FOUNDATION ENGINEERING REPORT

PROPOSED EQUESTRIAN FACILITY
16 NASON HILL LANE

SHERBORN, MASSACHUSETTS

MARCH 24, 2017

Prepared For:

Mr. Michael Newman
16 Nason Hill Lane
Sherborn, MA 01770

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PROJECT NO. 6351.2.00

March 24, 2017

Mr. Michael Newman
16 Nason Hill Lane
Sherborn, MA 01770

Reference: Proposed Equestrian Facility, 16 Nason Hill Lane; Sherborn, Massachusetts
Foundation Engineering Report

Dear Mr. Newman:

This letter report documents the results of our subsurface exploration, geotechnical engineering assessment, and foundation design study for the proposed equestrian facility to be located at 16 Nason Hill Lane in Sherborn, Massachusetts. Refer to the Project Location Plan, **Figure 1**, for the general site location.

This report was prepared in accordance with our proposal dated March 3, 2017 and the subsequent authorization of Mr. Michael Newman. These services are subject to the limitations presented in **Appendix A.**

Purpose and Scope

The purposes of the subsurface exploration program, geotechnical engineering assessment, and foundation design study are to assess the subsurface soil and groundwater conditions at the site as they relate to foundation design and construction and, based on this information, to provide safe and economic design recommendations for the proposed addition.

Foundation design includes foundation support of the proposed structure and its lowest level slab, treatment of the lowest level slab in consideration of groundwater, lateral earth pressures on foundation walls, and seismic design considerations in accordance with the provisions of the Eighth Edition of the Massachusetts State Building Code (Code). Foundation construction considerations are also presented herein.

Available Information

Information provided to McPhail Associates LLC (McPhail) included an existing conditions drawing entitled "Existing Conditions Plan, 16 Nason Hill Lane, Sherborn, Massachusetts" dated August 26, 2016 prepared by GLM Engineering Consultants, Inc. of Holliston, Massachusetts. Also provided to us was a set of 14 drawings designated 1.0 through 13.0 and VP-70, entitled "70' VP Structure", dated December 2012 and prepared by Calhoun Superstructure.

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Existing Conditions

Located at the east end of the cul-de-sac of Nason Hill Lane, the subject site is bounded by residential properties and/or moderately wooded areas on all sides. The approximate 11.3 acre site is currently improved with an 8,930 square-foot (plan area) single-family home, outdoor tennis courts, an in-ground pool and an approximate 1,200 square-foot (plan area) barn. In general, the ground surface across the improved portion of the site slopes downward from north to south from about Elevation +124 to +92 across a horizontal distance of about 420 feet. Across the proposed Equestrian Facility, the ground surface slopes downward from west to east from about Elevation +108 to about +91 across a horizontal distance of about 250 feet.

The existing site conditions are provided on the enclosed **Figure 2**, entitled "Subsurface Exploration Plan".

Elevations indicated herein are in feet and are referenced to the existing conditions plan referenