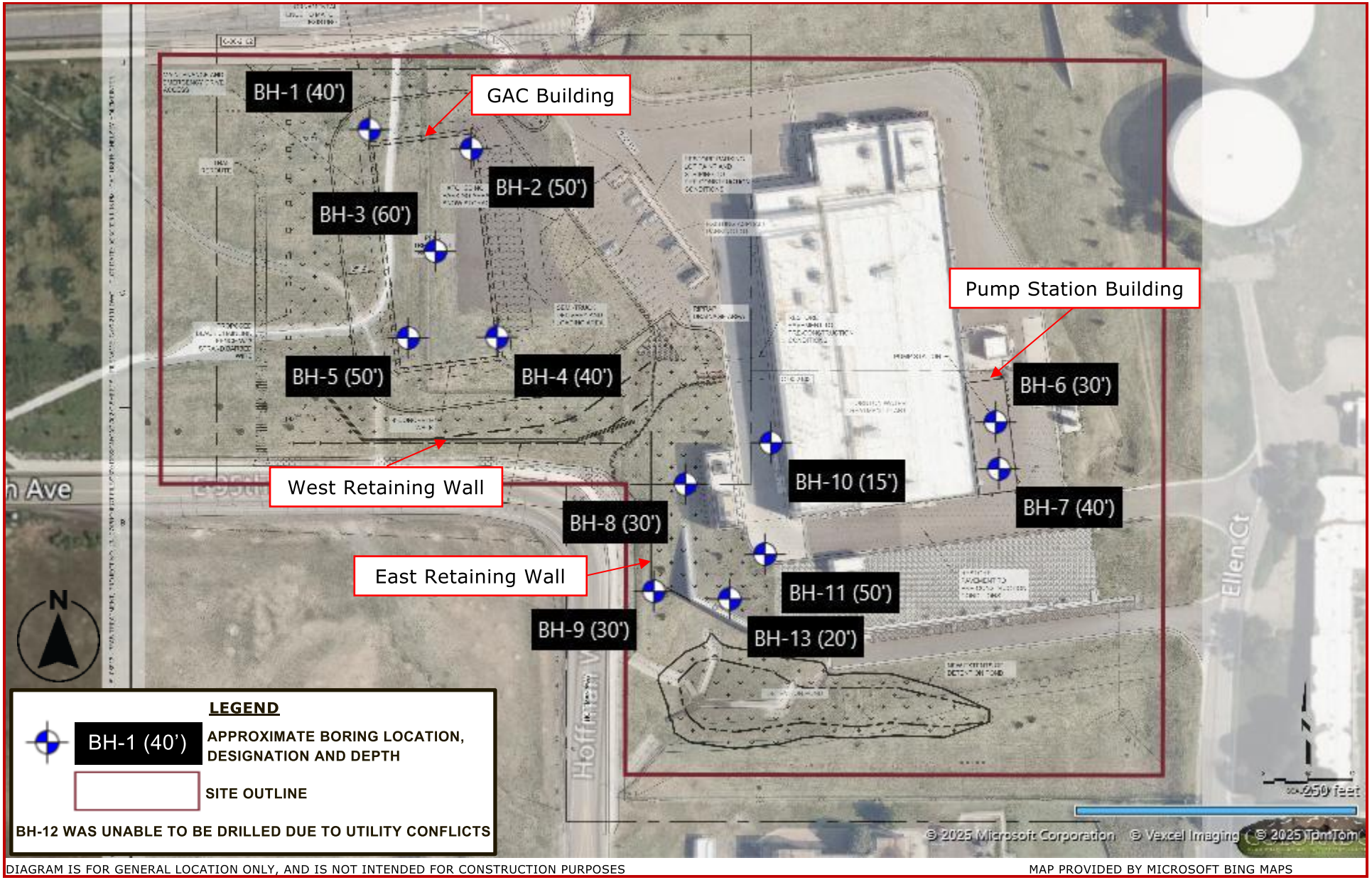


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (Boring Nos. BH-1 to BH-13)
Swell/consolidation (31 pages)
Grain Size Distribution (5 pages)
Unconfined Compressive Strength (4 pages)
Moisture-density relationship (Proctor)
Direct shear test (2 pages)
Corrosivity
Summary of Laboratory Test Results (3 pages)

Note: All attachments are one page unless noted above.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-1

Location: See Exploration Plan

Latitude: 39.8704° Longitude: -104.9763°

Depth (Ft.) Elevation: 5412.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
		FILL - SANDY LEAN CLAY (CL), brown to olive brown, stiff to very stiff			7-10			15.0	113	44-20-24	61
					5-7			21.6	103		
		7.0 5405									
2		Approximate Finished Floor Elevation: 5405.0 feet			6-6	-0.1 @ 500 psf		23.5	90		
					7-7			22.7	97		
		15.0 5397			11-16			18.8	101		
4		**SANDSTONE**, fine to coarse grained, light brown to light yellowish brown, medium hard			50/11"			17.5	105	47-15-32	31
					18-26			19.7	107		
		28.0 5384									
		CLAYSTONE, light brown to dark brown, firm to medium hard			15-19			22.2	103		
		34.0 5378									
		Approximate Finished Below Grade Elevation: 5378.0 feet			50/11"			18.0	112		
		40.0 5372			21-26			19.4	110		
		Boring Terminated at 40 Feet									

10
20
30
40

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
Terracon

Logged by
JL

Boring Started
07-07-2025

Boring Completed
07-07-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-2

Location: See Exploration Plan

Latitude: 39.8704° Longitude: -104.9760°

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 5410.0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.3	**ASPHALT**, about 4 inches / 5409.75										
			FILL - FAT CLAY (CH), trace sand and silt, brown, stiff				5-7			22.1	102		
		5.0	5405				6-8	+0.6 @ 500 psf		21.4	102	51-12-39	87
2			Approximate Finished Floor Elevation: 5405.0 feet				10-6			24.4	99		
							5-8			21.2	101		
		13.0	5397	10									
			SANDSTONE, fine to coarse grained, olive brown to grayish brown, soft to very hard				11-15			19.8	90		
				20			8-14			24.3	100		
4							50/6"	+0.4 @ 500 psf		16.5	98	33-28-5	46
				30			50/4"			16.4	91		
		32.0	5378										
			Approximate Finished Below Grade Elevation: 5378.0 feet				22-26			19.9	109		
		39.0	5371										
			CLAYSTONE, light brown to bluish gray, medium hard to very hard	40			50/10"			18.8	112		
							50/10"			19.8	110		
		50.0	5360	50			50/6"			17.1	111		
			Boring Terminated at 50 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-08-2025

Boring Completed
07-08-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and patched with asphalt upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-3

Location: See Exploration Plan

Latitude: 39.8701° Longitude: -104.9761°

Model Layer	Depth (Ft.)	Elevation: 5409.0 (Ft.) +/-	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	0.2	**ASPHALT**, about 2 inches 5408.83								
		FILL - LEAN CLAY (CL), with sand, trace silt and gravel, varies to fat clay with sand,								
	4.0	brown, soft to stiff 5405								
		Approximate Finished Floor Elevation: 5405.0 feet								
				2-2			24.2			
				3-3			25.7	93		
				4-5			24.8	94	47-14-33	83
				5-5	+0.2 @ 500 psf		20.4	105		
2				6-9			21.8	103		
				8-7			24.9	97		
				8-10			28.4	83	54-18-36	75
				5-7			15.1	103		
	31.0	5378								
		Approximate Finished Below Grade Elevation:								
	33.0	5378.0 feet 5376								
		SANDSTONE, fine to coarse grained, yellowish brown, firm		10-19			22.6	104		
				14-20			23.9	103		
	43.0	5366								
		CLAYSTONE, gray, soft to hard		9-14			23.7	101		
4				50/10"		11740	20.3	108		
				50/9"	+3.4 @ 500 psf		22.2	104		
	60.0	5349		50/9"			18.2	113		
		Boring Terminated at 60 Feet								

Depth (Ft.) 10 20 30 40 50 60

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-08-2025

Boring Completed
07-08-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and patched with asphalt upon completion.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-4

Location: See Exploration Plan

Latitude: 39.8699° Longitude: -104.9759°

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 5404.0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.5	**TOPSOIL**, about 6 inches 5403.5										
2		1.0	**FILL - SANDY LEAN CLAY (CL)**, brown to gray, stiff 5403				8-9			22.5	99		
			Approximate Finished Floor Elevation: 5405.0 feet				7-9			26.7	92		
		6.0	5398										
			FILL - FAT CLAY (CH), trace sand, silt and gravel, olive brown to dark brown, medium stiff to stiff				2-6			24.3	94	54-16-38	91
				10			5-9	+0.1 @ 500 psf		23.7	100		
							5-9			22.7	101		
				20			4-6			22.7	95		
		24.0	5380										
		26.0	**SANDSTONE**, with clay, fine to coarse grained, olive brown, firm to hard 5378				11-13	+1.4 @ 500 psf		18.3	104		
4			Approximate Finished Below Grade Elevation: 5378.0 feet	30			15-27			6.4	123		
							50/8"			19.4	107		
		39.0	5365										
		40.0	**CLAYSTONE**, gray, medium hard 5364	40			21-24		10640	20.7	105		
			Boring Terminated at 40 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-08-2025

Boring Completed
07-08-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and patched with asphalt upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-5

Location: See Exploration Plan

Latitude: 39.8699° Longitude: -104.9762°

Depth (Ft.) Elevation: 5406.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		1.0 **FILL - FAT CLAY (CH)**, with sand, trace gravel, olive brown to brown, medium stiff to very stiff 5405									
		Approximate Finished Floor Elevation: 5405.0 feet			4-7			16.1	108		
					4-6			23.8	96		
					5-6	+0.5 @ 500 psf		21.9	104	53-17-36	81
					6-7			21.5	97		
		10									
					8-12			11.3	111		
					9-9			18.4	97		
		20									
					10-12			17.3	90		
		28.0 5378									
		Approximate Finished Below Grade Elevation: 5378.0 feet			5-8			25.3	93		
		30									
					6-7			34.2	87		
		36.0 5370									
4		**CLAYSTONE**, grayish brown to brown, soft to hard	▽								
			▽		50/9"			19.4	107		
		40									
					10-12	+1.0 @ 500 psf		25.4	98		
		50.0 5356			50/10"			31.9	78		
		50									
		Boring Terminated at 50 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
▽ 38 feet while drilling
▽ 40 feet upon completion of drilling

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
Terracon

Logged by
JL

Boring Started
07-07-2025

Boring Completed
07-07-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-6

Location: See Exploration Plan

Latitude: 39.8697° Longitude: -104.9743°

Approximate Finished Floor Elevation: 5400.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 5400.0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.5	5399.5 **ASPHALT**, about 6 inches										
			FILL - CLAYEY SAND (SC), trace gravel and asphalt fragments, fine to coarse grained, dark brown to light gray, medium dense				8-9			12.9	114	31-16-15	31
		5.0	5395				8-18			14.2	98		
2			**FILL - SANDY FAT CLAY (CH)**, trace silt and gravel, brown to olive brown, stiff to very stiff				6-7			26.3	92		
				10			9-14	-0.3 @ 500 psf		25.6	93	57-21-36	62
							11-13			30.1	88		
				20			5-9			32.5	86		
							10-5			24.8	98		
		29.0	5371										
4		30.0	5370 **CLAYSTONE**, gray, firm										
		30.4	5369.6 ***Boring Terminated at 30 Feet***	30			10-20			20.6	105		
			Approximate Finished Below Grade Elevation: 5369.6 feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-11-2025

Boring Completed
07-11-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and patched with asphalt upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-7

Location: See Exploration Plan

Latitude: 39.8696° Longitude: -104.9743°

Approximate Finished Floor Elevation: 5400.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Elevation: 5400.0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.5	5399.5 **ASPHALT**, about 6 inches										
2			**FILL - CLAYEY SAND (SC)**, trace gravel and asphalt fragments, fine to coarse grained, dark brown to olive brown, loose to medium dense				8-9			11.8	107	35-15-20	35
							10-12			10.7	107		
							10-12	-0.5 @ 500 psf		13.2	103	35-21-14	22
				10			9-8			11.4	104		
							8-11			25.3	86		
				20			8-11			28.1	92		
							5-7			26.3	86		
		28.0	5372										
3		30.4	**POORLY GRADED GRAVEL (GP)**, trace clay, fine to coarse grained, reddish brown, medium dense 5369.6	30			7-11			7.7	119		
		33.5	Approximate Finished Below Grade Elevation: 5369.6 feet 5366.5										
4			**CLAYSTONE**, interbedded with sandstone, gray to olive brown, medium hard to hard				50/7"			29.9	95		
		40.0	5360	40			16-34			28.0	98		
			Boring Terminated at 40 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
29 feet while drilling
28 feet upon completion of drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-11-2025

Boring Completed
07-11-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and patched with asphalt upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-8

Location: See Exploration Plan

Latitude: 39.8696° Longitude: -104.9753°

Depth (Ft.) Elevation: 5387.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.5 **ASPHALT**, about 6 inches 5386.5									
2		**FILL - SANDY FAT CLAY (CH)**, trace silt and gravel, brown to olive brown, soft to stiff			4-3			24.9	86		
					2-2			22.6	89	51-26-25	62
					6-5	-0.5 @ 500 psf		30.0	90		
					5-4			20.0	97		
		10									
					5-6			20.5	93		
		18.0 5369									
4		**CLAYSTONE**, trace sand, grayish brown, firm to medium hard			12-20		6080	19.8	104		
		20									
					10-15	+3.4 @ 500 psf		26.1	95	68-32-36	99
		30.0 5357									
		Boring Terminated at 30 Feet			17-25			18.4	106		
		30									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-10-2025

Boring Completed
07-10-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-9

Location: See Exploration Plan

Latitude: 39.8693° Longitude: -104.9754°

Depth (Ft.) Elevation: 5374.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.3 **TOPSOIL**, about 4 inches 5373.67									
2		**FILL - FAT CLAY (CH)**, trace sand, silt and gravel, olive brown to gray, stiff to very stiff			9-10			13.1	103		
					7-9			19.6	96		
		8.0 5366			8-11	+0.7 @ 500 psf		23.2	92		
4		**CLAYSTONE**, interbedded with sandstone, olive brown to bluish gray, firm to hard			12-16	+0.6 @ 500 psf		22.0	98	50-20-30	98
		10			50/9"			19.5	107		
		20			50/7"			14.5	94		
					20-27		6860	21.5	103	57-19-38	99
		30.0 5344			22-28			18.5	104		
		Boring Terminated at 30 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-10-2025

Boring Completed
07-10-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-10

Location: See Exploration Plan

Latitude: 39.8697° Longitude: -104.9750°

Depth (Ft.) Elevation: 5400.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.7 **CONCRETE**, about 8 inches 5399.33									
2		**FILL - CLAYEY SAND (SC)**, trace silt and gravel, fine to coarse grained, brown, loose to medium dense			3-5	+0.8 @ 200 psf		15.5	108	38-21-17	40
					7-4	-0.4 @ 500 psf		34.0	79		
					8-8	-0.9 @ 750 psf		13.3	99		
		10			4-5	-0.7 @ 1000 psf		23.2	90		
		15.0 5385			6-8	-1.3 @ 1500 psf		23.1	94		
		Boring Terminated at 15 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-11-2025

Boring Completed
07-11-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and capped with concrete upon completion.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-11

Location: See Exploration Plan

Latitude: 39.8694° Longitude: -104.9751°

Depth (Ft.) Elevation: 5398.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.8 **CONCRETE**, about 10 inches 5397.17									
2		**FILL - CLAYEY SAND (SC)**, trace gravel, fine to coarse grained, brown, very loose to medium dense			4-6	-0.1 @ 200 psf		17.8	106	50-18-32	37
					4-6	-0.3 @ 500 psf		15.8	109		
					3-2	-0.9 @ 750 psf		15.5	106		
		10			4-2	-0.6 @ 1000 psf		12.9	110		
					7-10	-0.7 @ 1500 psf		14.5	108		
		20			7-12	-0.9 @ 2000 psf		13.5	111	34-17-17	31
					6-7						
		30			4-7			23.6	88		
					6-7			24.1	94		
		40			4-3			20.4	97		
		44.5 5353.5									
4		**CLAYSTONE**, trace silt and sand, gray, soft to medium hard			4-6			12.5	111		
		50.0 5348			50/10"			18.2	94		
		Boring Terminated at 50 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-15-2025

Boring Completed
07-15-2025

Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings and capped with concrete upon completion.

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Boring Log No. BH-13

Location: See Exploration Plan

Latitude: 39.8693° Longitude: -104.9752°

Depth (Ft.) Elevation: 5385.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Swell (%)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		0.5 **TOPSOIL**, about 6 inches 5384.5									
2		**FILL - CLAYEY SAND (SC)**, trace gravel, fine to coarse grained, gray to dark brown, loose to medium dense			5-8	-2.9 @ 200 psf		4.2	110	34-20-14	33
					8-8	-2.8 @ 500 psf		4.4	114		
					8-9						
		10			9-12	-0.5 @ 1000 psf		5.5	122		
		13.0 5372 **FILL - FAT CLAY (CH)**, trace silt and gravel, varies to clayey gravel with sand, olive brown to brown, medium stiff to stiff			6-6	-0.6 @ 1500 psf		21.6	97		
		20.0 5365			4-4	-0.5 @ 2000 psf		16.5	106	52-19-33	49
		20 ***Boring Terminated at 20 Feet***									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Ground surface elevation provided by Topographic Land Surveyors.

Water Level Observations
None encountered while drilling

Drill Rig
CME-55/300

Hammer Type
Automatic

Driller
Terracon

Logged by
AC

Boring Started
07-18-2025

Boring Completed
07-18-2025

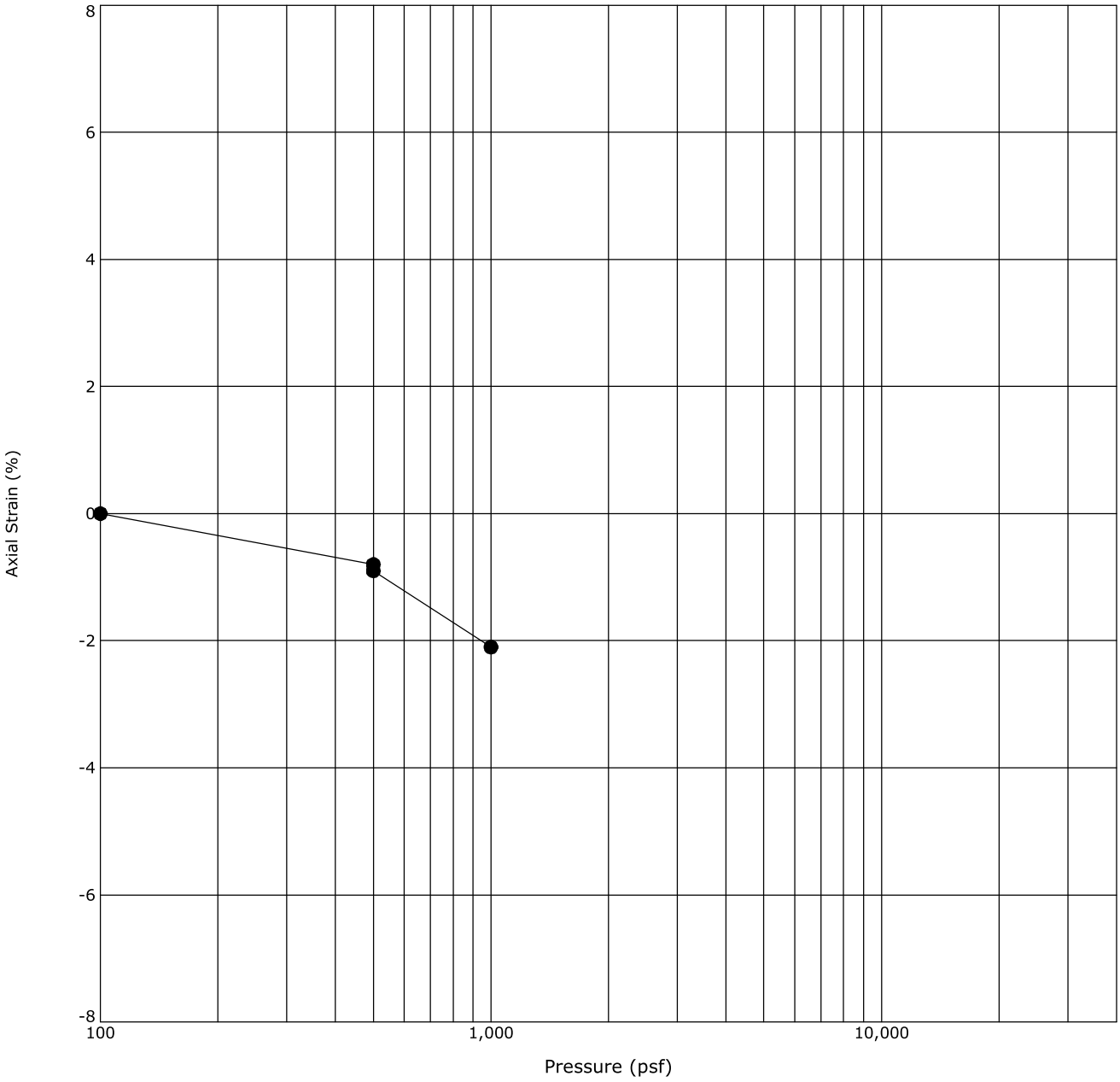
Notes

Advancement Method
4-inch diameter, solid-stem, continuous-flight power auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

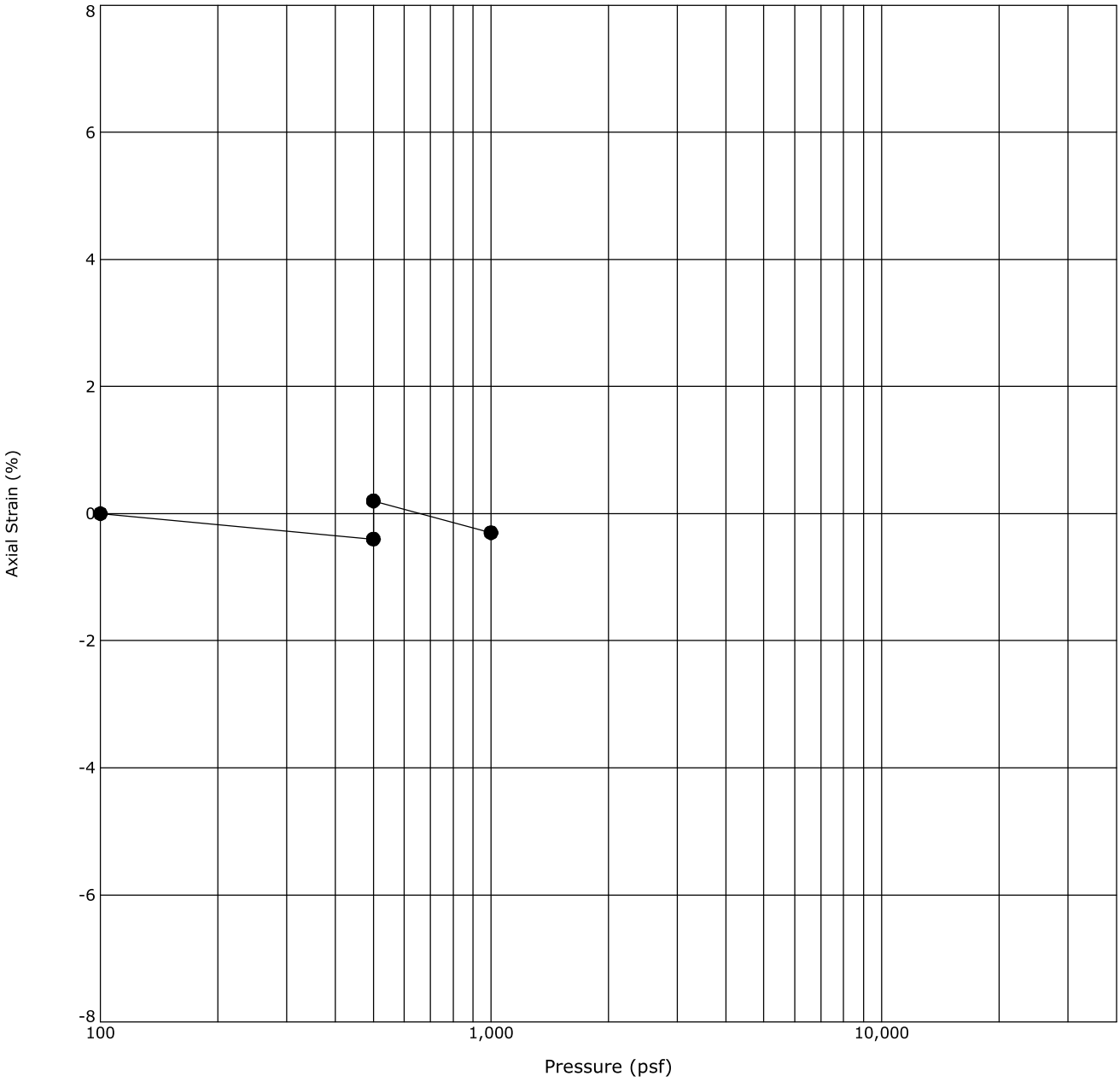


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-1	7 - 8	FILL - SANDY LEAN CLAY	CL	90	23.5

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

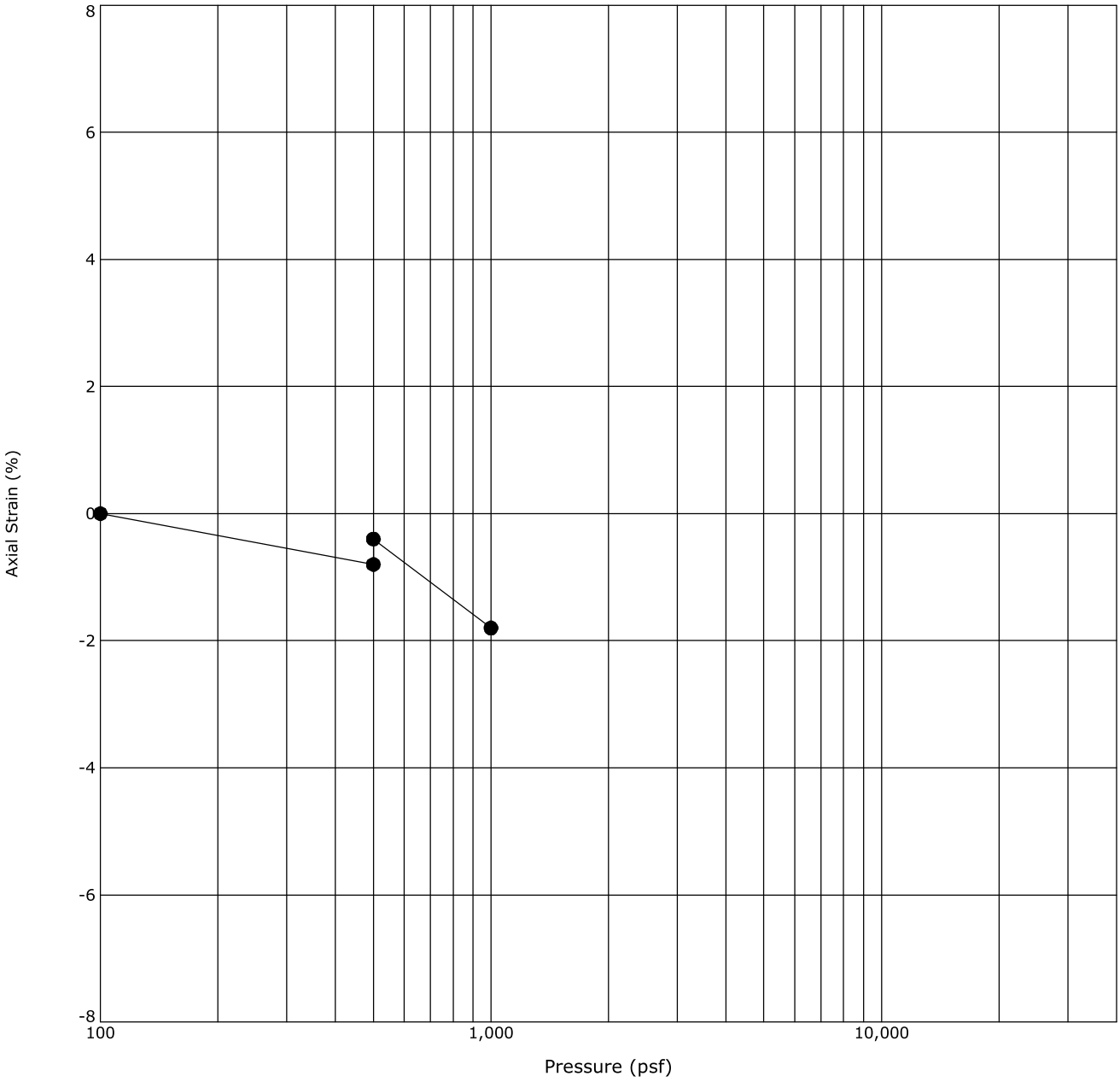


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-2	4 - 5	FILL - FAT CLAY	CH	102	21.4

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

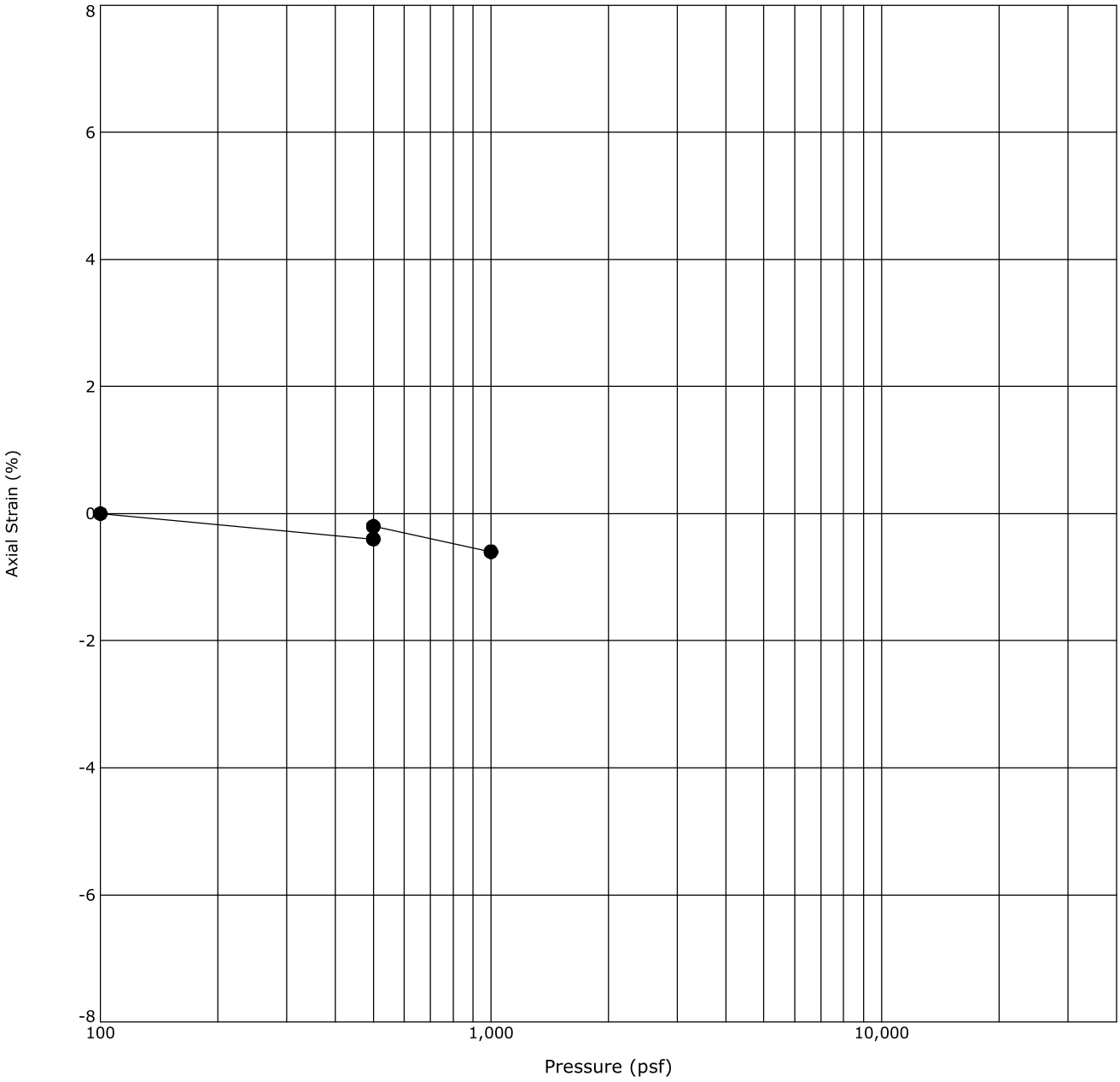


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-2	24 - 25	SANDSTONE		98	16.5

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

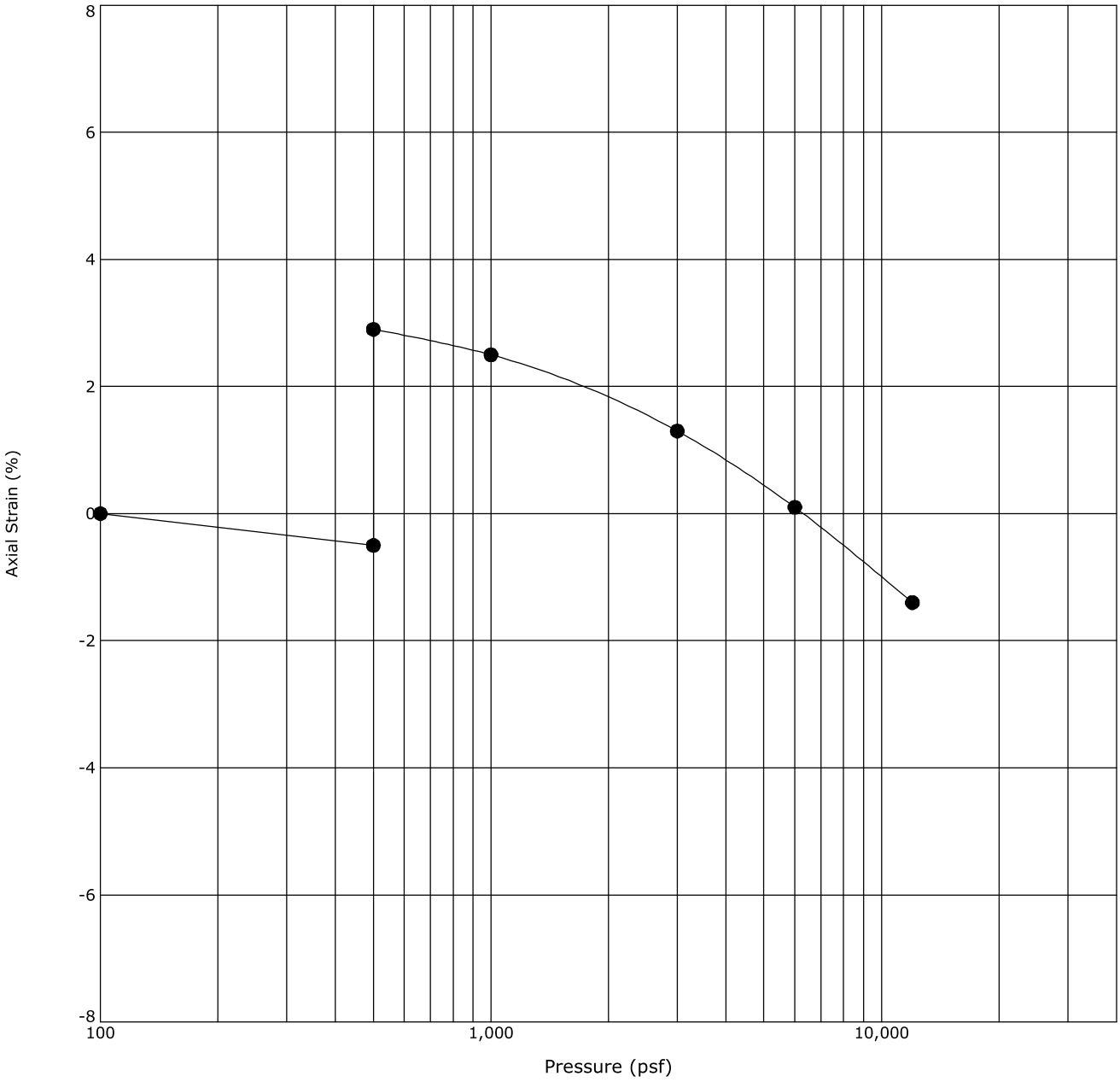


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-3	9 - 10	FILL - LEAN CLAY with SAND	CL	105	20.4

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

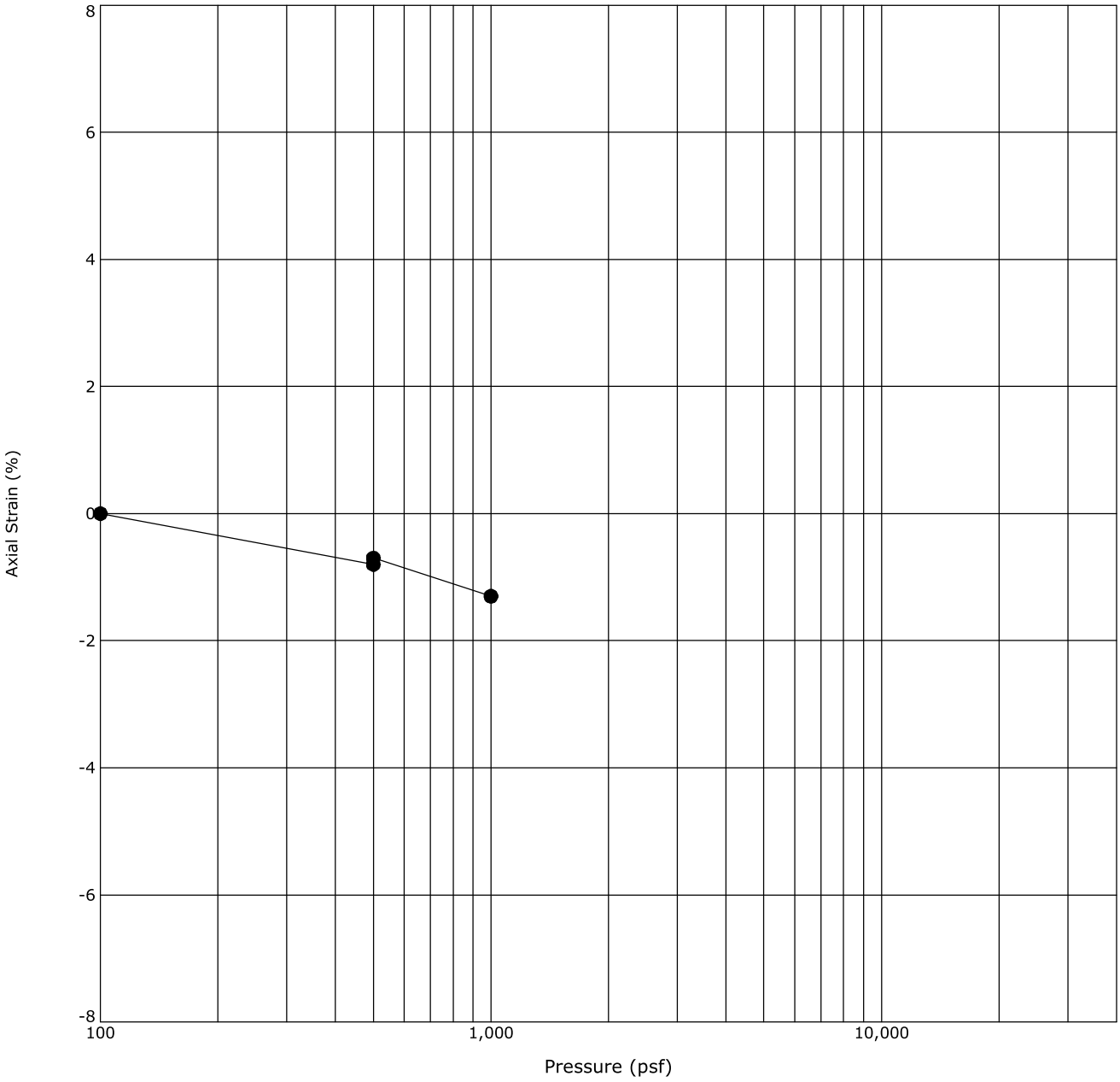


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-3	54 - 55	CLAYSTONE		104	22.2

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

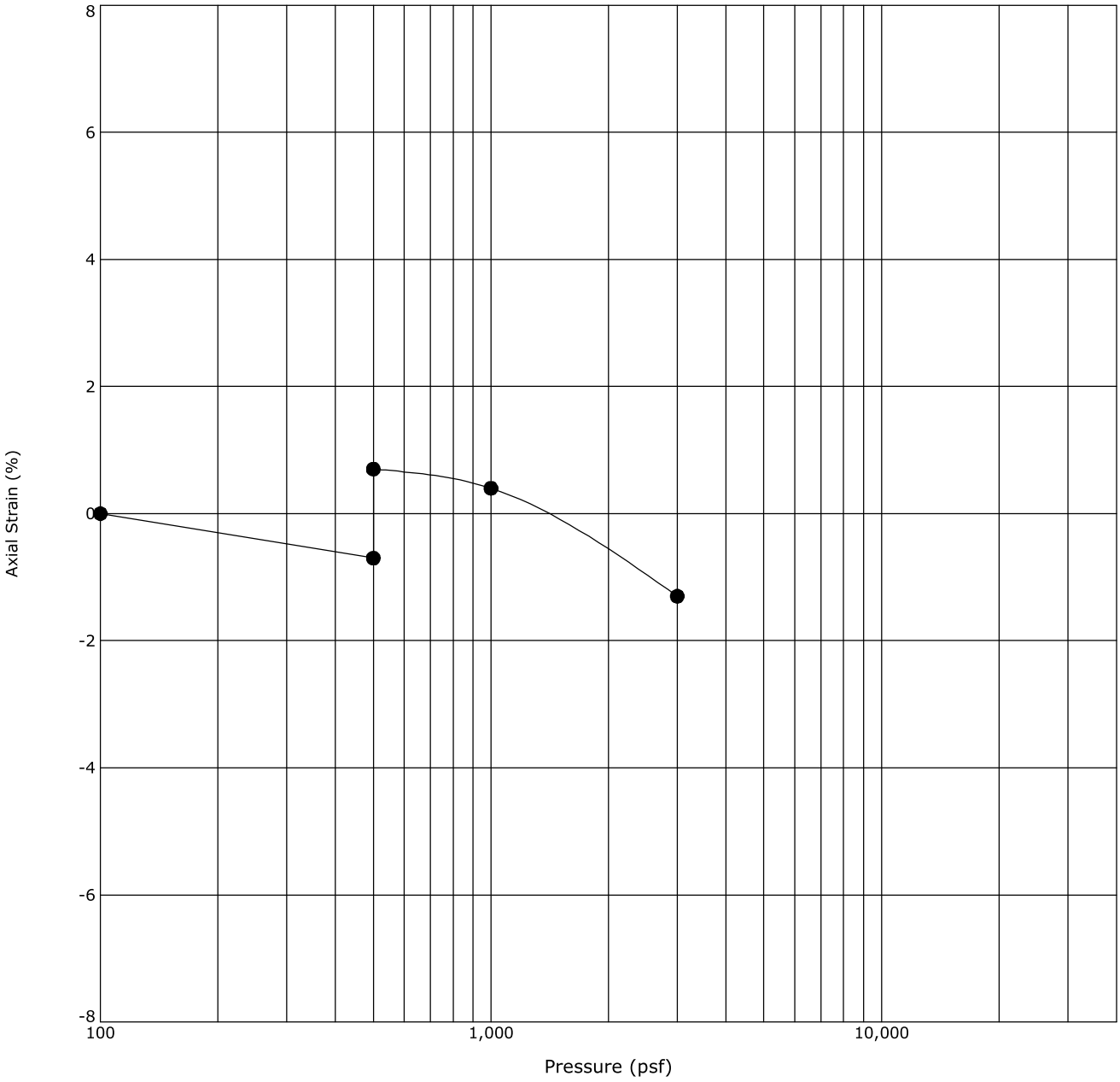


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-4	9 - 10	FILL - FAT CLAY	CH	100	23.7

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

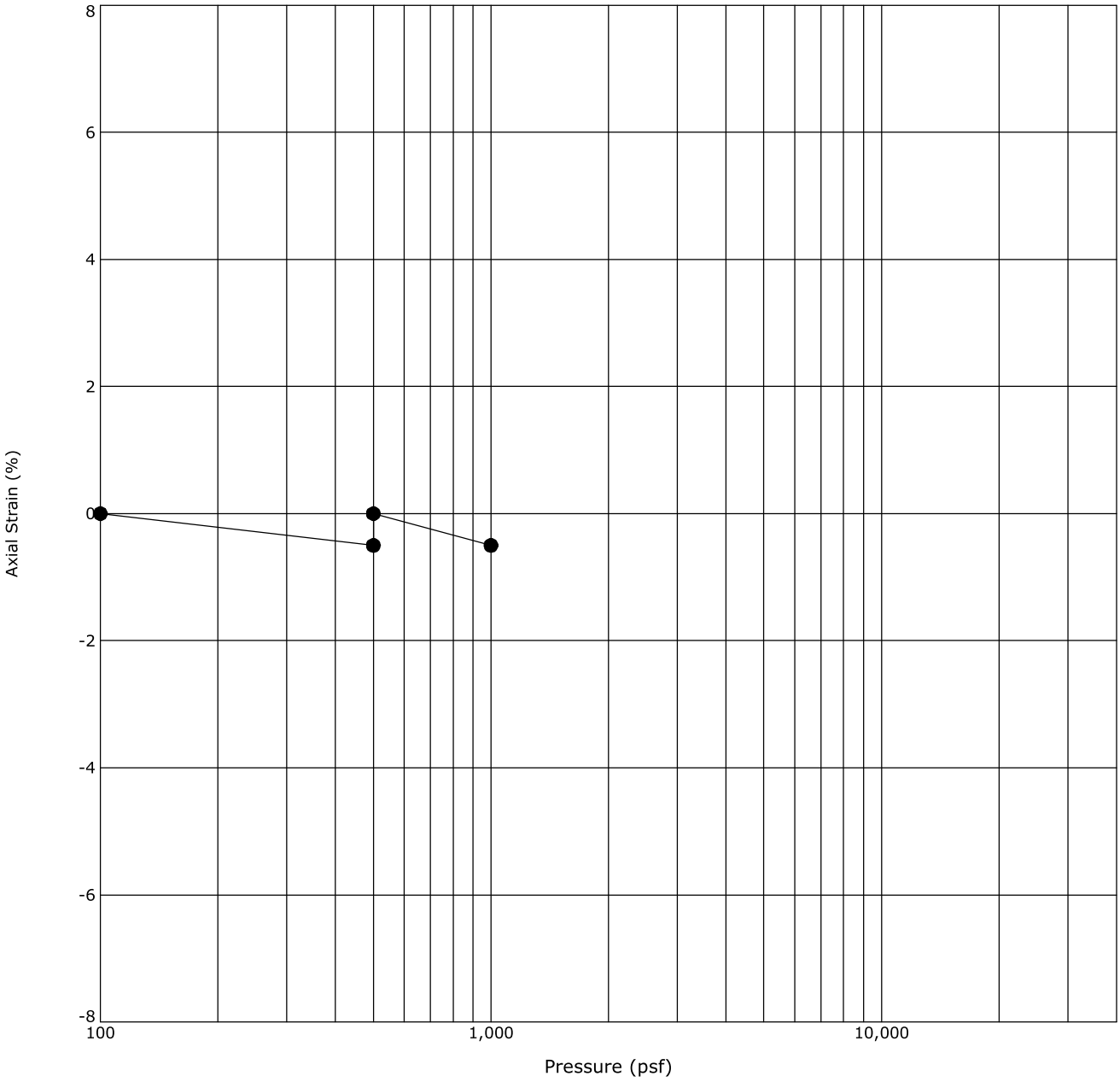


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-4	24 - 25	SANDSTONE		104	18.3

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

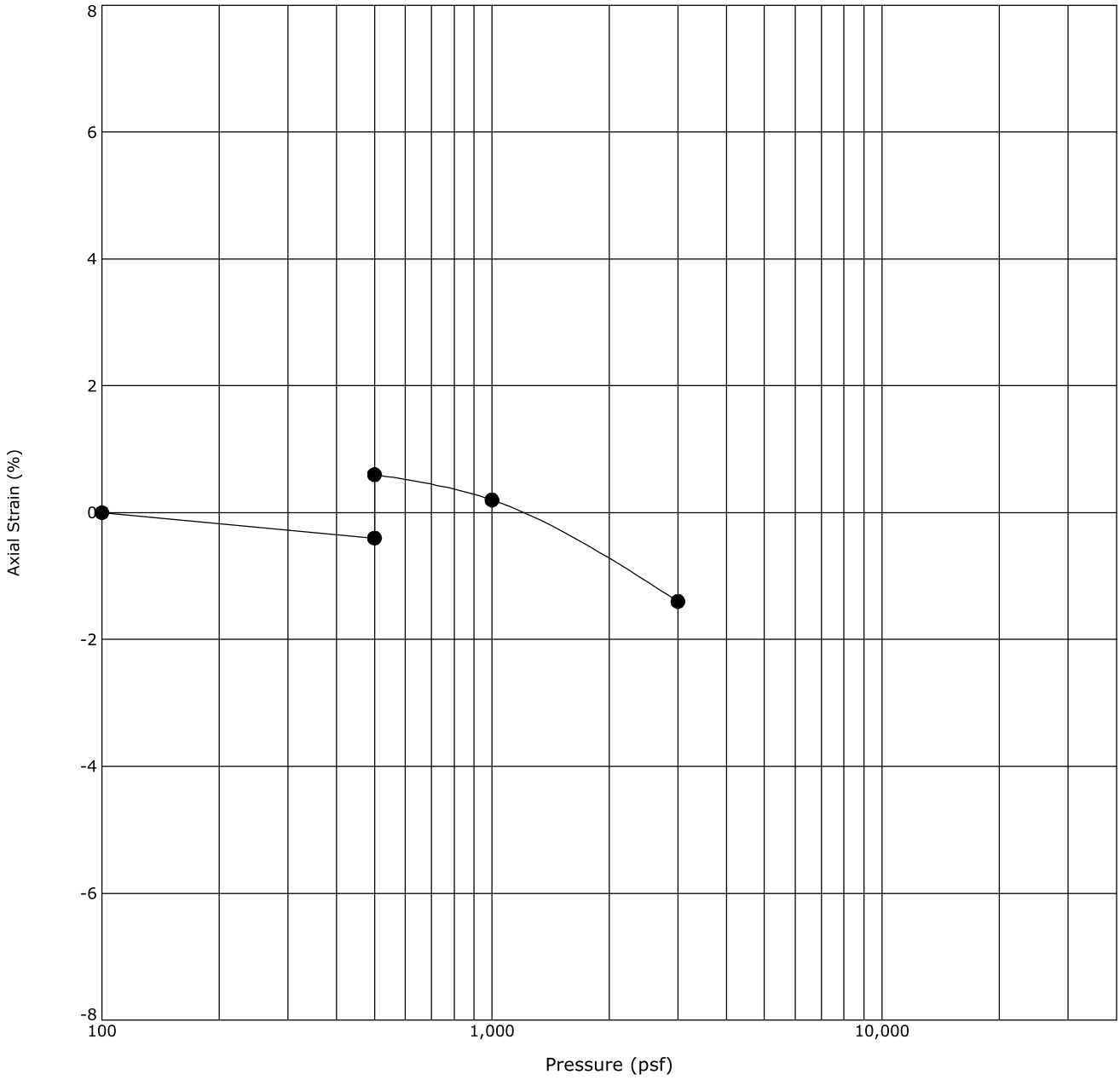


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-5	7 - 8	FILL - FAT CLAY with SAND	CH	104	21.9

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

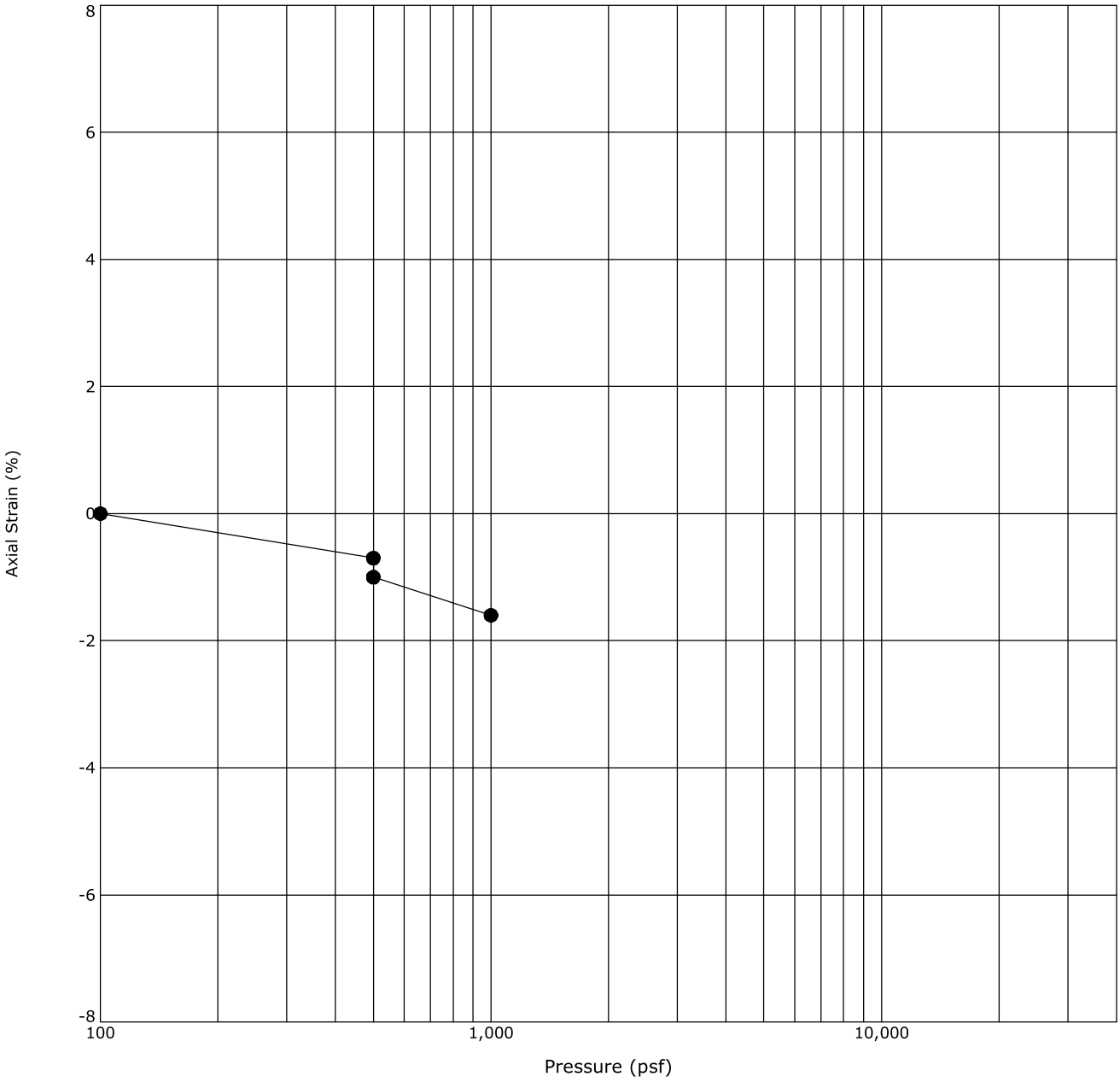


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-5	44 - 45	CLAYSTONE		98	25.4

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

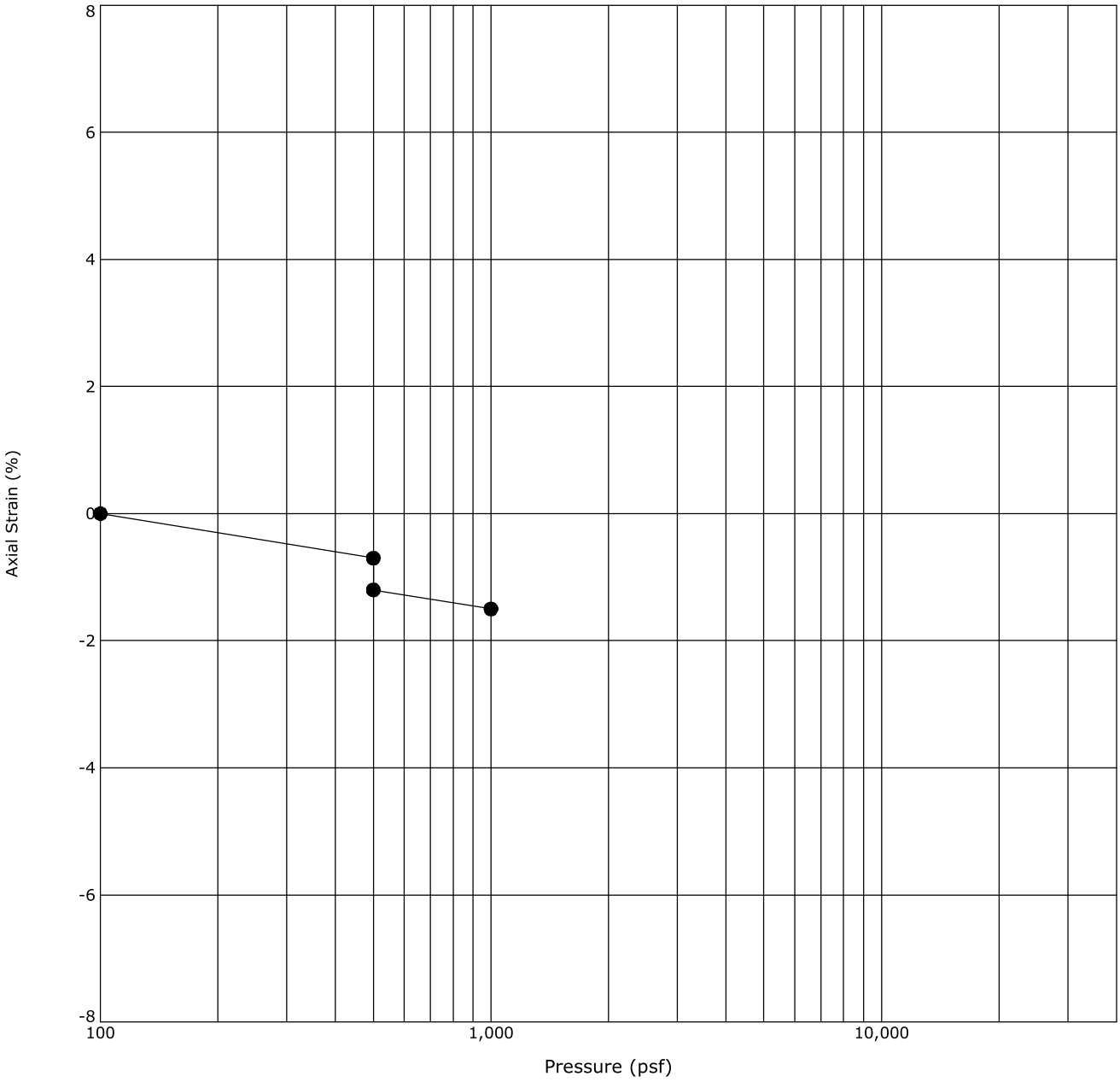


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-6	9 - 10	FILL - SANDY FAT CLAY	CH	93	25.6

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

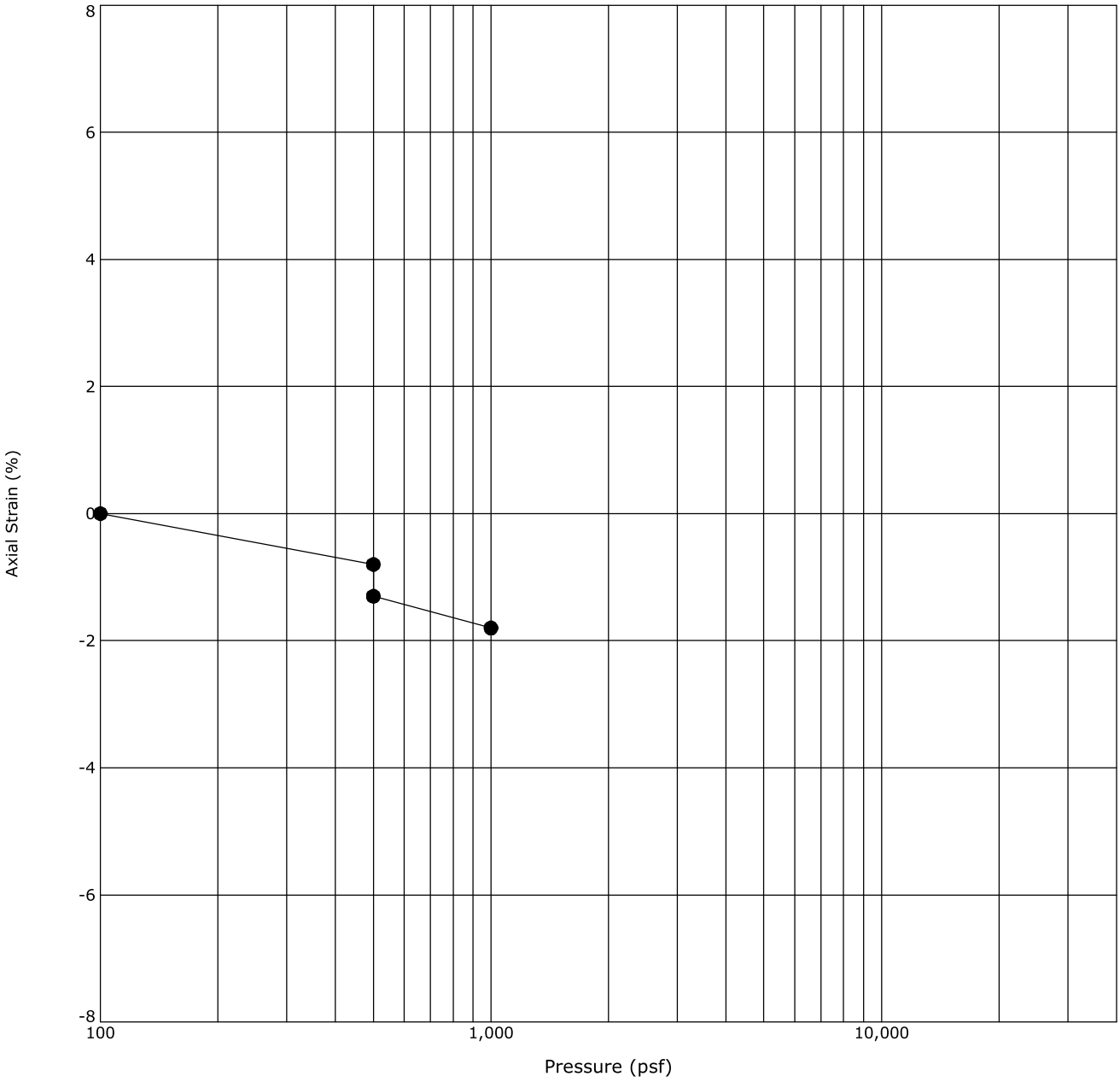


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-7	7 - 8	FILL - CLAYEY SAND	SC	103	13.2

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

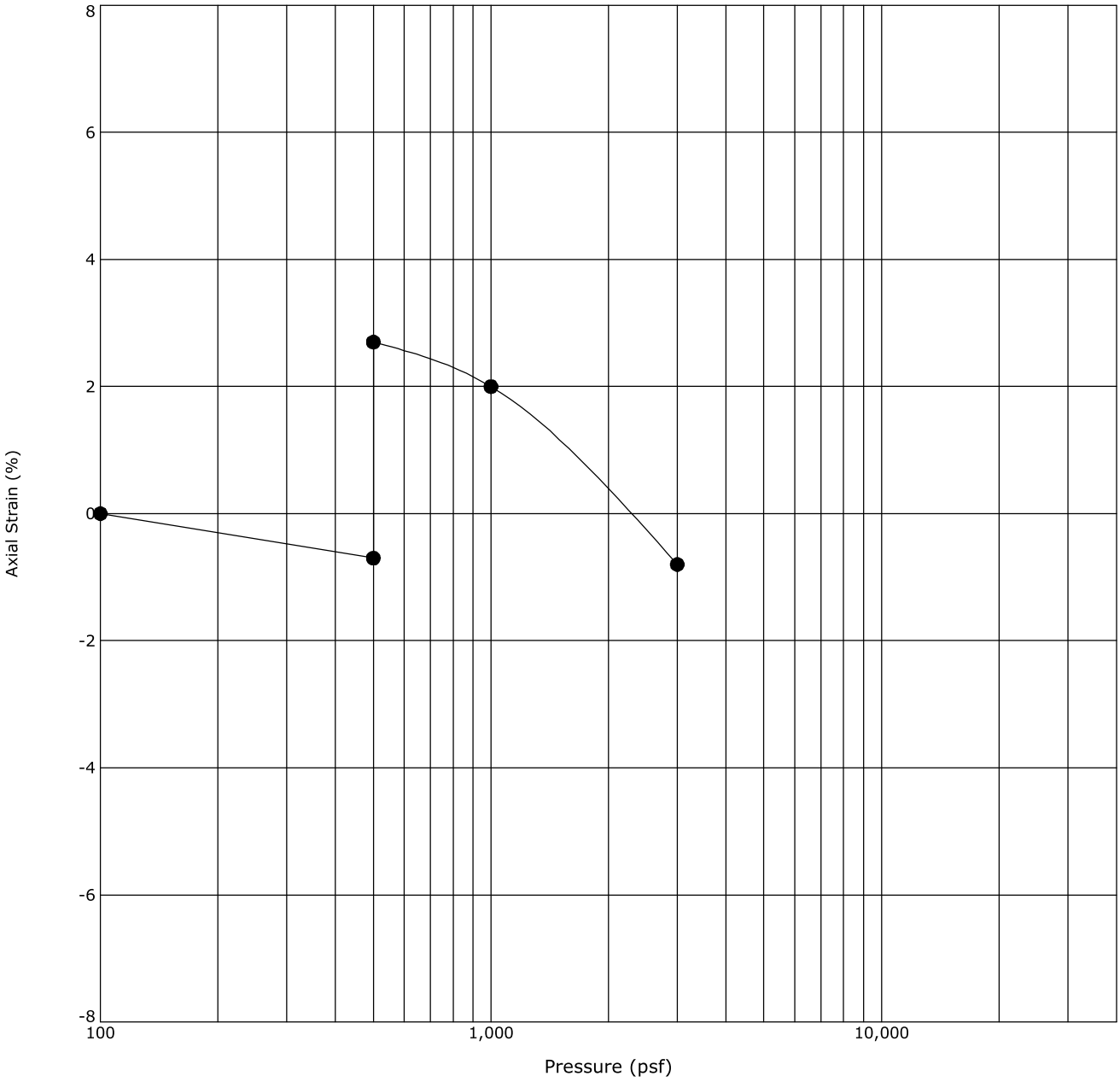


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-8	7 - 8	FILL - SANDY FAT CLAY	CH	90	30.0

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

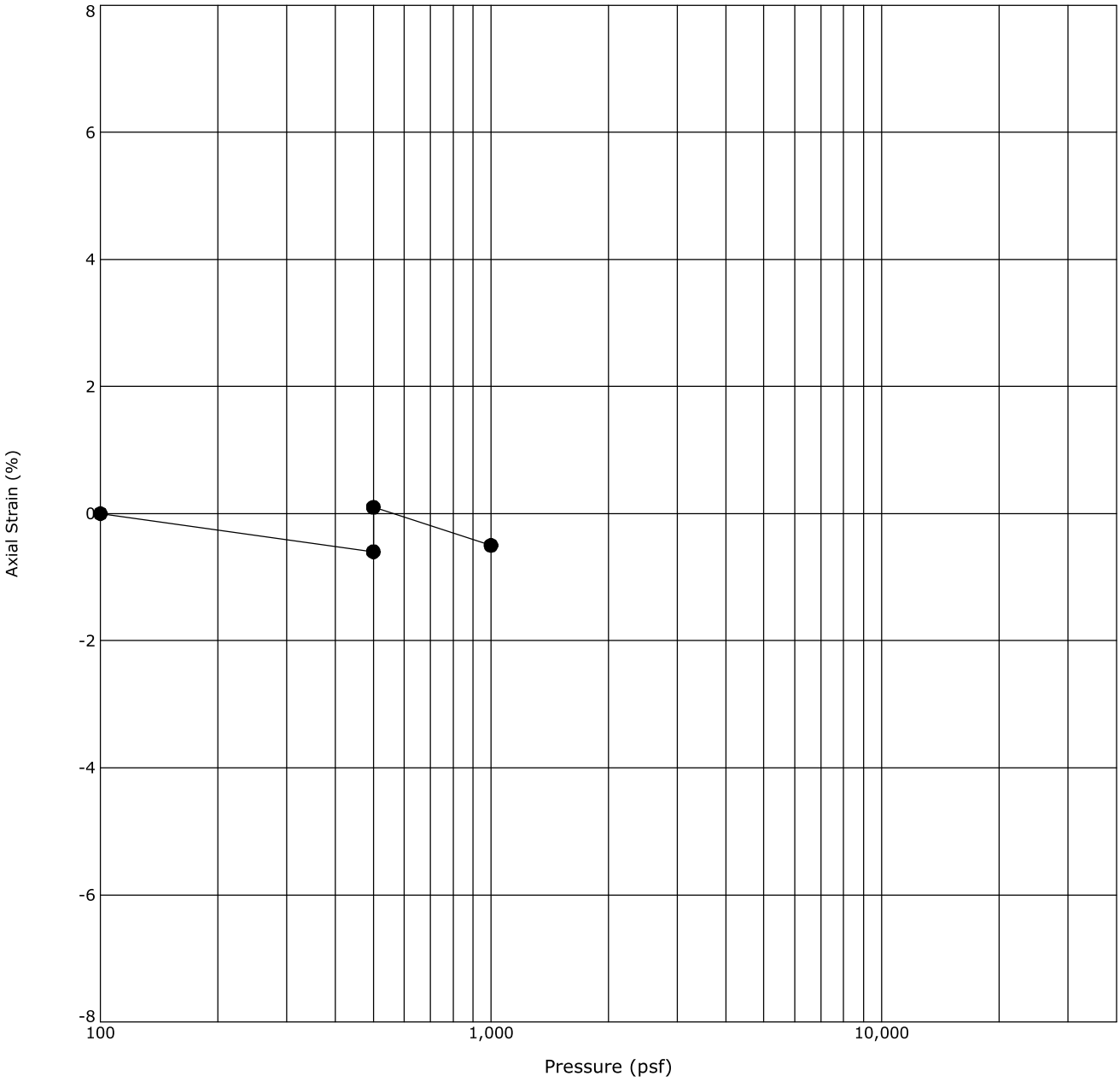


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-8	24 - 25	CLAYSTONE		95	26.1

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

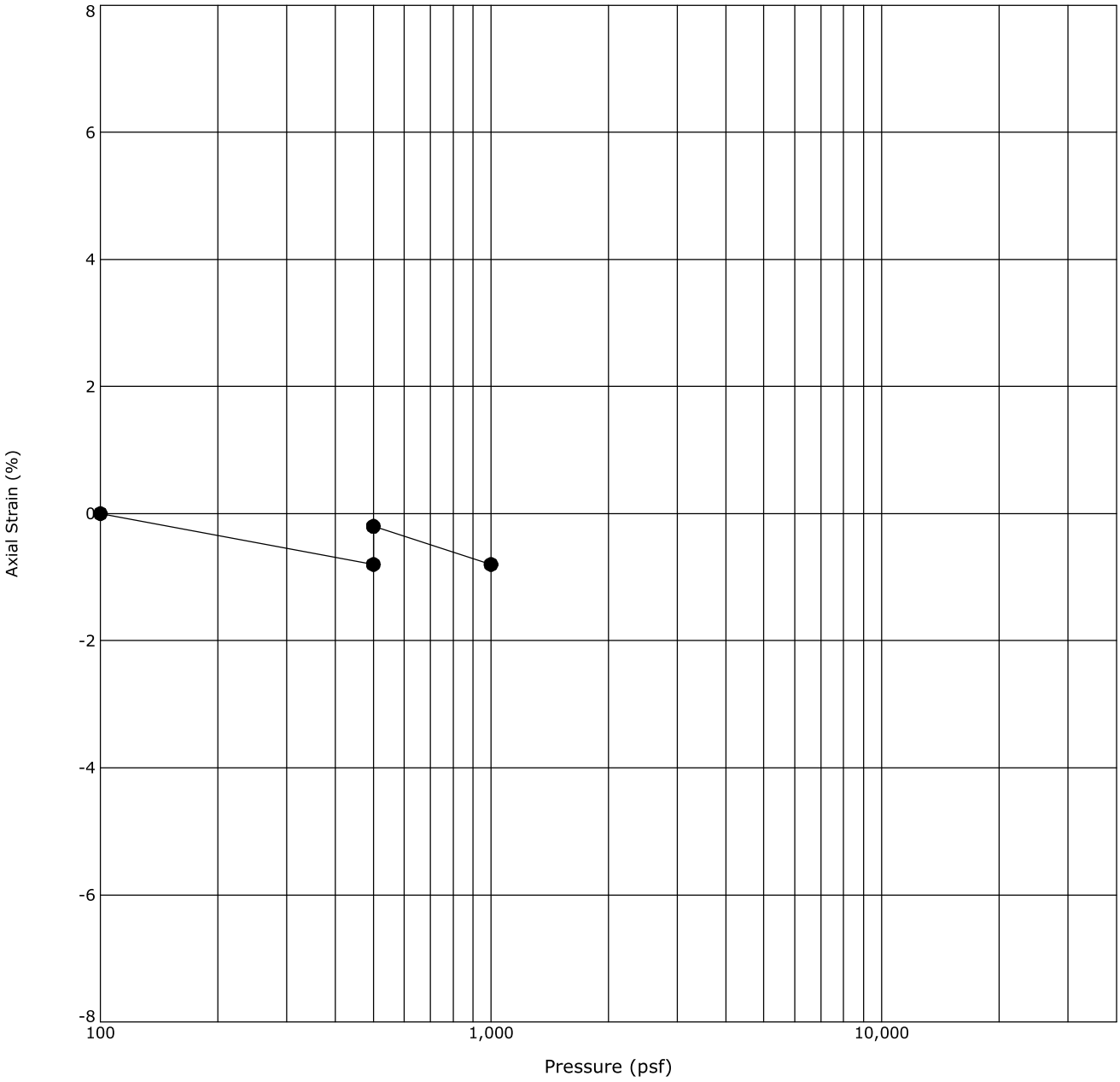


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-9	7 - 8	FILL - FAT CLAY	CH	92	23.2

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

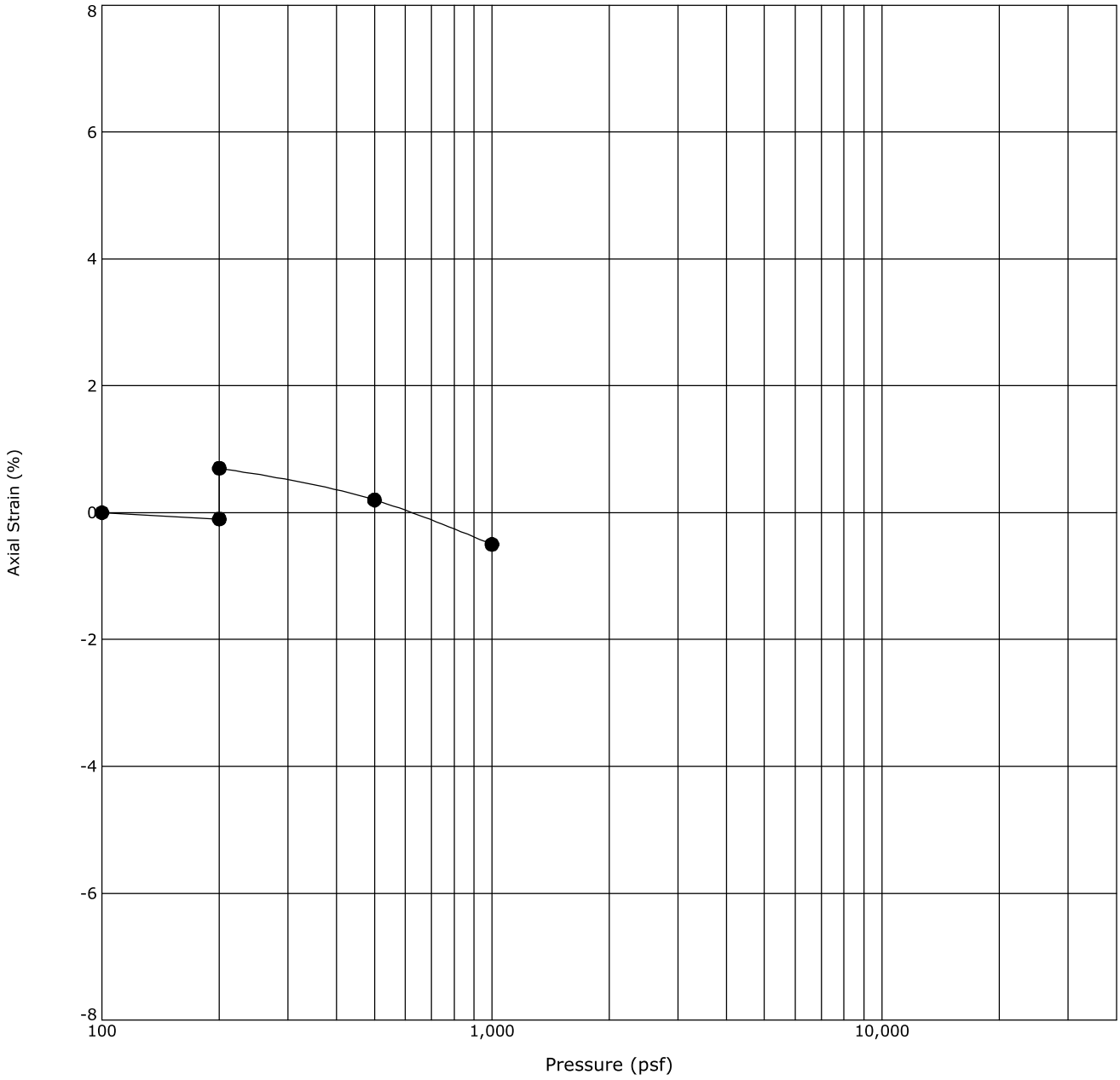


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-9	9 - 10	CLAYSTONE		98	22.0

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

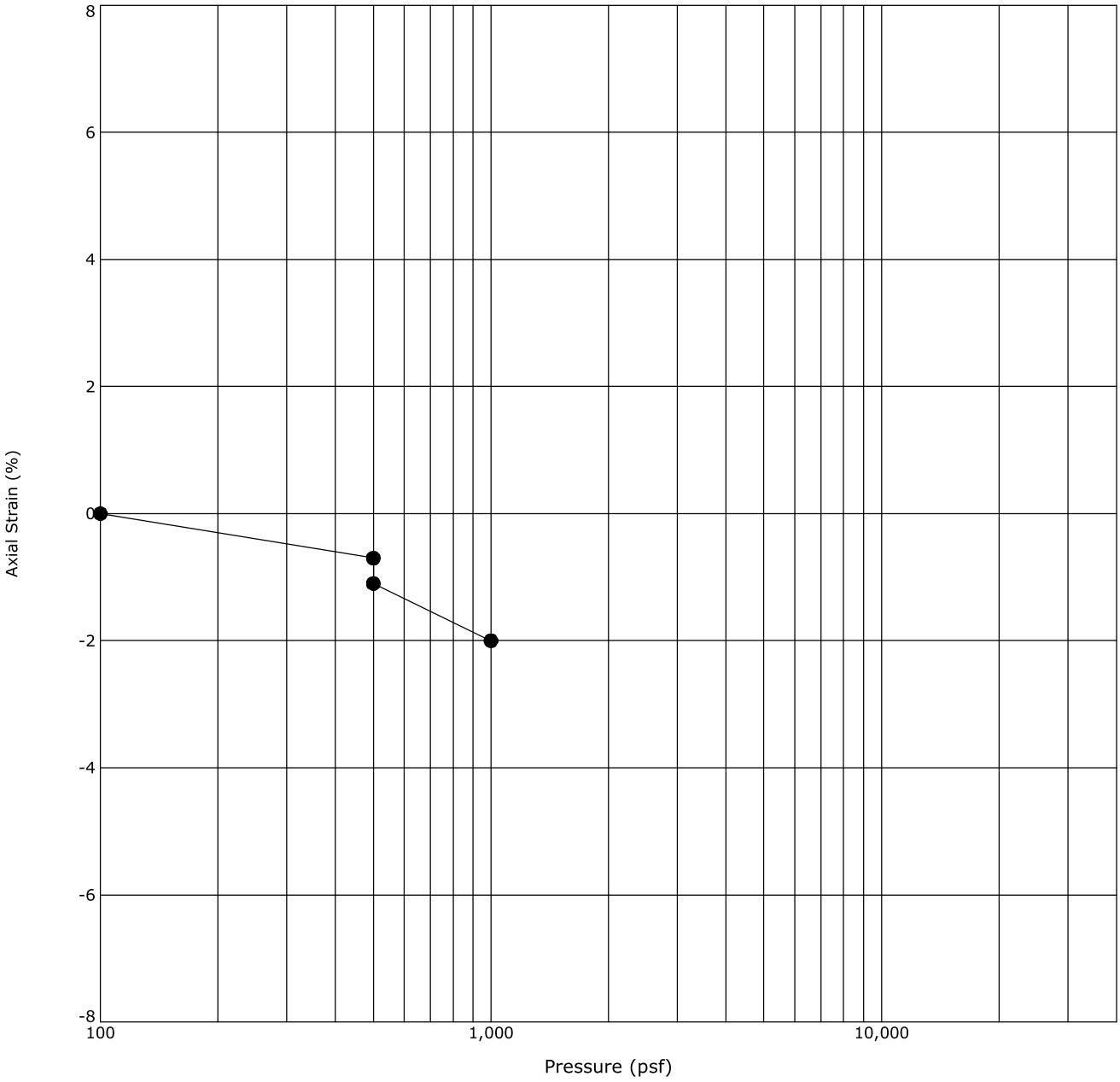


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-10	2 - 3	FILL - CLAYEY SAND	SC	108	15.5

Notes: Water was added at 200 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

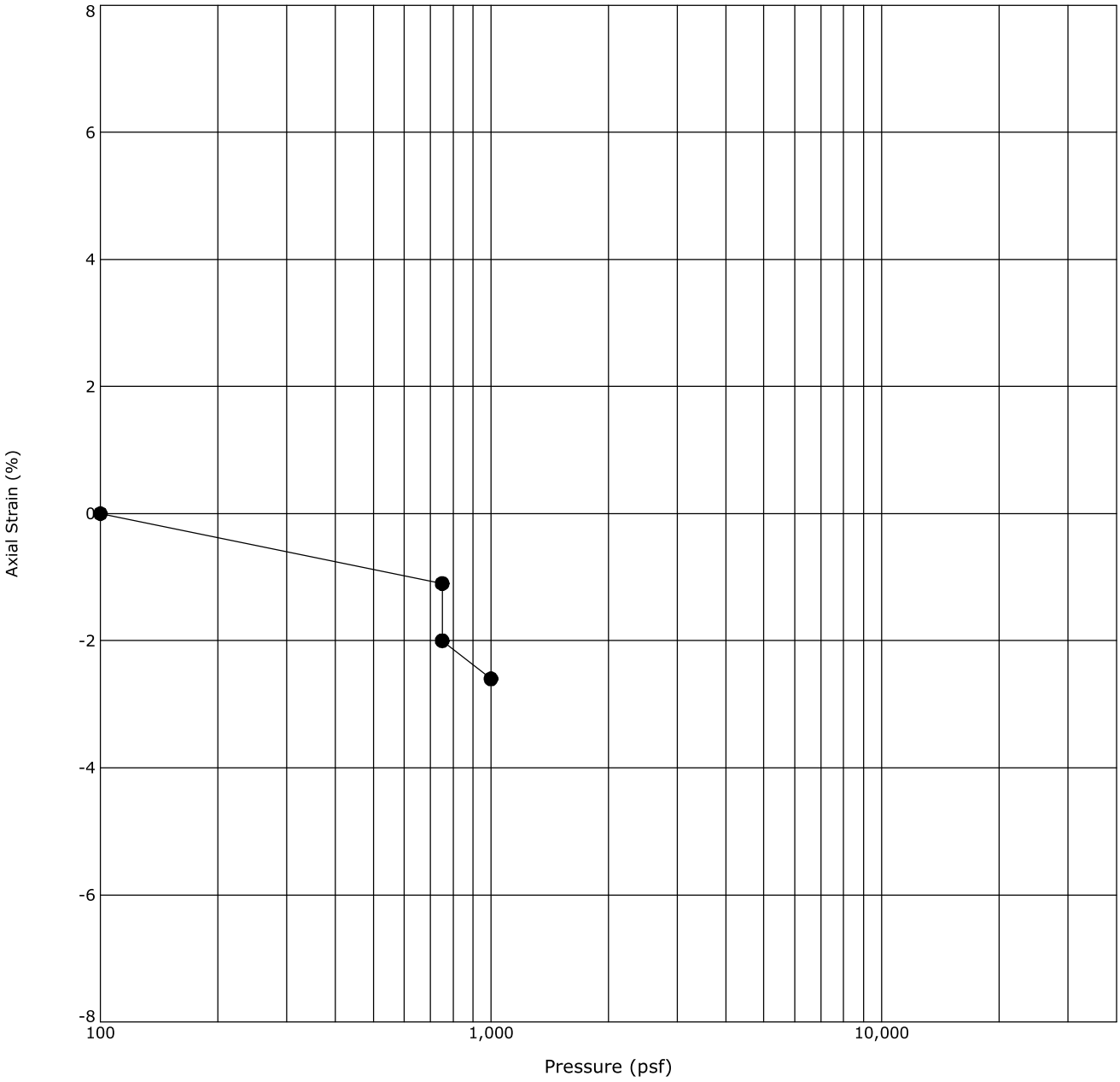


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-10	4 - 5	FILL - CLAYEY SAND	SC	79	34.0

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

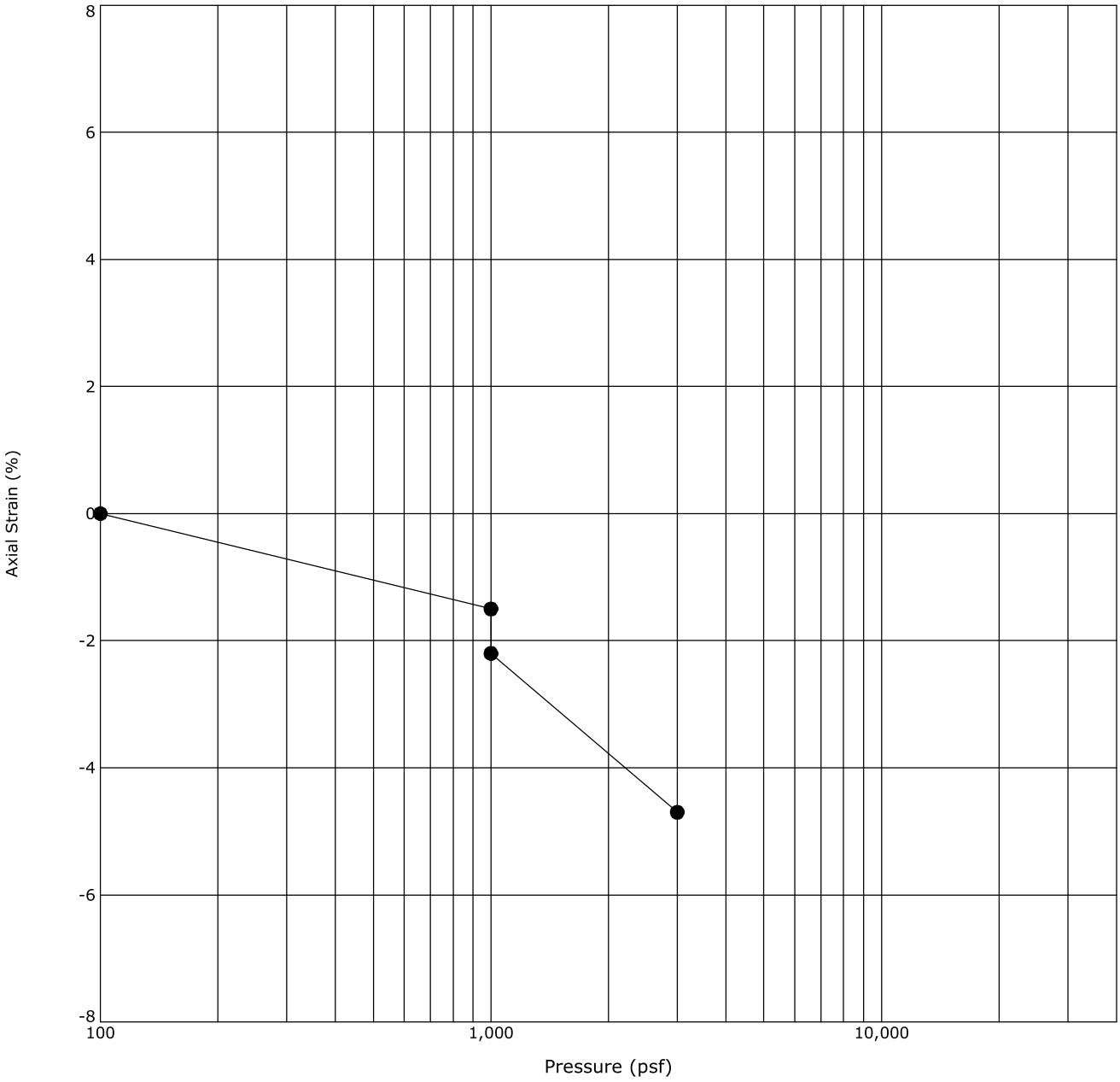


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-10	7 - 8	FILL - CLAYEY SAND	SC	99	13.3

Notes: Water was added at 750 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

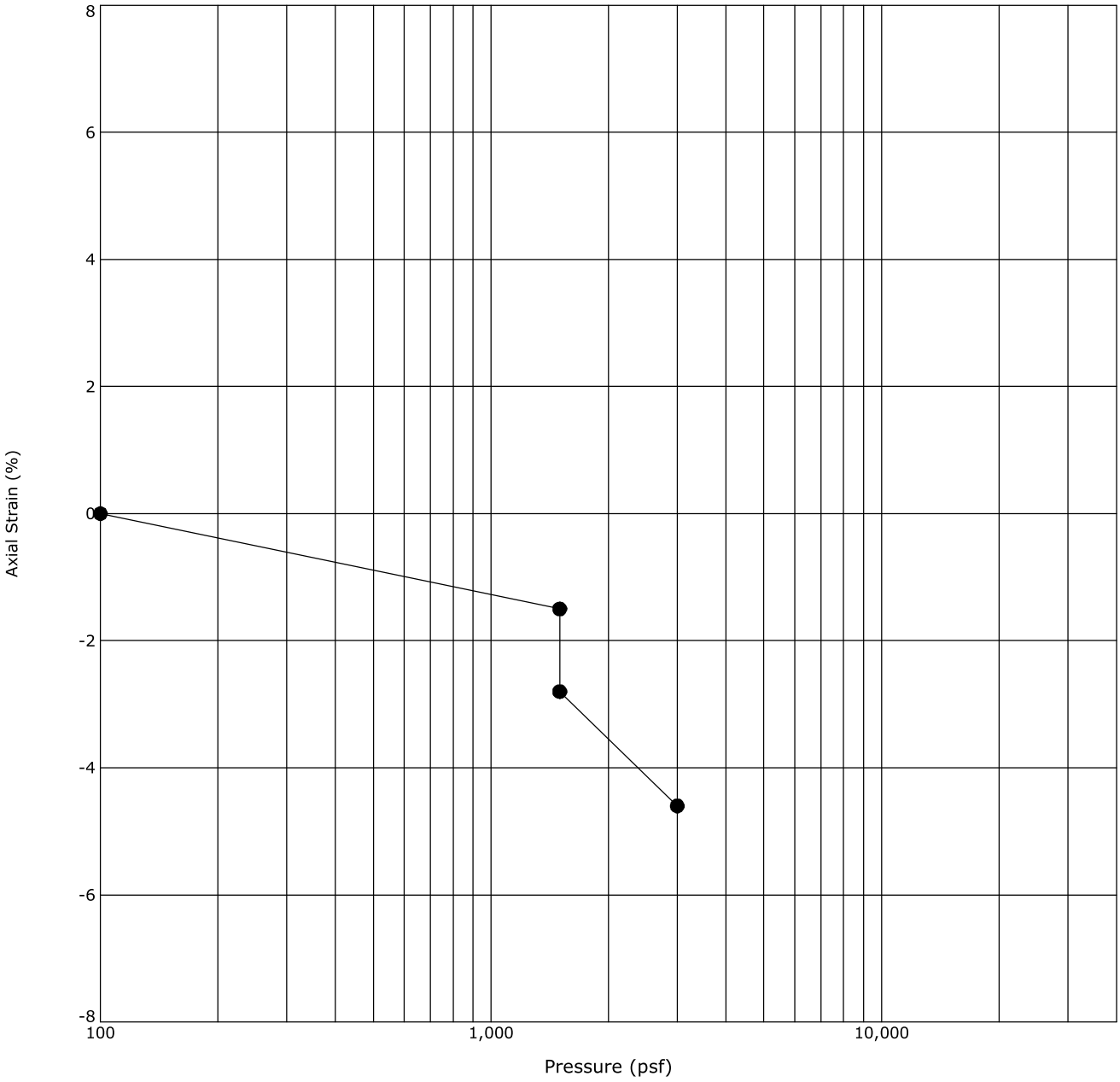


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-10	9 - 10	FILL - CLAYEY SAND	SC	90	23.2

Notes: Water was added at 1000 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

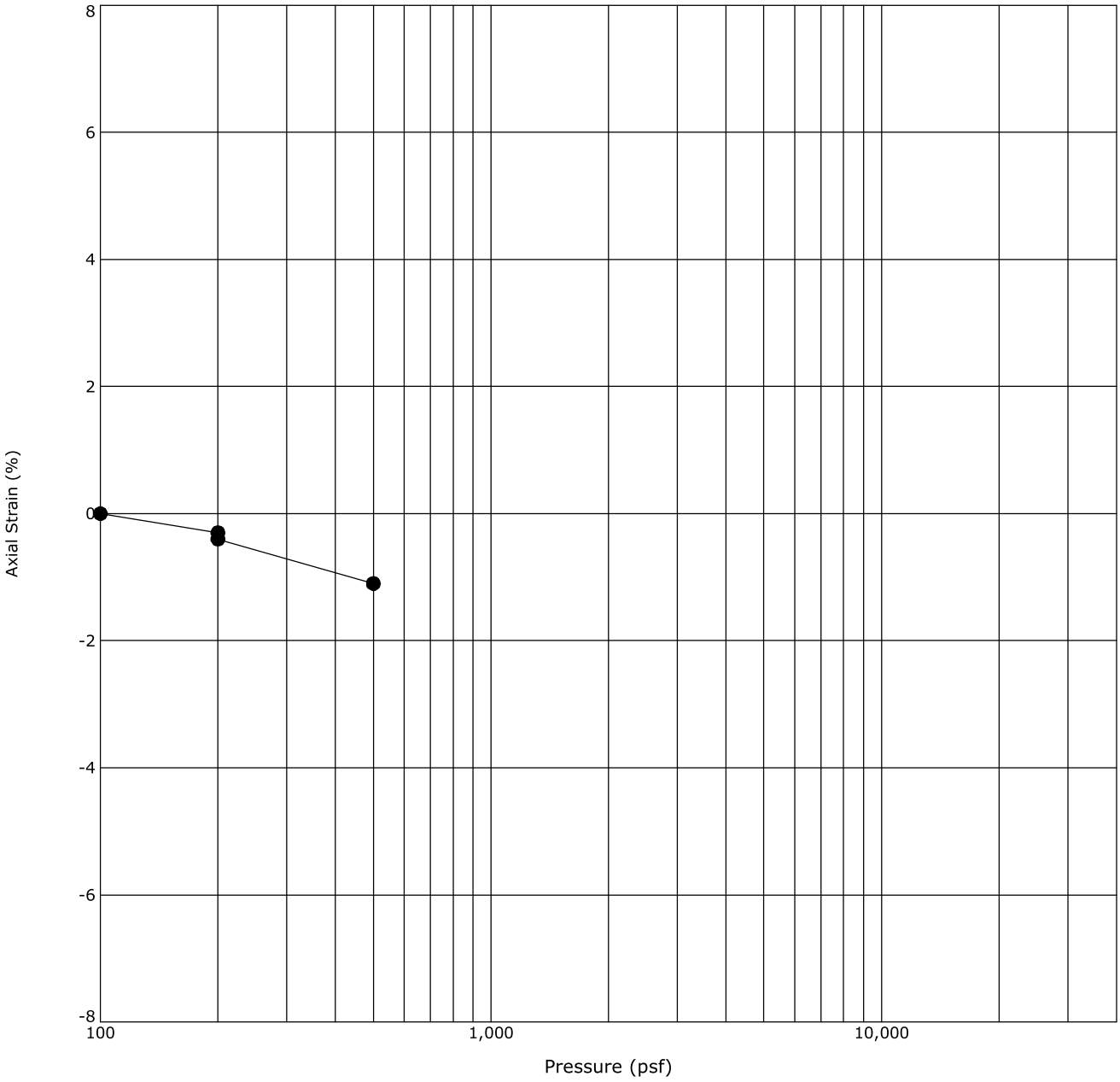


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-10	14 - 15	FILL - CLAYEY SAND	SC	94	23.1

Notes: Water was added at 1500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

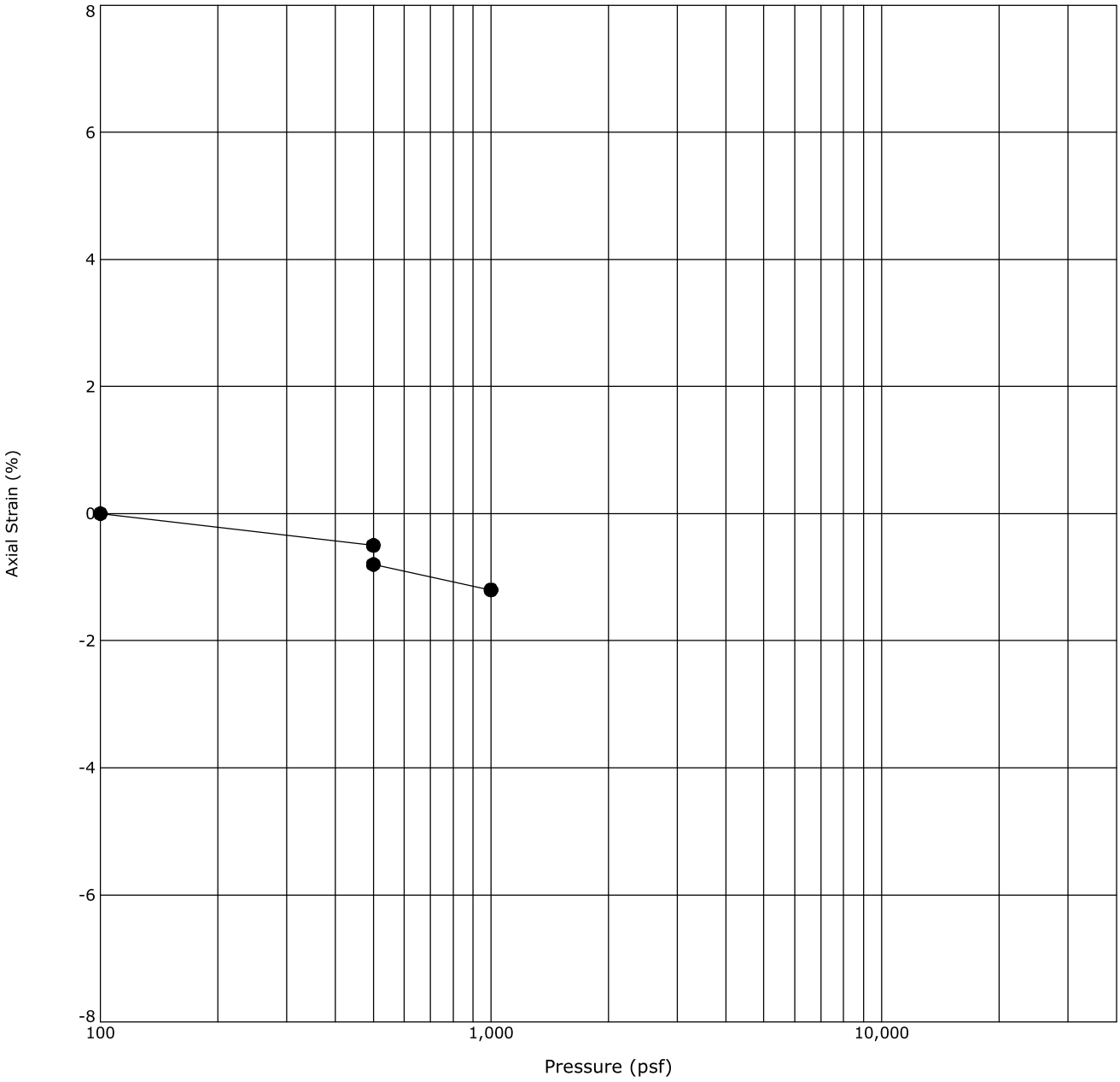


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	2 - 3	FILL - CLAYEY SAND	SC	106	17.8

Notes: Water was added at 200 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

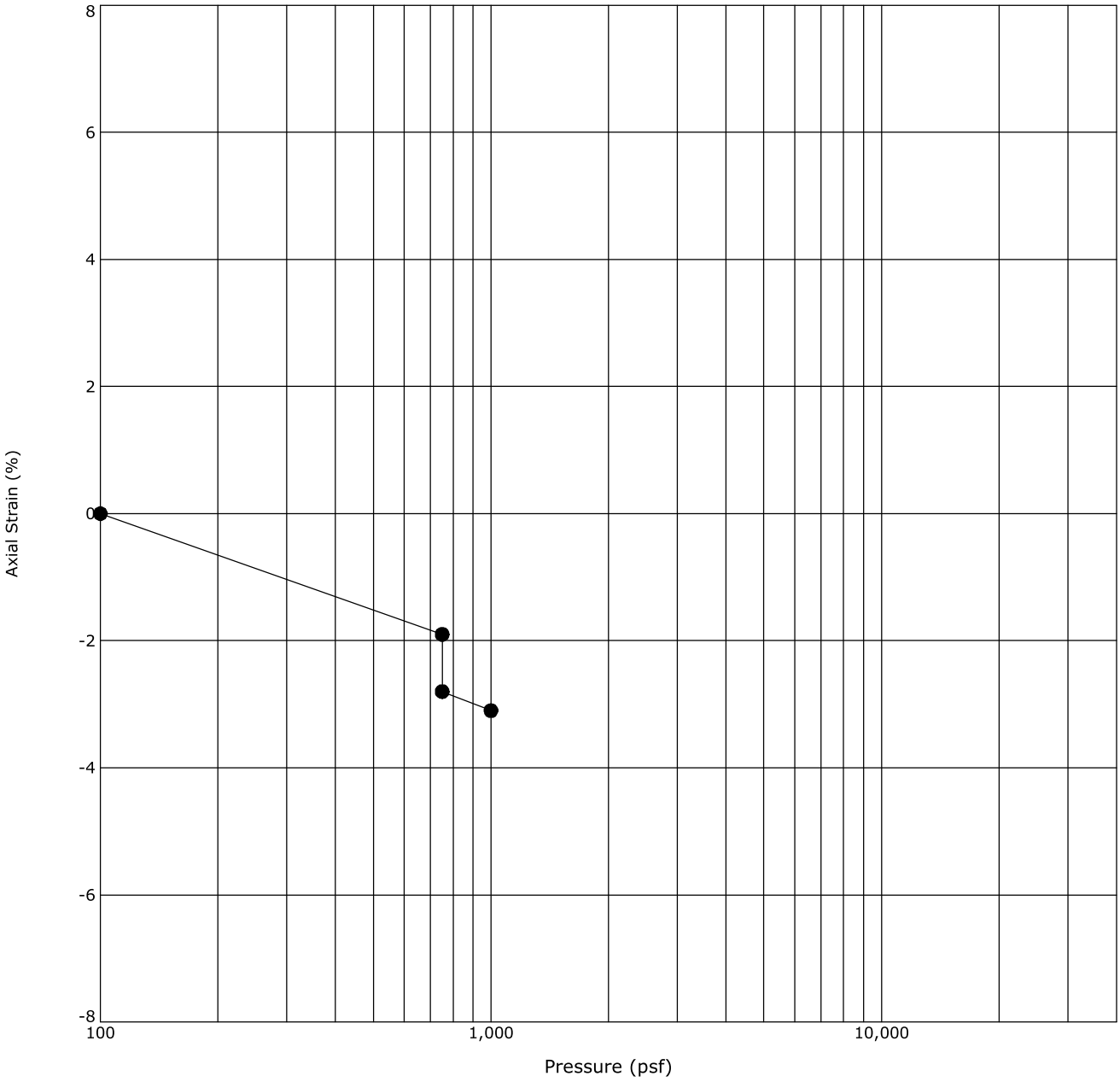


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	4 - 5	FILL - CLAYEY SAND	SC	109	15.8

Notes: Water was added at 500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

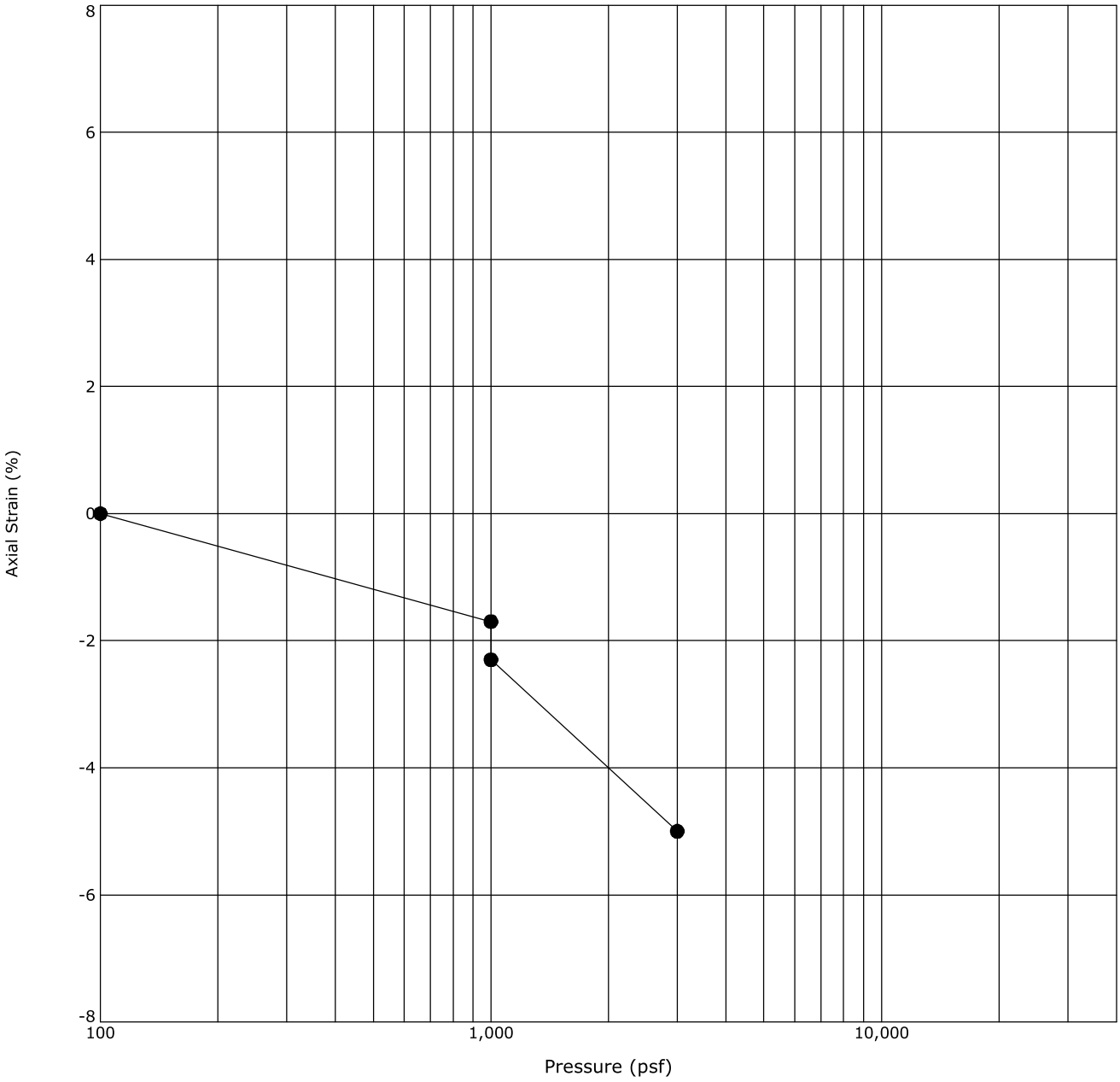


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	7 - 8	FILL - CLAYEY SAND	SC	106	15.5

Notes: Water was added at 750 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

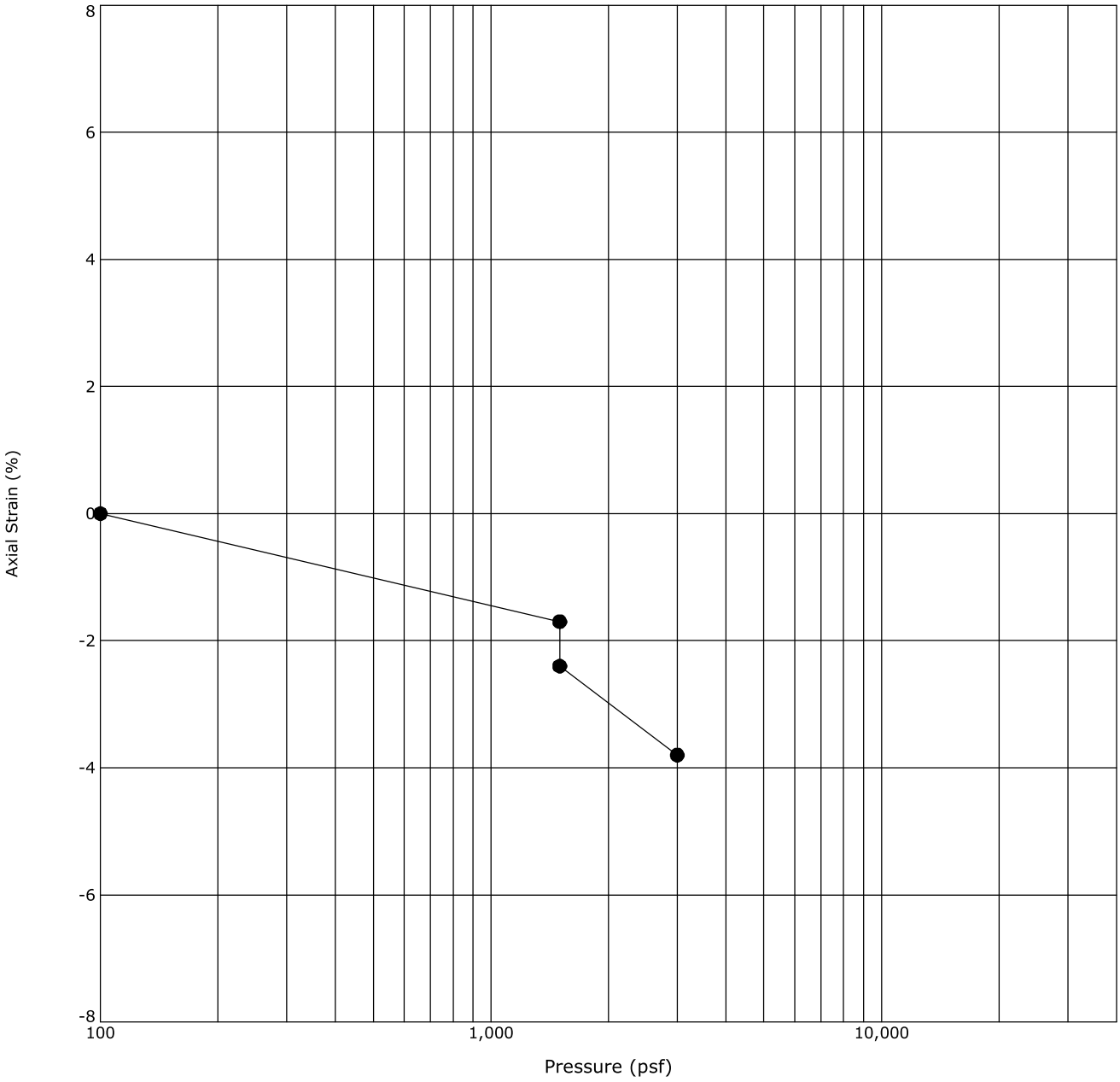


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	9 - 10	FILL - CLAYEY SAND	SC	110	12.9

Notes: Water was added at 1000 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

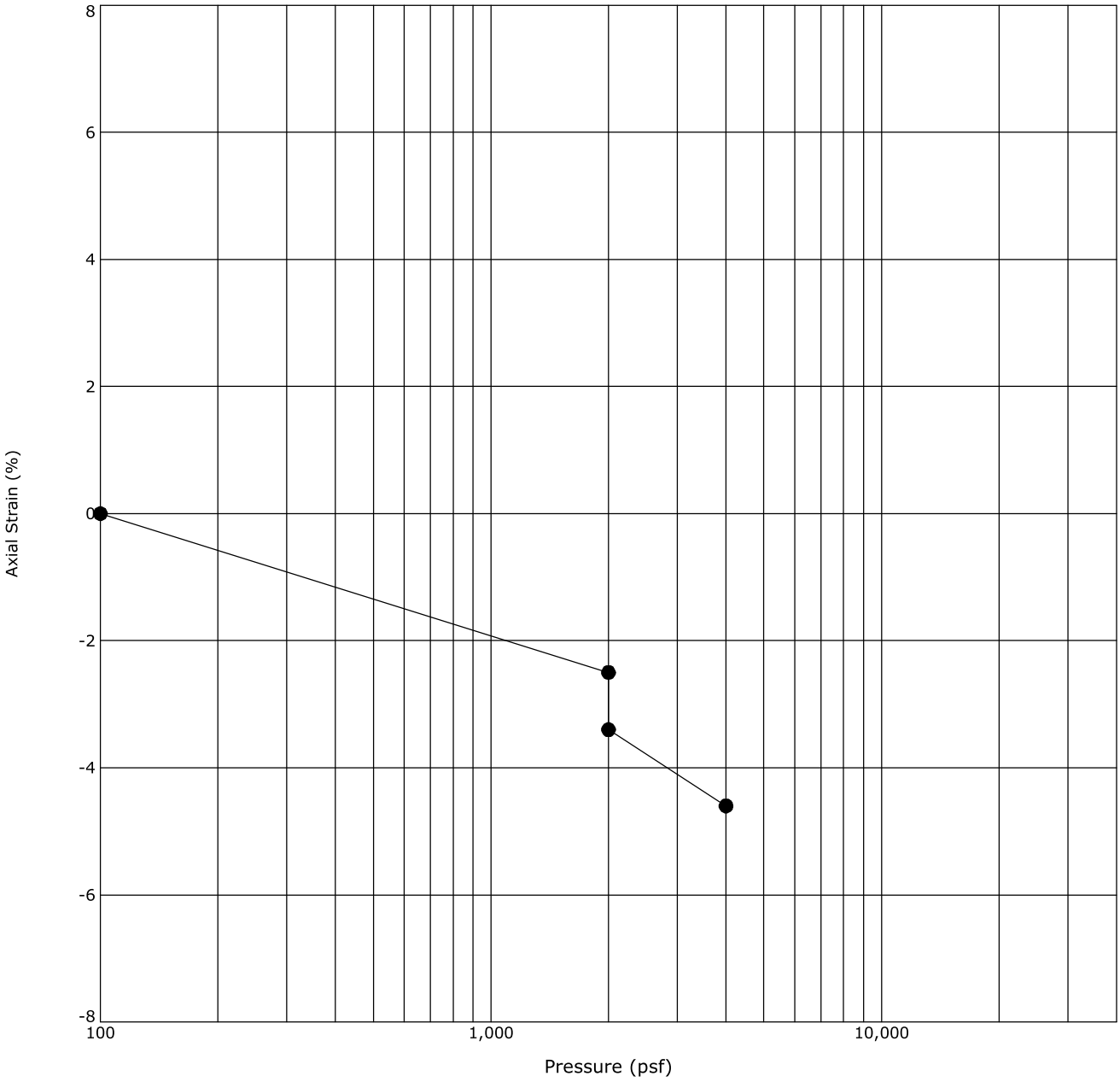


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	14 - 15	FILL - CLAYEY SAND	SC	108	14.5

Notes: Water was added at 1500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

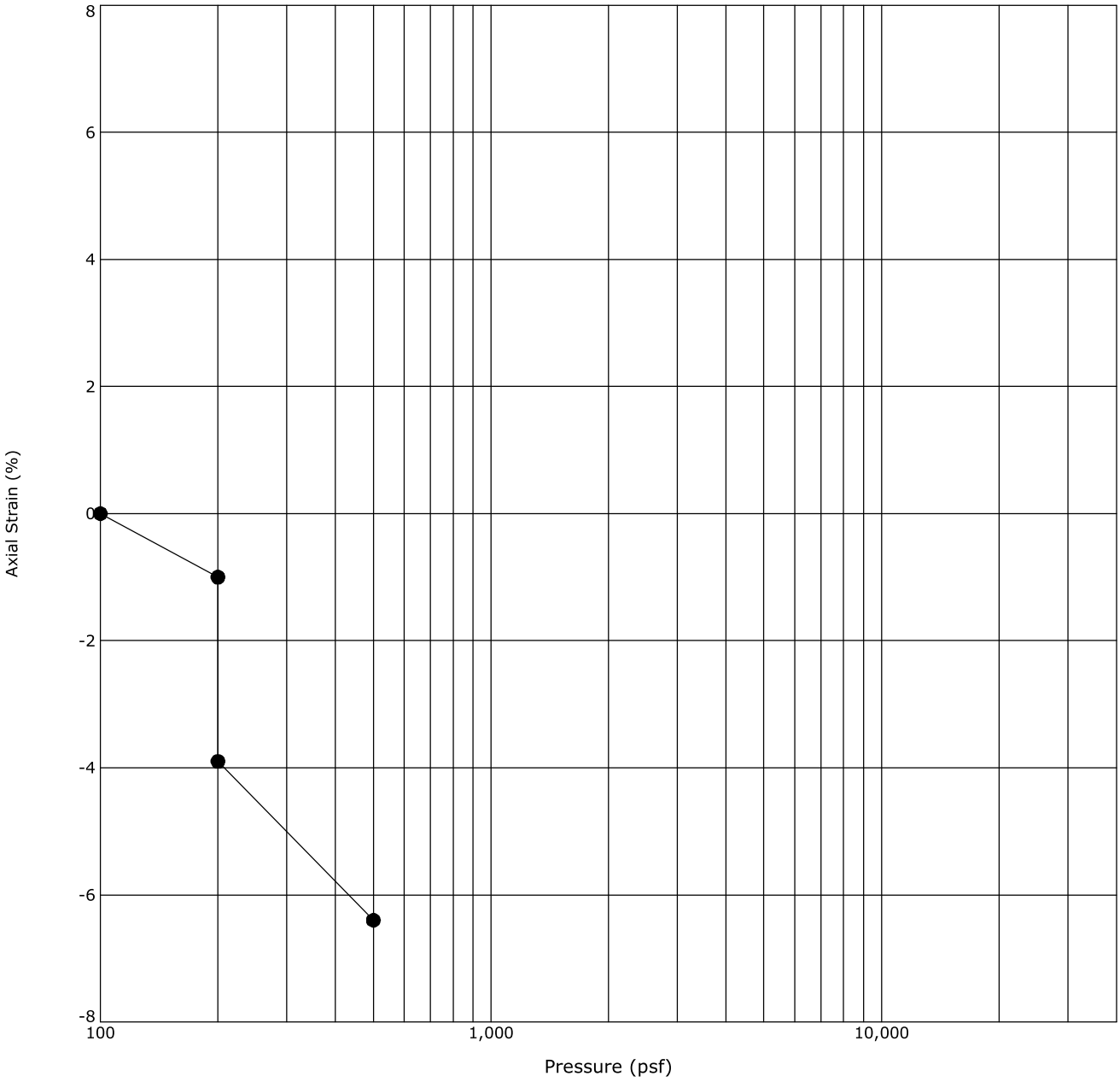


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-11	19 - 20	FILL - CLAYEY SAND	SC	111	13.5

Notes: Water was added at 2000 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

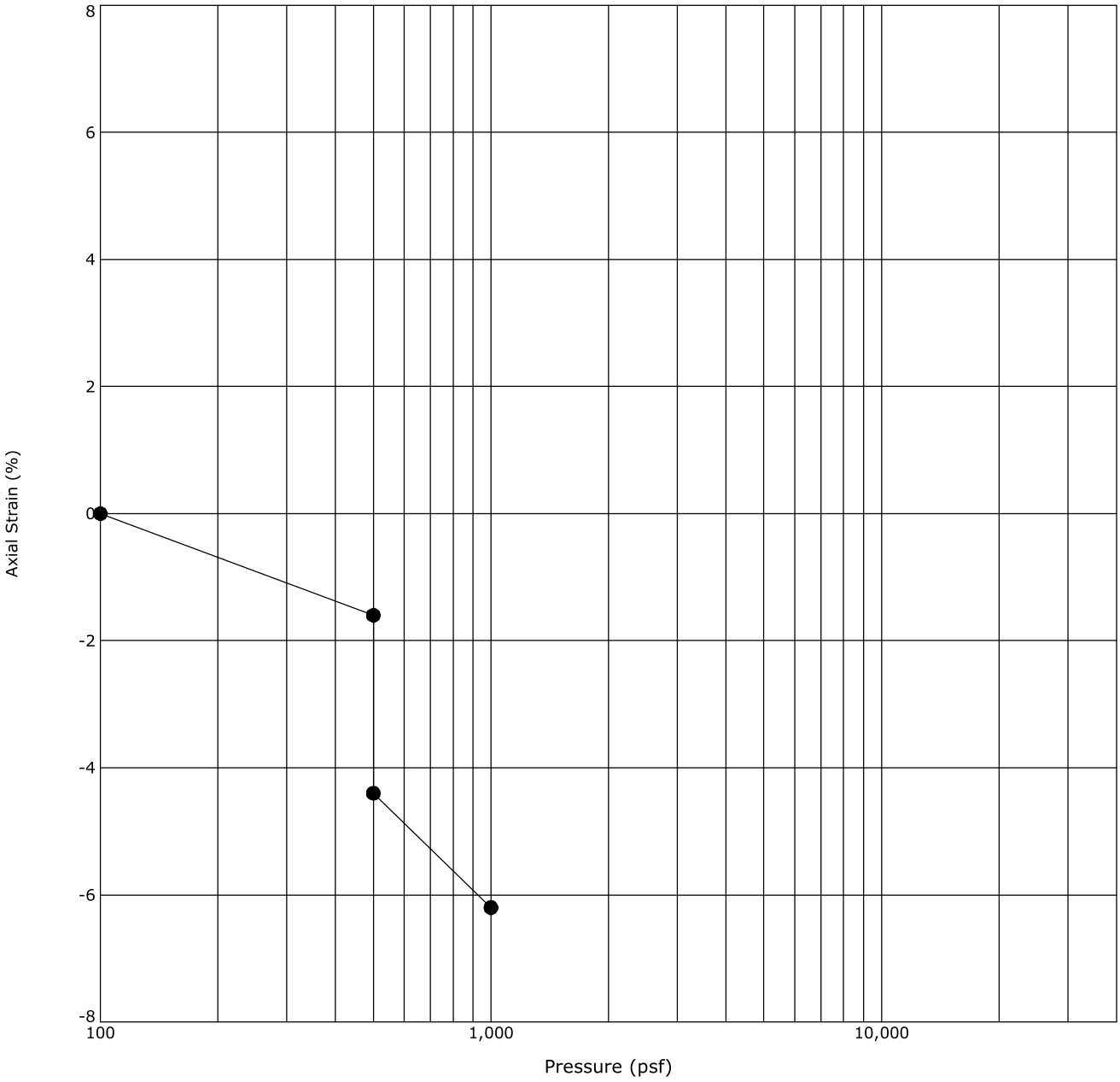


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-13	2 - 3	FILL - CLAYEY SAND	SC	110	4.2

Notes: Water was added at 200 psf. Sample likely disturbed.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

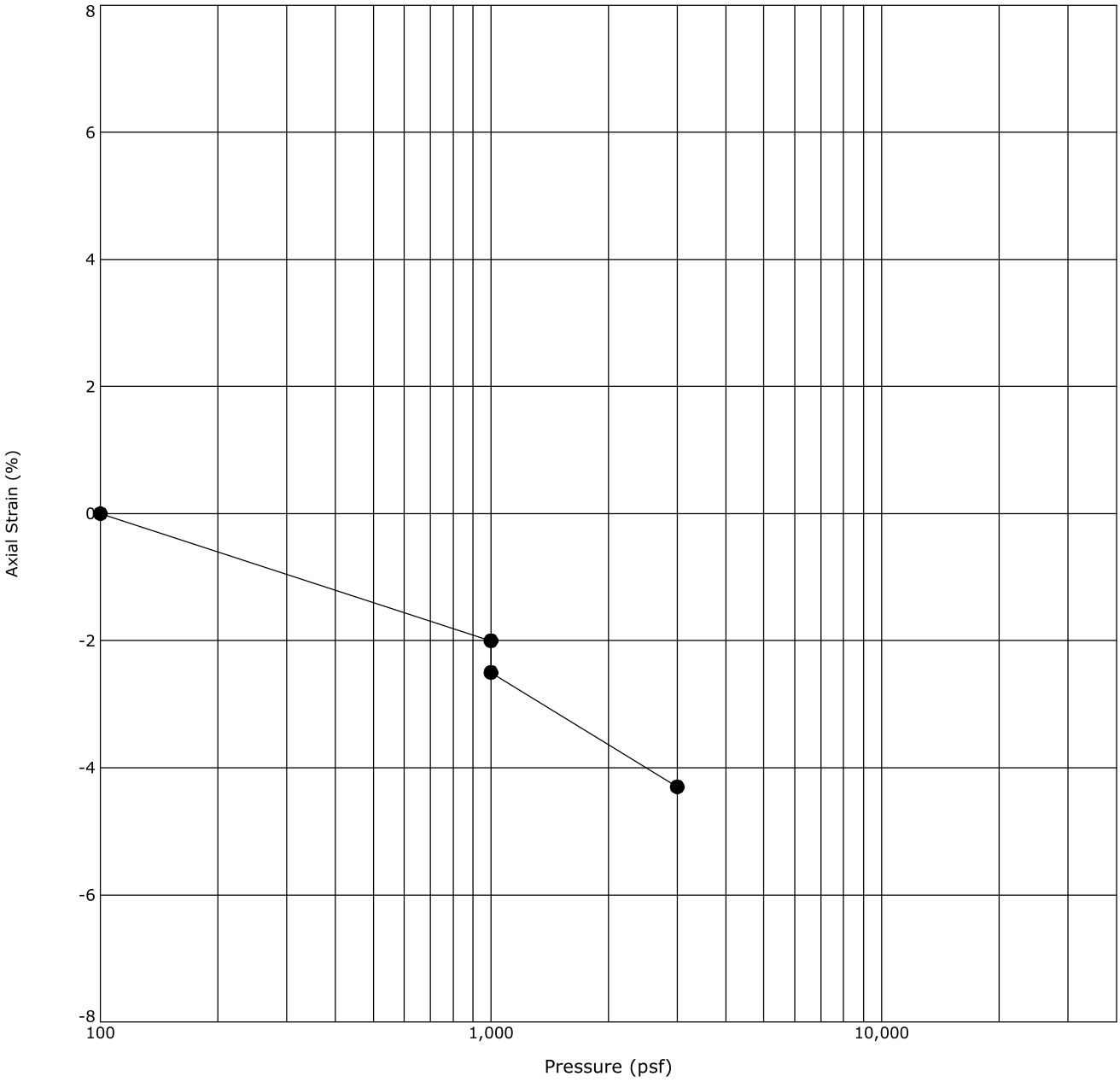


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-13	4 - 5	FILL - CLAYEY SAND	SC	114	4.4

Notes: Water was added at 500 psf. Sample likely disturbed.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

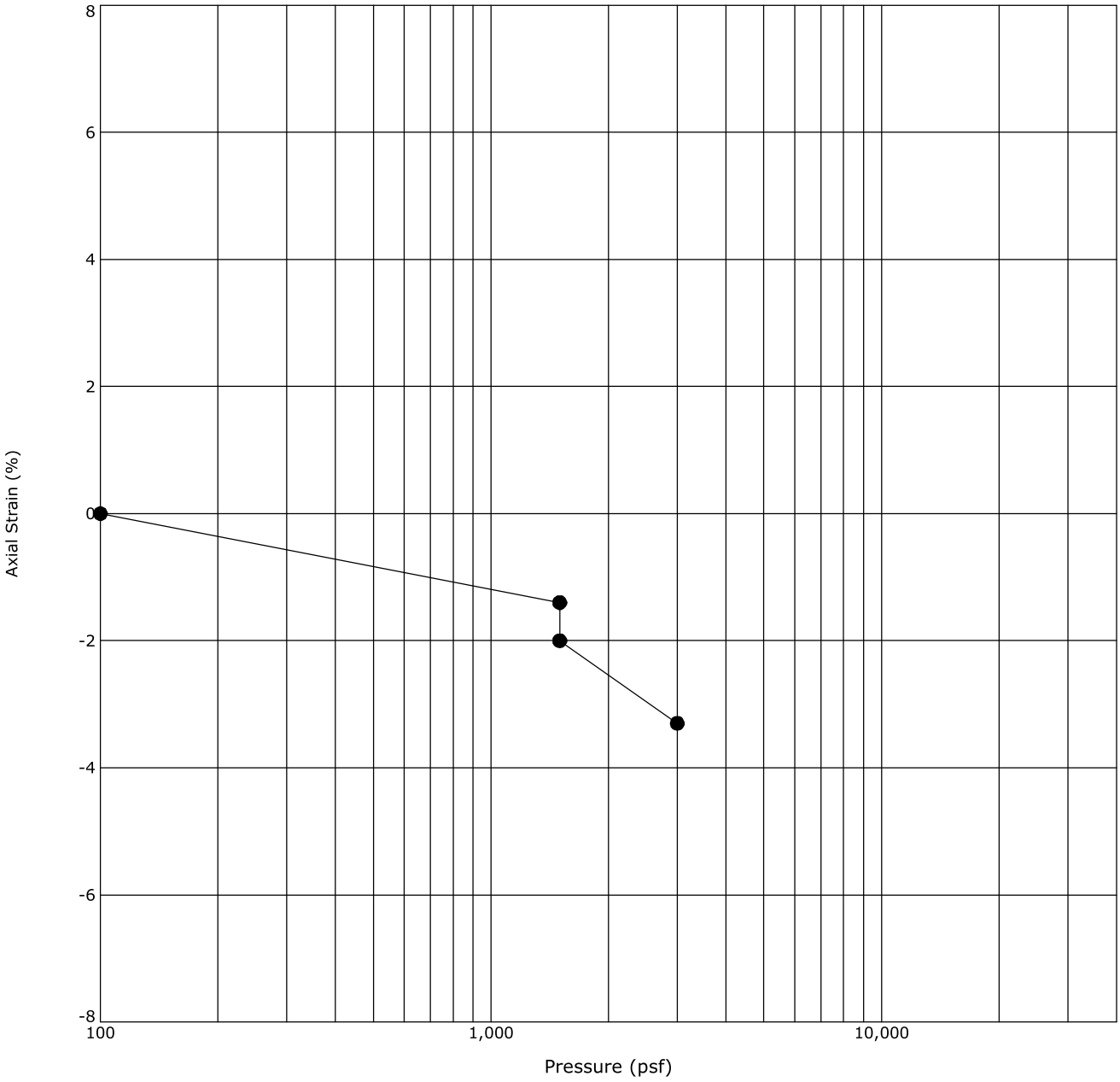


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-13	9 - 10	FILL - CLAYEY SAND	SC	122	5.5

Notes: Water was added at 1000 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse

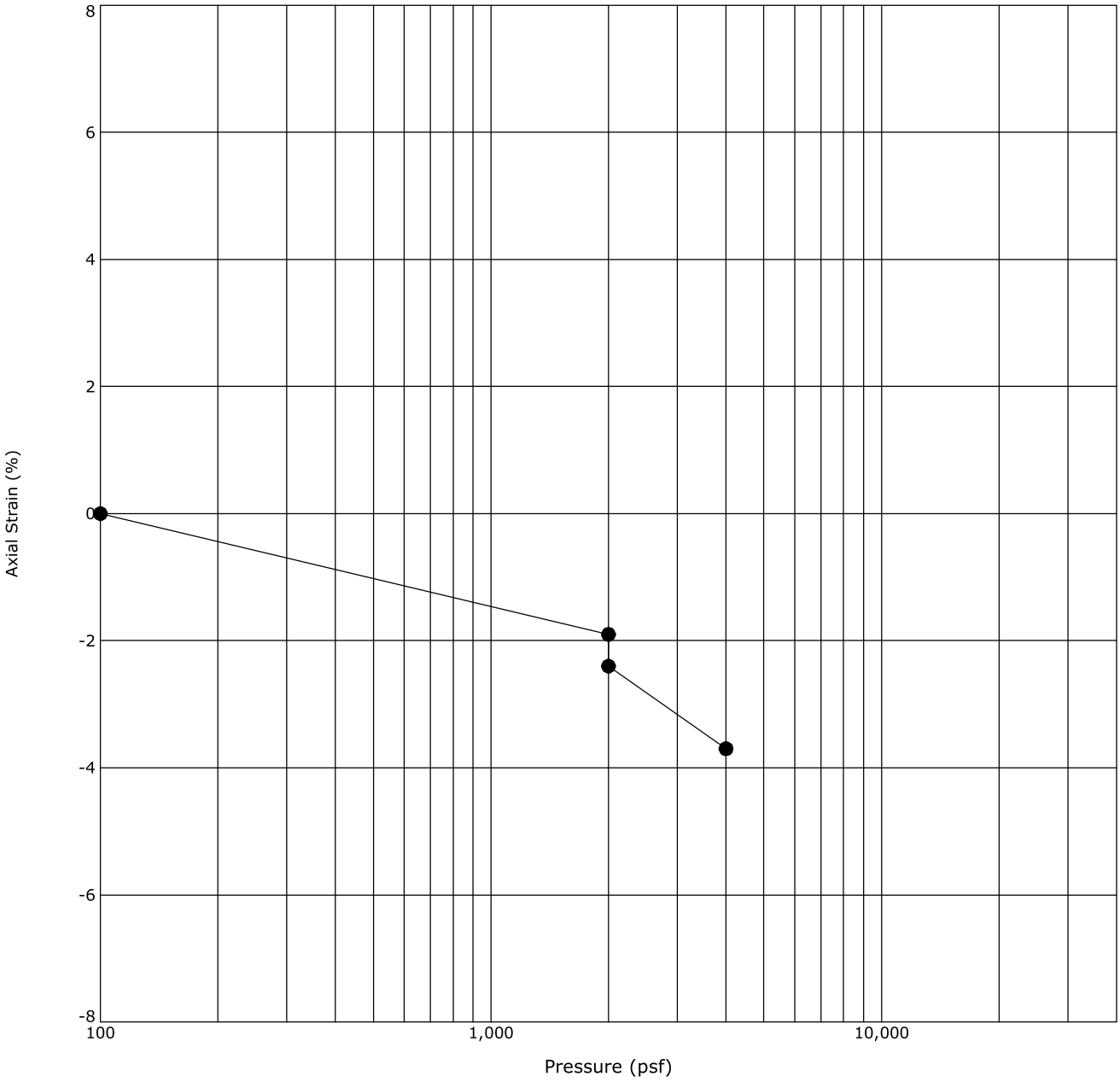


Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-13	14 - 15	FILL - FAT CLAY	CH	97	21.6

Notes: Water was added at 1500 psf.

10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

One-Dimensional Swell or Collapse



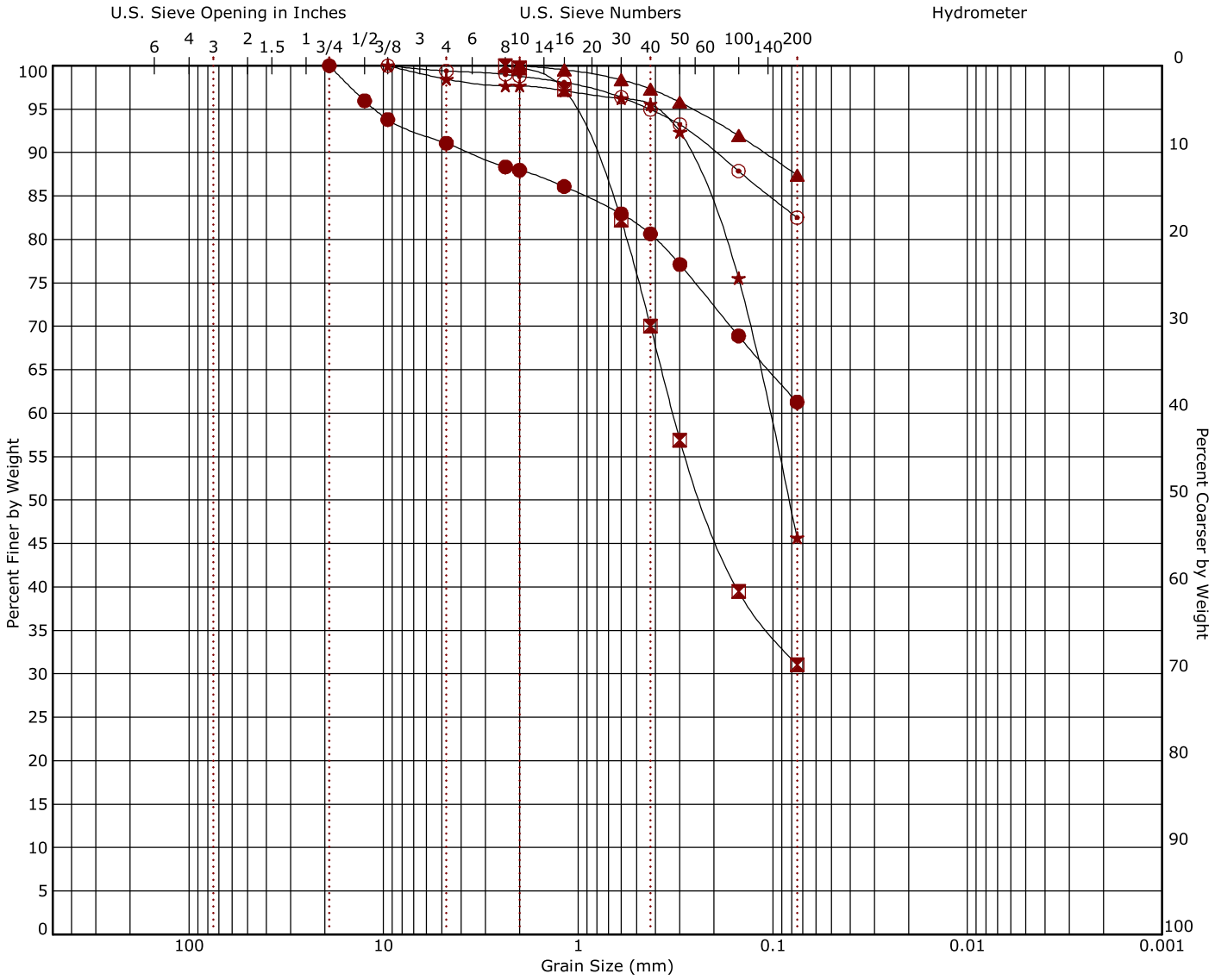
Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	BH-13	19 - 20	FILL - FAT CLAY	CH	106	16.5

Notes: Water was added at 2000 psf.

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
●	BH-1	0 - 5	SANDY LEAN CLAY	CL	A-7-6 (12)	44	20	24		
⊠	BH-1	19 - 20	CLAYEY SAND	SC	A-2-7 (4)	47	15	32		
▲	BH-2	4 - 5	FAT CLAY	CH	A-7-6 (34)	51	12	39		
★	BH-2	24 - 25	SILTY SAND	SM	A-4 (0)	33	28	5		
⊙	BH-3	7 - 8	LEAN CLAY with SAND	CL	A-7-6 (27)	47	14	33		

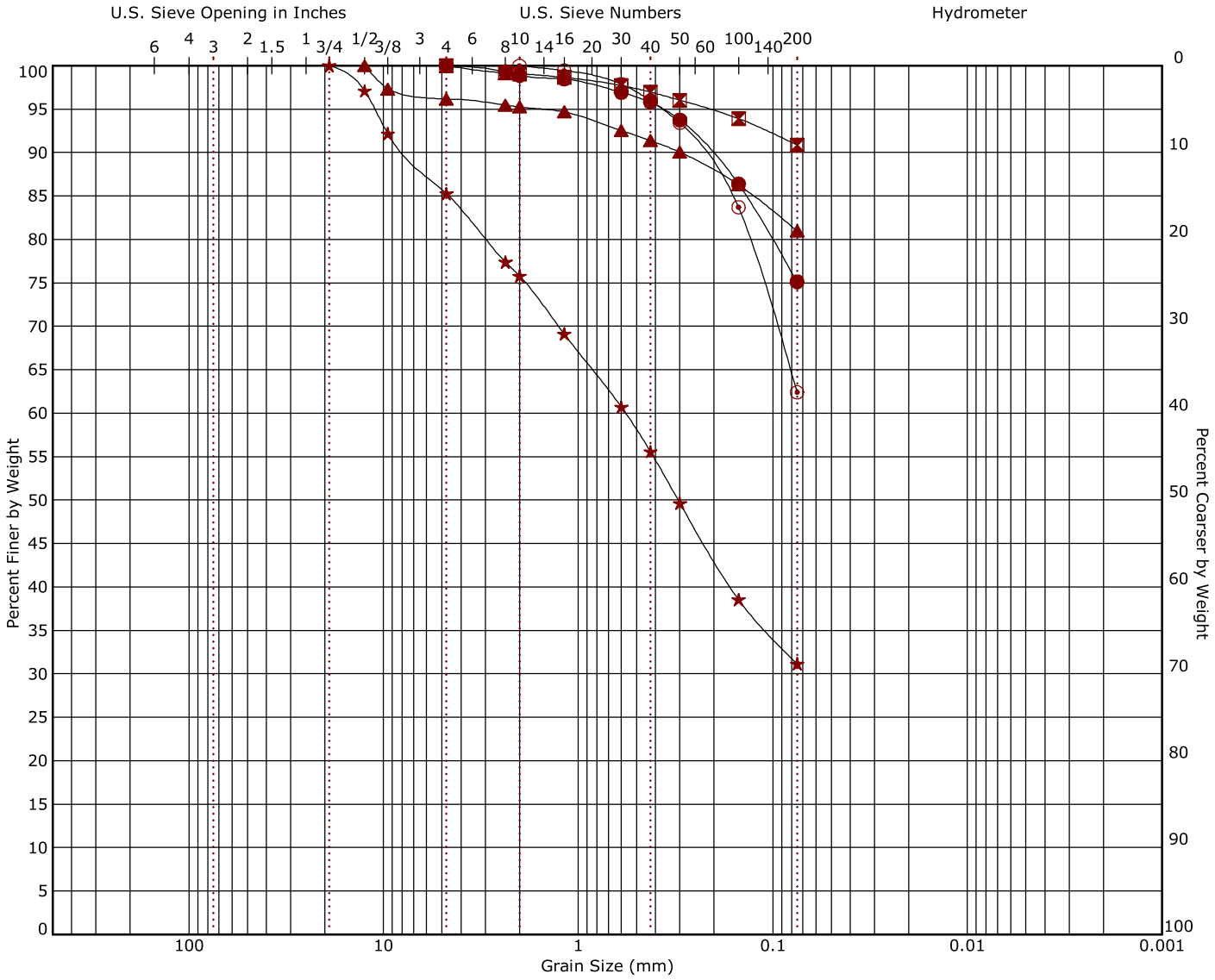
Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	BH-1	0 - 5	19				0.0	8.9	29.8	61.3		
⊠	BH-1	19 - 20	2.36	0.326			0.0	0.0	68.9	31.1		
▲	BH-2	4 - 5	2				0.0	0.0	12.6	87.4		
★	BH-2	24 - 25	9.5	0.105			0.0	1.5	52.8	45.7		
⊙	BH-3	7 - 8	9.5				0.0	0.6	16.9	82.5		

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
●	BH-3	24 - 25	FAT CLAY with SAND	CH	A-7-6 (26)	54	18	36		
⊠	BH-4	7 - 8	FAT CLAY	CH	A-7-6 (36)	54	16	38		
▲	BH-5	7 - 8	FAT CLAY with SAND	CH	A-7-6 (29)	53	17	36		
★	BH-6	0 - 5	CLAYEY SAND	SC	A-2-6 (1)	31	16	15		
⊙	BH-6	9 - 10	SANDY FAT CLAY	CH	A-7-6 (20)	57	21	36		

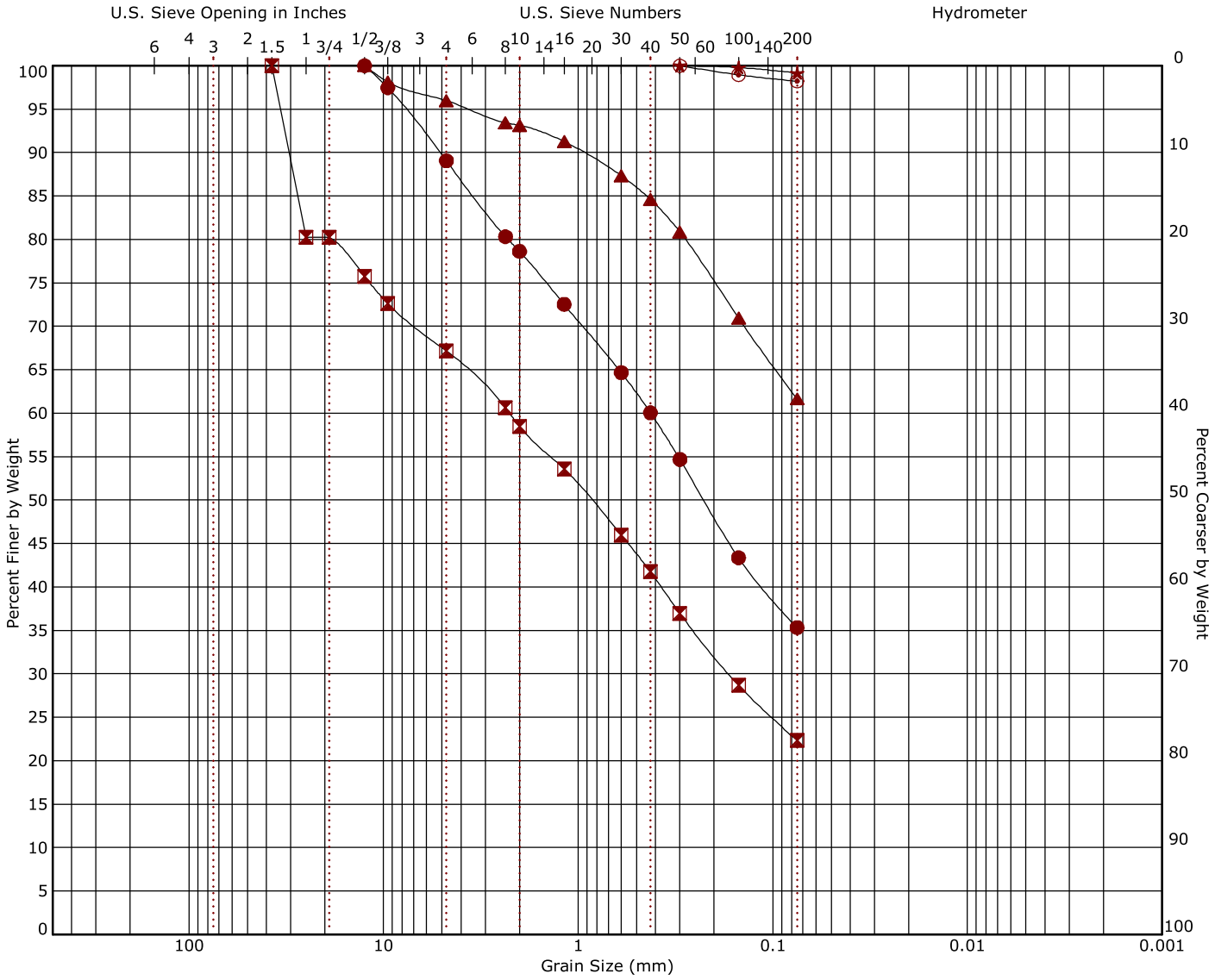
Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	BH-3	24 - 25	4.75				0.0	0.0	24.9	75.1		
⊠	BH-4	7 - 8	4.75				0.0	0.0	9.1	90.9		
▲	BH-5	7 - 8	12.5				0.0	3.8	15.2	81.0		
★	BH-6	0 - 5	19	0.571			0.0	14.7	54.1	31.2		
⊙	BH-6	9 - 10	2				0.0	0.0	37.6	62.4		

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
●	BH-7	0 - 5	CLAYEY SAND	SC	A-2-6 (2)	35	15	20		
⊠	BH-7	7 - 8	CLAYEY SAND with GRAVEL	SC	A-2-6 (0)	35	21	14		
▲	BH-8	4 - 5	SANDY FAT CLAY	CH	A-7-6 (14)	51	26	25		
★	BH-8	24 - 25	FAT CLAY	CH	A-7-5 (44)	68	32	36		
⊙	BH-9	9 - 10	FAT CLAY	CH	A-7-6 (32)	50	20	30		

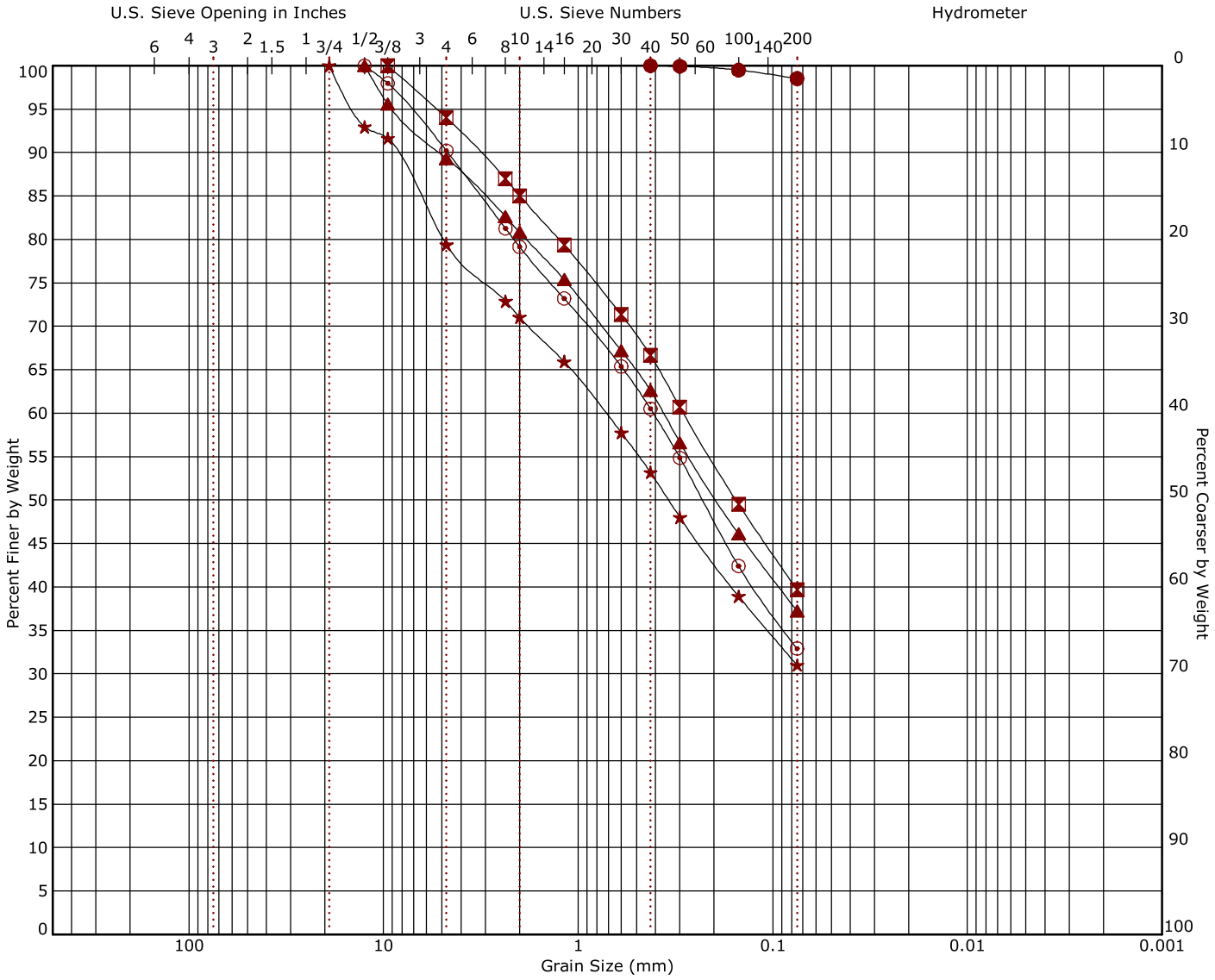
Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	BH-7	0 - 5	12.5	0.424			0.0	10.9	53.7	35.3		
⊠	BH-7	7 - 8	37.5	2.25	0.167		0.0	32.8	44.8	22.3		
▲	BH-8	4 - 5	12.5				0.0	4.0	34.3	61.6		
★	BH-8	24 - 25	0.3				0.0	0.0	0.8	99.2		
⊙	BH-9	9 - 10	0.3				0.0	0.0	1.8	98.2		

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
●	BH-9	24 - 25	FAT CLAY	CH	A-7-6 (42)	57	19	38		
⊠	BH-10	0 - 5	CLAYEY SAND	SC	A-6 (3)	38	21	17		
▲	BH-11	0 - 5	CLAYEY SAND	SC	A-7-6 (5)	50	18	32		
★	BH-11	19 - 20	CLAYEY SAND with GRAVEL	SC	A-2-6 (1)	34	17	17		
⊙	BH-13	0 - 5	CLAYEY SAND	SC	A-2-6 (1)	34	20	14		

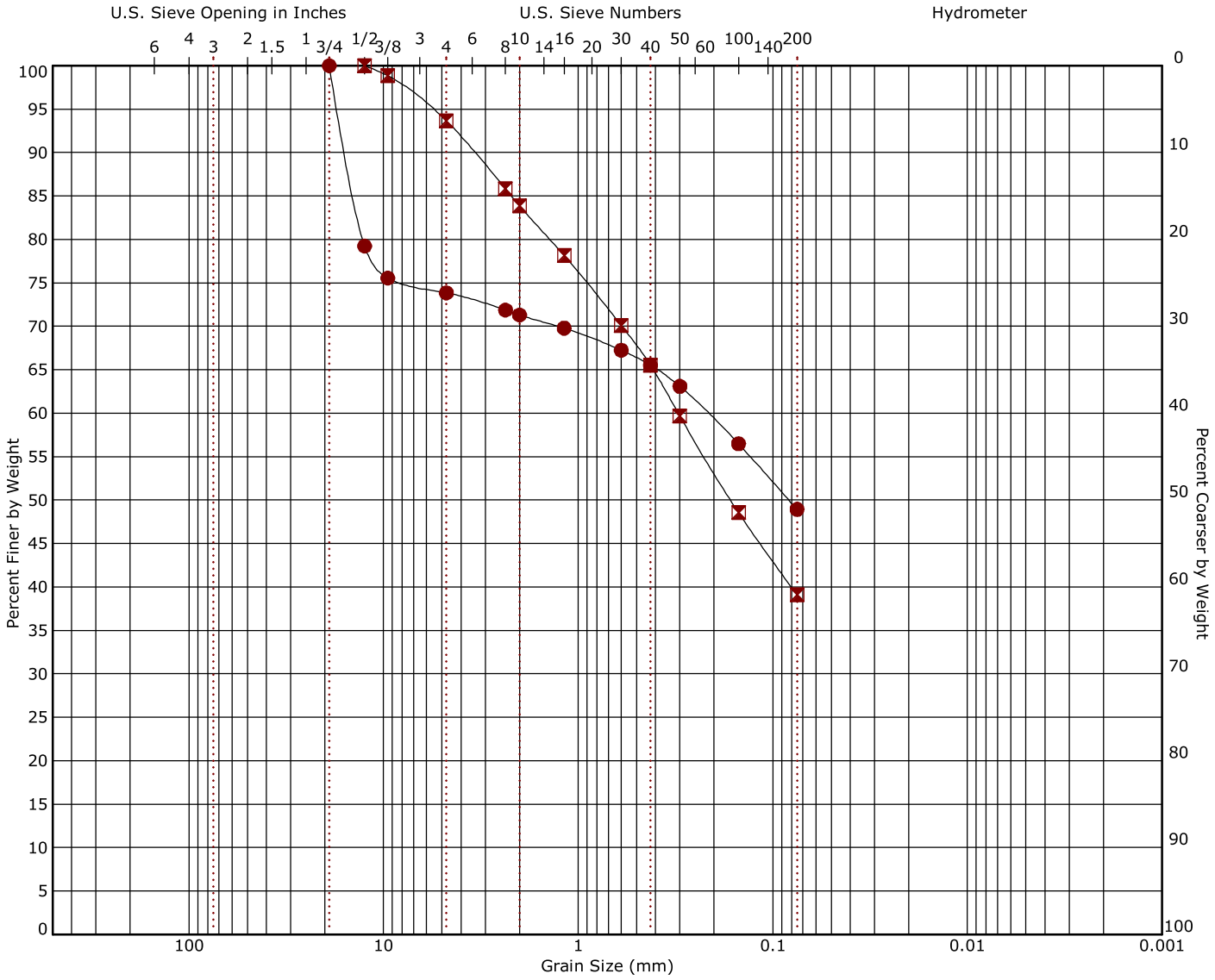
Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	BH-9	24 - 25	0.425				0.0	0.0	1.5	98.5		
⊠	BH-10	0 - 5	9.5	0.287			0.0	6.0	54.3	39.7		
▲	BH-11	0 - 5	12.5	0.365			0.0	10.7	52.1	37.3		
★	BH-11	19 - 20	19	0.722			0.0	20.6	48.4	31.0		
⊙	BH-13	0 - 5	12.5	0.412			0.0	9.8	57.3	32.9		

Proposed TWTP PFAS Building
920 East Thornton Parkway | Thornton, Colorado
Terracon Project No. 25245207

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

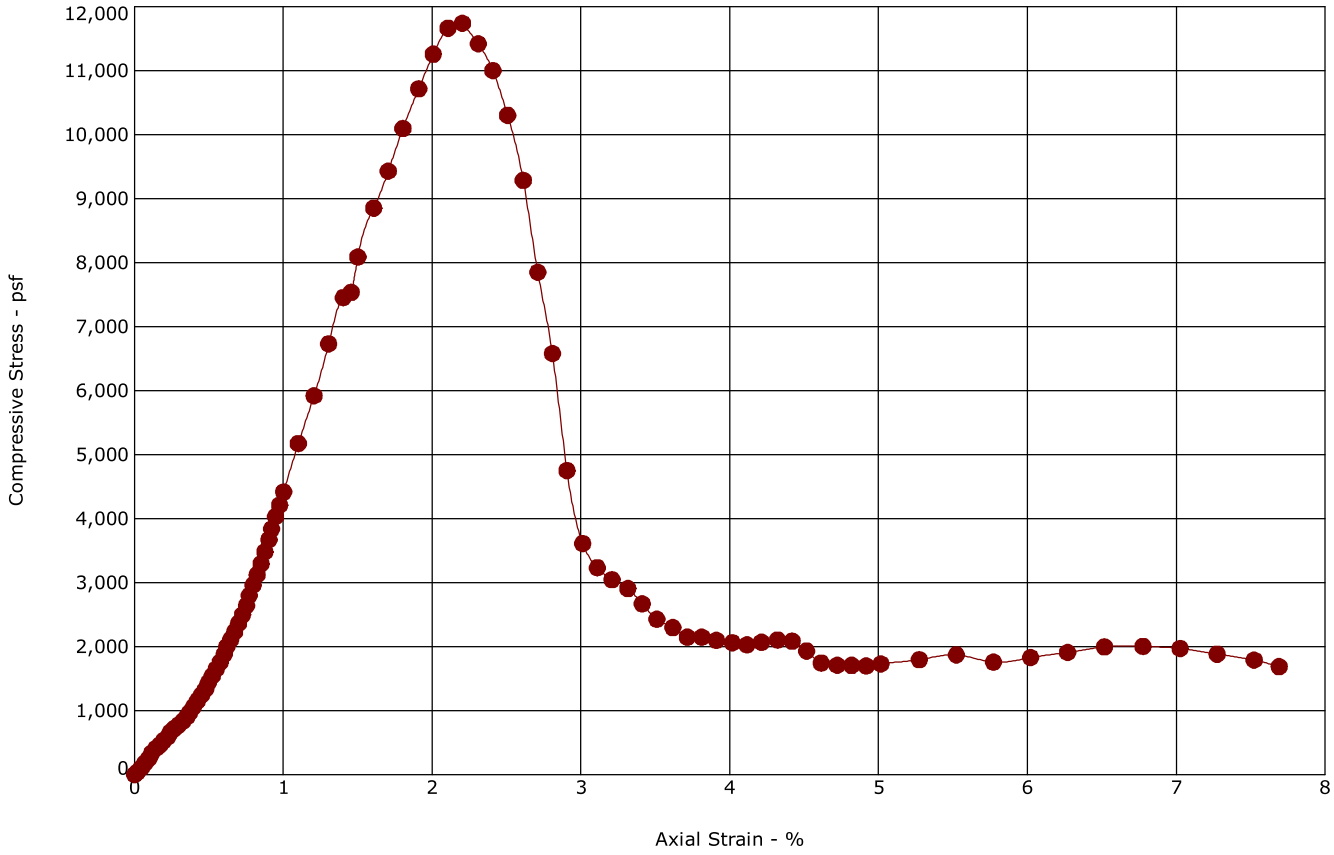
Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
BH-13	19 - 20	CLAYEY GRAVEL with SAND	GC	A-7-6 (11)	52	19	33		
COMP BH-10/ BH-11/BH-13	0 - 5	CLAYEY SAND	SC	A-6 (3)	38	19	19		

Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
BH-13	19 - 20	19	0.217			0.0	26.1	24.9	48.9		
COMP BH-10/ BH-11/BH-13	0 - 5	12.5	0.306			0.0	6.3	54.6	39.1		

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

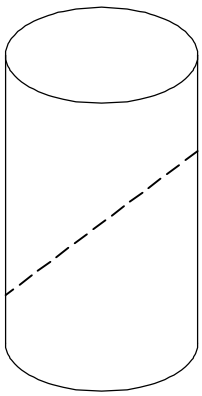
Unconfined Compression Test

ASTM D2166



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
BH-3	49 - 50	CARS					CLAYSTONE

Specimen Failure Mode	Specimen Test Data	
	Moisture Content (%):	20.3
	Dry Density (pcf):	108
	Diameter (in.):	1.93
	Height (in.):	4.00
	Height / Diameter Ratio:	2.08
	Calculated Saturation (%):	97.86
	Calculated Void Ratio:	0.56
	Assumed Specific Gravity:	2.7
	Failure Strain (%):	2.20
	Unconfined Compressive Strength (psf):	11740
	Undrained Shear Strength (psf):	5870
	Strain Rate (in/min):	0.0401
	Remarks:	

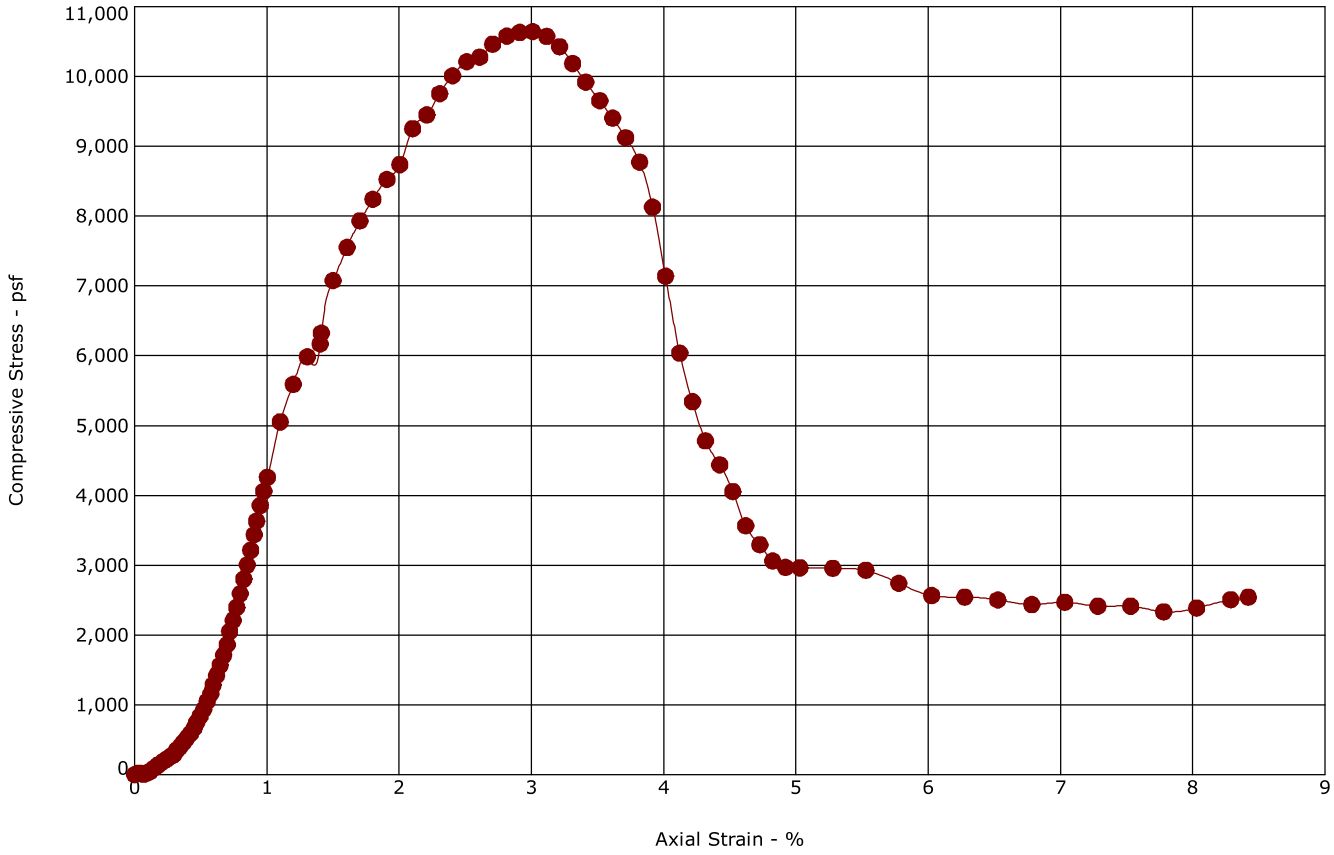


Failure Mode: Shear (dashed)

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

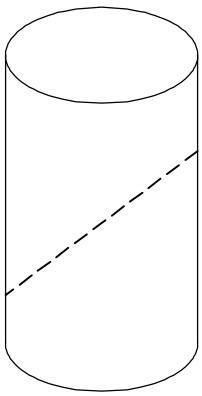
Unconfined Compression Test

ASTM D2166



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
BH-4	39 - 40	CARS					CLAYSTONE

Specimen Failure Mode	Specimen Test Data	
	Moisture Content (%):	20.7
	Dry Density (pcf):	105
	Diameter (in.):	1.93
	Height (in.):	4.00
	Height / Diameter Ratio:	2.07
	Calculated Saturation (%):	92.38
	Calculated Void Ratio:	0.61
	Assumed Specific Gravity:	2.7
	Failure Strain (%):	3.01
	Unconfined Compressive Strength (psf):	10642
	Undrained Shear Strength (psf):	5321
	Strain Rate (in/min):	0.0399
	Remarks:	

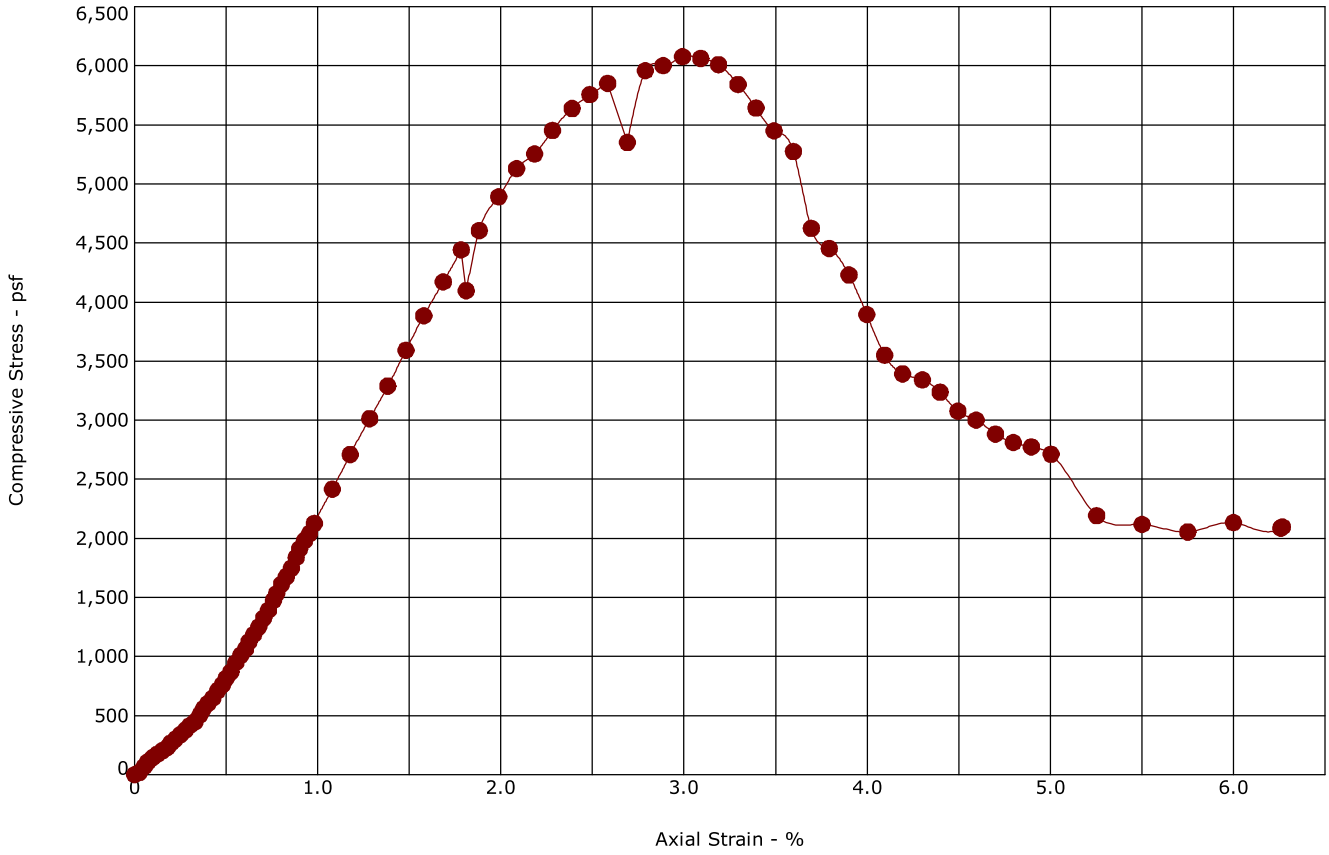


Failure Mode: Shear (dashed)

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

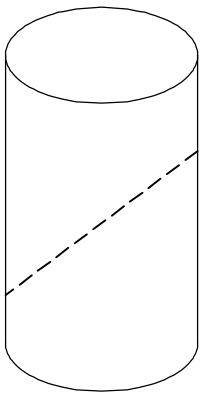
Unconfined Compression Test

ASTM D2166



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
BH-8	19 - 20	CARS					CLAYSTONE

Specimen Failure Mode	Specimen Test Data	
	Moisture Content (%):	19.8
	Dry Density (pcf):	104
	Diameter (in.):	1.92
	Height (in.):	4.00
	Height / Diameter Ratio:	2.08
	Calculated Saturation (%):	85.92
	Calculated Void Ratio:	0.62
	Assumed Specific Gravity:	2.7
	Failure Strain (%):	2.99
	Unconfined Compressive Strength (psf):	6077
	Undrained Shear Strength (psf):	3038
	Strain Rate (in/min):	0.0400
	Remarks:	

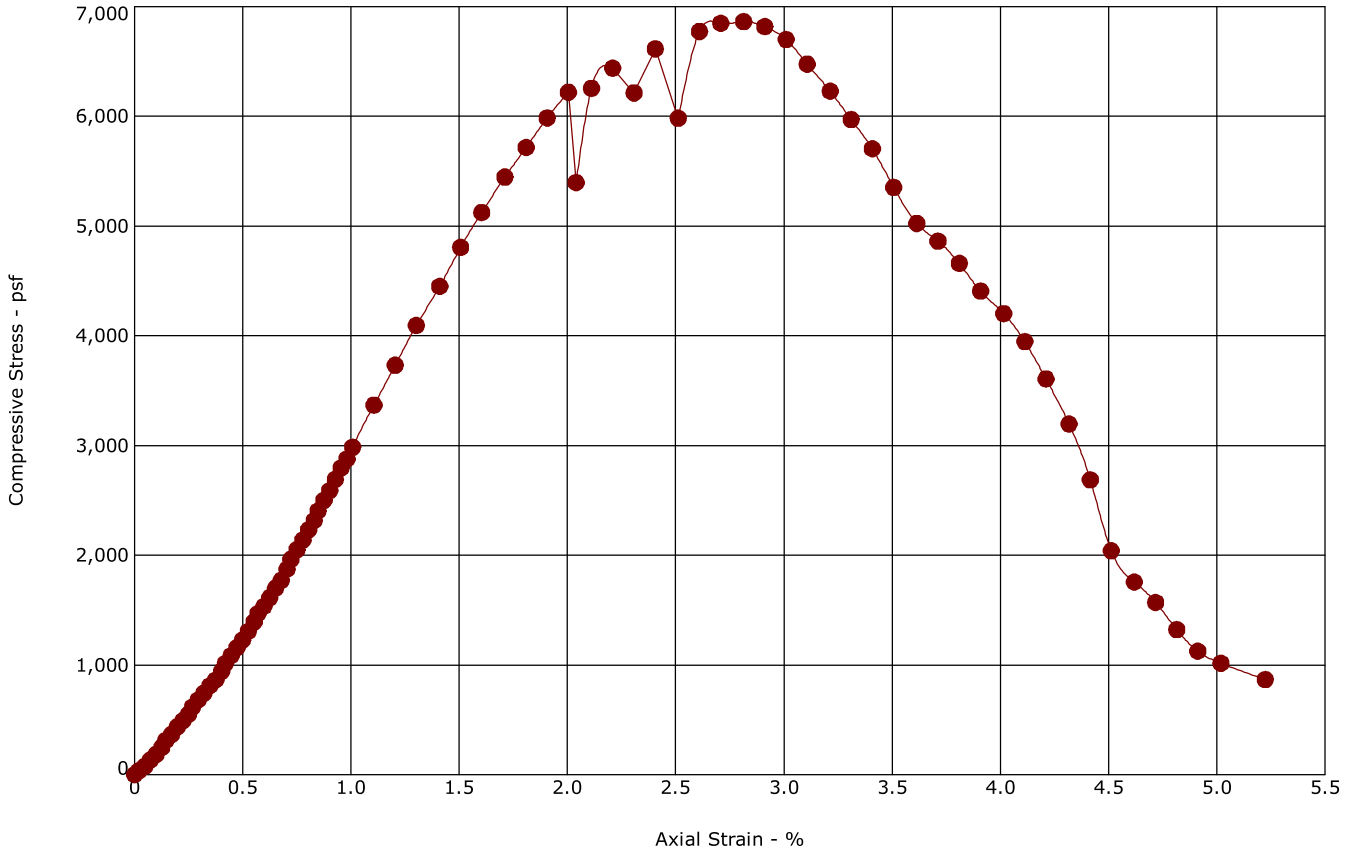


Failure Mode: Shear (dashed)

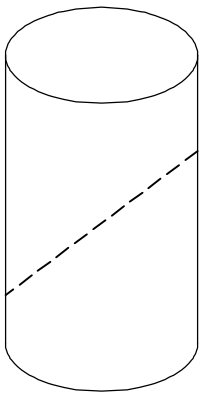
Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

Unconfined Compression Test

ASTM D2166



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
BH-9	24 - 25	CARS	57	19	38	98.5	CLAYSTONE

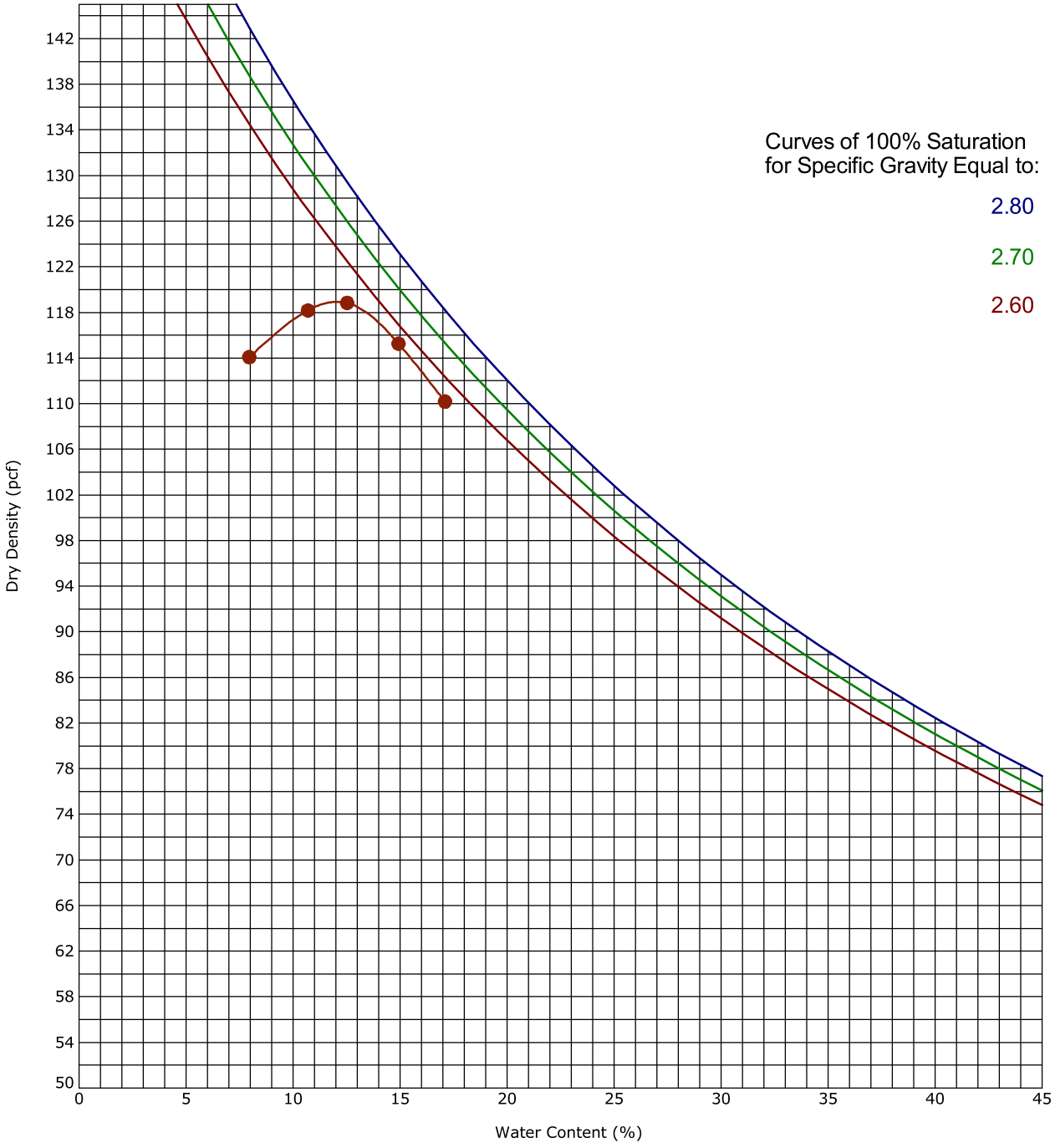
Specimen Failure Mode	Specimen Test Data	
	Moisture Content (%):	21.5
	Dry Density (pcf):	103
	Diameter (in.):	1.92
	Height (in.):	4.02
	Height / Diameter Ratio:	2.09
	Calculated Saturation (%):	91.26
	Calculated Void Ratio:	0.64
	Assumed Specific Gravity:	2.7
	Failure Strain (%):	2.81
	Unconfined Compressive Strength (psf):	6863
	Undrained Shear Strength (psf):	3432
	Strain Rate (in/min):	0.0401
	Remarks:	

Failure Mode: Shear (dashed)

Terracon
10625 W I70 Frontage Rd N Ste 3
Wheat Ridge, CO

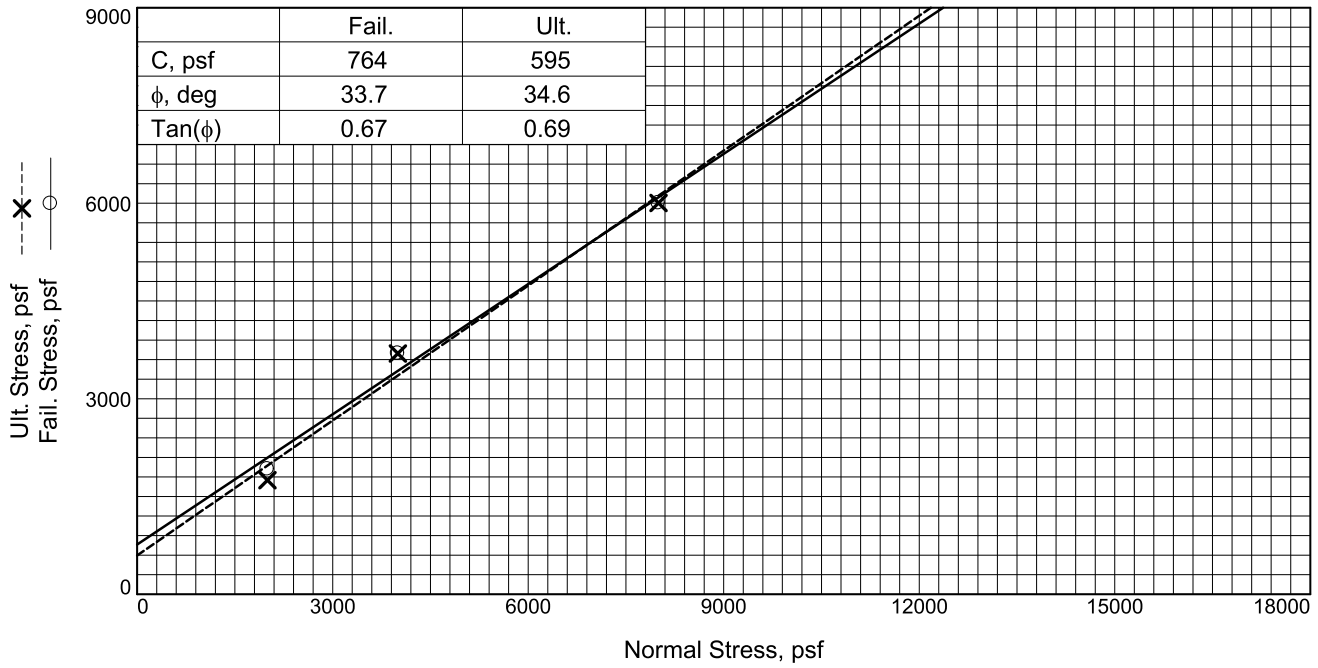
Moisture-Density Relationship

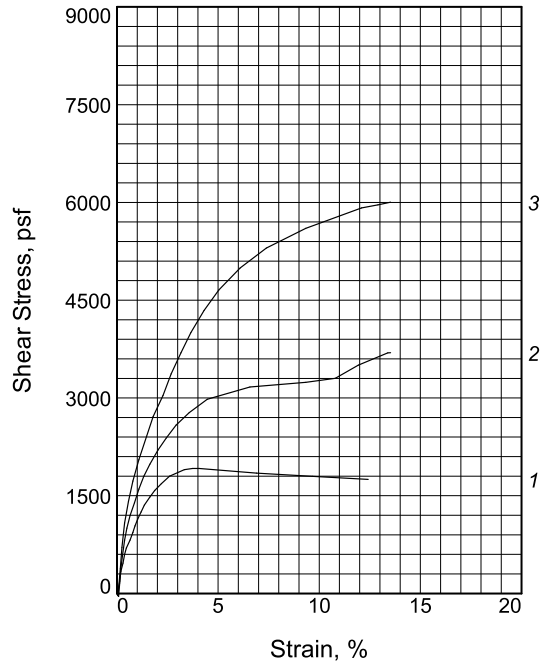
ASTM D698-Method B



Boring ID	Depth (Ft)	Description of Materials
COMP BH-10/BH-11/BH-13	0 - 5	CLAYEY SAND(SC)

Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)
39	0.0	38	19	19	ASTM D698-Method B	118.9	12.0





Sample No.		1	2	3
Initial	Water Content, %	12.0	11.0	13.6
	Dry Density, pcf	114.4	115.1	111.2
	Saturation, %	68.6	64.2	71.4
	Void Ratio	0.4738	0.4645	0.5151
	Diameter, in.	1.85	1.85	1.85
	Height, in.	0.98	0.98	0.98
At Test	Water Content, %	19.9	17.5	17.7
	Dry Density, pcf	117.4	122.0	122.3
	Saturation, %	123.2	124.0	126.1
	Void Ratio	0.4354	0.3811	0.3780
	Diameter, in.	1.85	1.85	1.85
	Height, in.	0.96	0.93	0.89
Normal Stress, psf		2000	4000	8000
Fail. Stress, psf		1919	3694	6003
Strain, %		3.7	13.5	13.5
Ult. Stress, psf		1750	3694	6003
Strain, %		12.4	13.5	13.5
Strain rate, in./min.		0.001	0.001	0.001

Sample Type: Undisturbed
Description: SC, Clayey Sand

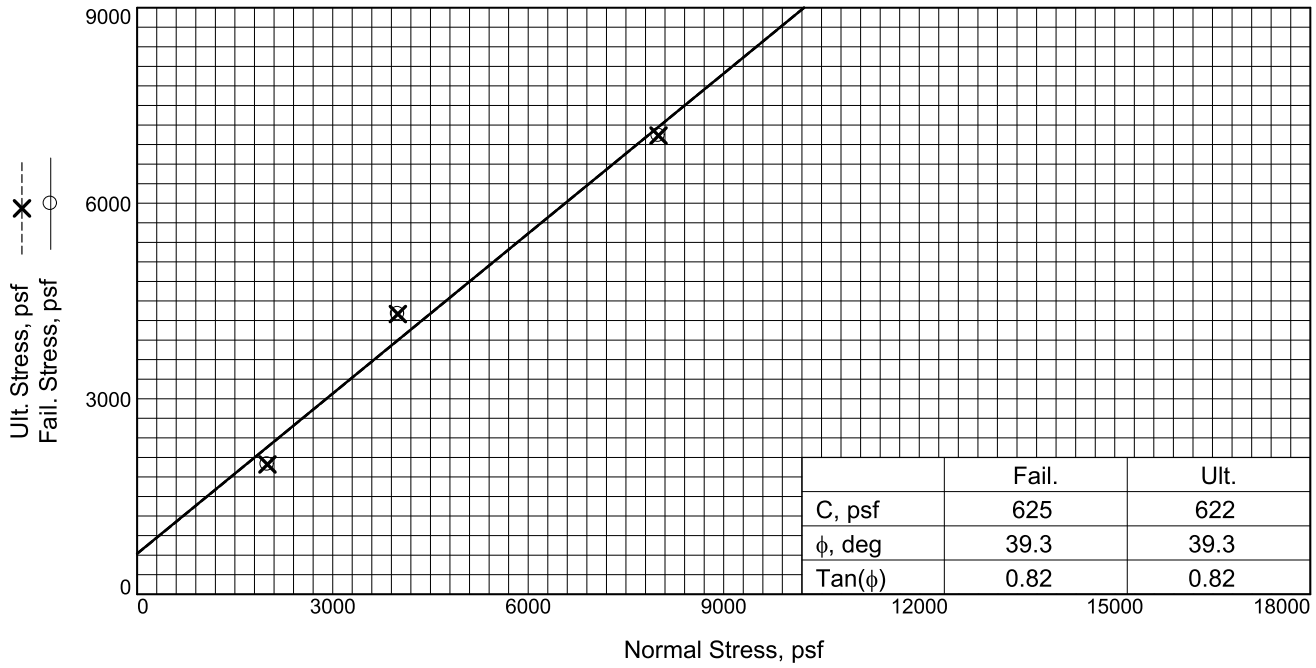
LL= 50 **PL=** 18 **PI=** 32
Assumed Specific Gravity= 2.7
Remarks:

Client: Brown and Caldwell

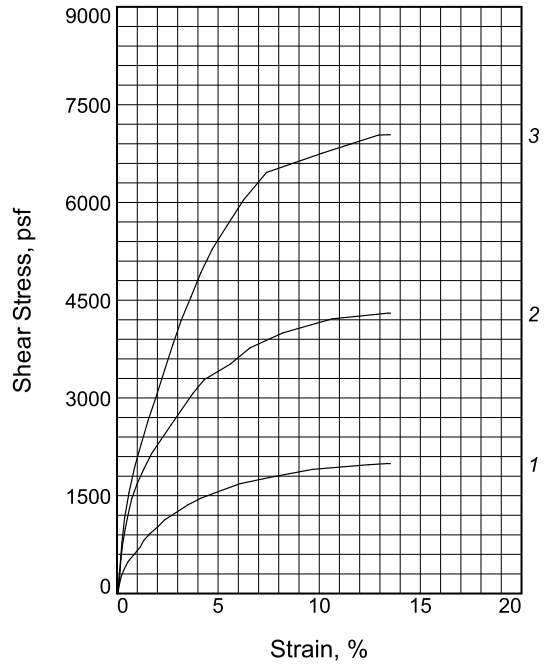
Project: Proposed TWTP PFAS Building

Location: BH-11
Depth: 24' - 25'
Proj. No.: 25245207 **Date Sampled:** 7/25/2025

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Wheat Ridge, Colorado



	Fail.	Ult.
C, psf	625	622
ϕ, deg	39.3	39.3
Tan(ϕ)	0.82	0.82



Sample No.		1	2	3
Initial	Water Content, %	4.3	8.2	7.6
	Dry Density, pcf	116.5	112.1	111.9
	Saturation, %	25.9	43.9	40.6
	Void Ratio	0.4470	0.5032	0.5066
	Diameter, in.	1.85	1.85	1.85
	Height, in.	0.98	0.98	0.98
At Test	Water Content, %	16.7	15.5	15.1
	Dry Density, pcf	122.4	119.0	125.2
	Saturation, %	119.1	100.6	117.7
	Void Ratio	0.3775	0.4168	0.3460
	Diameter, in.	1.85	1.85	1.85
	Height, in.	0.93	0.93	0.88
Normal Stress, psf		2000	4000	8000
Fail. Stress, psf		1993	4301	7038
Strain, %		13.4	13.4	13.5
Ult. Stress, psf		1992	4299	7038
Strain, %		13.5	13.5	13.5
Strain rate, in./min.		0.001	0.001	0.001

Sample Type: Undisturbed
Description: SC, Clayey Sand

LL= 34 **PL=** 20 **PI=** 14
Assumed Specific Gravity= 2.7
Remarks:

Client: Brown and Caldwell

Project: Proposed TWTP PFAS Building

Location: BH-13
Depth: 7' - 8'
Proj. No.: 25245207 **Date Sampled:** 7/28/2025

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Wheat Ridge, Colorado

Client
Brown and Caldwell

Project
Proposed TWTP PFAS Building
25245207

Results from Corrosion Testing

Sample Location	BH-3	BH-6	BH-8
Sample Depth (ft.)	0 - 5	0 - 5	0 - 5
pH Analysis, ASTM D4972	8.05	8.25	7.36
Water Soluble Sulfate (SO4), AASHTO T290, (%)	<0.10	<0.10	<0.10
Chlorides, AASHTO T291, (mg/kg)	19	51	60
Resistivity (Saturated), ASTM G57, (ohm-cm)	1200	1600	610
Sulfides, ASTM A674 - X1.6, (Negative/Trace/ Present)	Present	Trace	Trace

Analyzed By: Daryl Lee
Laboratory Supervisor

The tests were performed in general accordance with applicable ASTM and AASHTO test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUMMARY OF LABORATORY TEST RESULTS

Proposed TWTP PFAS Building - Thornton, Colorado
Terracon Project No. 25245207

Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		Direct Shear		Moisture-Density Relationship			Particle Size Distribution, Percent Passing by Weight							Atterberg Limits		Unconfined Compressive Strength (psf)	Water Soluble Sulfates (%)	Chlorides (mg/kg)	pH	Sulfides (mg/kg)	Resistivity (ohm-cm)	Remarks
					Surcharge (ksf)	Swell (%)	Φ Ult. (deg)	C. Ult. (psf)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Test Method	1-1/2"	1"	3/4"	#4	#10	#40	#200	LL	PI							
BH-1	0 - 5	CL										100	100	100	91	88	81	61	44	24							
BH-1	2	CL	15.0	113																							
BH-1	4	CL	21.6	103																							
BH-1	7	CL	23.5	90	0.5	-0.1																					3
BH-1	9	CL	22.7	97																							
BH-1	14	CL	18.8	101																							
BH-1	19		17.5	105								100	100	100	100	100	70	31	47	32							
BH-1	24		19.7	107																							
BH-1	29		22.2	103																							
BH-1	34		18.0	112																							
BH-1	39		19.4	110																							
BH-2	2	CH	22.1	102																							
BH-2	4	CH	21.4	102	0.5	+0.6						100	100	100	100	100	97	87	51	39							3
BH-2	7	CH	24.4	99																							
BH-2	9	CH	21.2	101																							
BH-2	14		19.8	90																							
BH-2	19		24.3	100																							
BH-2	24		16.5	98	0.5	+0.4						100	100	100	98	98	96	46	33	5							3
BH-2	29		16.4	91																							
BH-2	34		19.9	109																							
BH-2	39		18.8	112																							
BH-2	44		19.8	110																							
BH-2	49		17.1	111																							
BH-3	0 - 5	CL																				<0.10	19	8.05	Present	1200	
BH-3	2	CL	24.2																								
BH-3	4	CL	25.7	93																							
BH-3	7	CL	24.8	94								100	100	100	99	99	95	83	47	33							
BH-3	9	CL	20.4	105	0.5	+0.2																					3
BH-3	14	CL	21.8	103																							
BH-3	19	CL	24.9	97																							
BH-3	24	CL	28.4	83								100	100	100	100	99	96	75	54	36							
BH-3	29	CL	15.1	103																							
BH-3	34		22.6	104																							
BH-3	39		23.9	103																							
BH-3	44		23.7	101																							
BH-3	49		20.3	108																	11740						
BH-3	54		22.2	104	0.5	+3.4																					3
BH-3	59		18.2	113																							
BH-4	2	CL	22.5	99																							
BH-4	4	CL	26.7	92																							
BH-4	7	CH	24.3	94								100	100	100	100	99	97	91	54	38							
BH-4	9	CH	23.7	100	0.5	+0.1																					3
BH-4	14	CH	22.7	101																							
BH-4	19	CH	22.7	95																							
BH-4	24		18.3	104	0.5	+1.4																					3
BH-4	29		6.4	123																							
BH-4	34		19.4	107																							
BH-4	39		20.7	105																	10640						
BH-5	2	CH	16.1	108																							
BH-5	4	CH	23.8	96																							
BH-5	7	CH	21.9	104	0.5	+0.5						100	100	100	96	95	91	81	53	36							3

Notes:
Initial Dry Density and Initial Water Content are in-situ values unless otherwise notes
* = Partially disturbed sample
- = Compression/settlement
NV = no value
NP = non-plastic

Remarks:
1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)
3 Water added to sample
4 Minus #200 Only
5 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
6 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

Terracon
Explore with us

SUMMARY OF LABORATORY TEST RESULTS

Proposed TWTP PFAS Building - Thornton, Colorado
Terracon Project No. 25245207

Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		Direct Shear		Moisture-Density Relationship			Particle Size Distribution, Percent Passing by Weight							Atterberg Limits		Unconfined Compressive Strength (psf)	Water Soluble Sulfates (%)	Chlorides (mg/kg)	pH	Sulfides (mg/kg)	Resistivity (ohm-cm)	Remarks
					Surcharge (ksf)	Swell (%)	Φ Ult. (deg)	C. Ult. (psf)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Test Method	1-1/2"	1"	3/4"	#4	#10	#40	#200	LL	PI							
BH-5	9	CH	21.5	97																							
BH-5	14	CH	11.3	111																							
BH-5	19	CH	18.4	97																							
BH-5	24	CH	17.3	90																							
BH-5	29	CH	25.3	93																							
BH-5	34	CH	34.2	87																							
BH-5	39		19.4	107																							
BH-5	44		25.4	98	0.5	+1.0																					3
BH-5	49		31.9	78																							
BH-6	0 - 5	SC										100	100	100	85	76	56	31	31	15		<0.10	51	8.25	Trace	1600	
BH-6	2	SC	12.9	114																							
BH-6	4	SC	14.2	98																							
BH-6	7	CH	26.3	92																							
BH-6	9	CH	25.6	93	0.5	-0.3						100	100	100	100	100	96	62	57	36							3
BH-6	14	CH	30.1	88																							
BH-6	19	CH	32.5	86																							
BH-6	24	CH	24.8	98																							
BH-6	29		20.6	105																							
BH-7	0 - 5	SC										100	100	100	89	79	60	35	35	20							
BH-7	2	SC	11.8	107																							
BH-7	4	SC	10.7	107																							
BH-7	7	SC	13.2	103	0.5	-0.5						100	90	90	67	58	42	22	35	14							3
BH-7	9	SC	11.4	104																							
BH-7	14	SC	25.3	86																							
BH-7	19	SC	28.1	92																							
BH-7	24	SC	26.3	86																							
BH-7	29	GP	7.7	119																							
BH-7	34		29.9	95																							
BH-7	39		28.0	98																							
BH-8	0 - 5	CH																				<0.10	60	7.36	Trace	610	
BH-8	2	CH	24.9	86																							
BH-8	4	CH	22.6	89								100	100	100	96	93	85	62	51	25							
BH-8	7	CH	30.0	90	0.5	-0.5																					3
BH-8	9	CH	20.0	97																							
BH-8	14	CH	20.5	93																							
BH-8	19		19.8	104																	6080						
BH-8	24		26.1	95	0.5	+3.4						100	100	100	100	100	100	99	68	36							3
BH-8	29		18.4	106																							
BH-9	2	CH	13.1	103																							
BH-9	4	CH	19.6	96																							
BH-9	7	CH	23.2	92	0.5	+0.7																					3
BH-9	9		22.0	98	0.5	+0.6						100	100	100	100	100	100	98	50	30							3
BH-9	14		19.5	107																							
BH-9	19		14.5	94																							
BH-9	24		21.5	103								100	100	100	100	100	100	99	57	38	6860						
BH-9	29		18.5	104																							
BH-10	0 - 5	SC										100	100	100	94	85	67	40	38	17							
BH-10	2	SC	15.5	108	0.2	+0.8																					3
BH-10	4	SC	34.0	79	0.5	-0.4																					3
BH-10	7	SC	13.3	99	0.75	-0.9																					3
BH-10	9	SC	23.2	90	1.0	-0.7																					3

Notes:

Initial Dry Density and Initial Water Content are in-situ values unless otherwise notes
* = Partially disturbed sample
- = Compression/settlement
NV = no value
NP = non-plastic

Remarks:

1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)
3 Water added to sample
4 Minus #200 Only
5 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
6 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

Terracon
Explore with us

SUMMARY OF LABORATORY TEST RESULTS

Proposed TWTP PFAS Building - Thornton, Colorado
Terracon Project No. 25245207

Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		Direct Shear		Moisture-Density Relationship			Particle Size Distribution, Percent Passing by Weight							Atterberg Limits		Unconfined Compressive Strength (psf)	Water Soluble Sulfates (%)	Chlorides (mg/kg)	pH	Sulfides (mg/kg)	Resistivity (ohm-cm)	Remarks
					Surcharge (ksf)	Swell (%)	Φ Ult. (deg)	C. Ult. (psf)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Test Method	1-1/2"	1"	3/4"	#4	#10	#40	#200	LL	PI							
BH-10	14	SC	23.1	94	1.5	-1.3																					3
BH-11	0 - 5	SC										100	100	100	89	81	63	37	50	32							
BH-11	2	SC	17.8	106	0.2	-0.1																					3
BH-11	4	SC	15.8	109	0.5	-0.3																					3
BH-11	7	SC	15.5	106	0.75	-0.9																					3
BH-11	9	SC	12.9	110	1.0	-0.6																					3
BH-11	14	SC	14.5	108	1.5	-0.7																					3
BH-11	19	SC	13.5	111	2.0	-0.9						100	100	100	79	71	53	31	34	17							3
BH-11	24	SC					34.6	595																			3
BH-11	29	SC	23.6	88																							
BH-11	34	SC	24.1	94																							
BH-11	39	SC	20.4	97																							
BH-11	44	SC	12.5	111																							
BH-11	49		18.2	94																							
BH-13	0 - 5	SC										100	100	100	90	79	61	33	34	14							
BH-13	2	SC	4.2	110	0.2	-2.9																					3
BH-13	4	SC	4.4	114	0.5	-2.8																					3
BH-13	7	SC					39.3	622																			3
BH-13	9	SC	5.5	122	1.0	-0.5																					3
BH-13	14	CH	21.6	97	1.5	-0.6																					3
BH-13	19	CH	16.5	106	2.0	-0.5						100	100	100	74	71	66	49	52	33							3
COMP BH-10/ BH-11/BH-13	0 - 5	SC							118.9	12.0	D698B	100	100	100	94	84	66	39	38	19							5

Notes:

Initial Dry Density and Initial Water Content are in-situ values unless otherwise notes
* = Partially disturbed sample
- = Compression/settlement
NV = no value
NP = non-plastic

Remarks:

1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)
3 Water added to sample
4 Minus #200 Only
5 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
6 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

Terracon
Explore with us

Supporting Information

Contents:

General Notes
Unified Soil Classification System

Note: All attachments are one page unless noted above.

Terracon
10625 W I70 Frontage Rd N
Ste 3
Wheat Ridge, CO

General Notes

Sampling



Water Level



Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Cave In Encountered

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

Field Tests

N	Standard Penetration Test Resistance (Blows/Ft.)
(HP)	Hand Penetrometer
(T)	Torvane
(DCP)	Dynamic Cone Penetrometer
UC	Unconfined Compressive Strength
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils
(More than 50% retained on No. 200 sieve.)
Density determined by Standard Penetration Resistance

Relative Density	Standard Penetration or N-Value (Blows/Ft.)	Ring Sampler (Blows/Ft.)
Very Loose	0 - 3	0 - 5
Loose	4 - 9	6 - 14
Medium Dense	10 - 29	15 - 46
Dense	30 - 50	47 - 79
Very Dense	> 50	≥ 80

Consistency of Fine-Grained Soils
(50% or more passing the No. 200 sieve.)
Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance

Consistency	Unconfined Compressive Strength Qu (psf)	Standard Penetration or N-Value (Blows/Ft.)	Ring Sampler (Blows/Ft.)
Very Soft	less than 500	0 - 1	< 3
Soft	500 to 1,000	2 - 4	3 - 5
Medium Stiff	1,000 to 2,000	4 - 8	6- 10
Stiff	2,000 to 4,000	8 - 15	11 - 18
Very Stiff	4,000 to 8,000	15 - 30	19 - 36
Hard	> 8,000	> 30	> 36

Bedrock

Consistency	Standard Penetration or N-Value (Blows/Ft.)	Ring Sampler (Blows/Ft.)
Weathered	< 20	< 24
Firm	20 - 29	24 - 35
Medium Hard	30 - 49	36 - 60
Hard	50 - 79	61 - 96
Very Hard	>79	> 96

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Terracon
10625 W I70 Frontage Rd N
Ste 3
Wheat Ridge, CO

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

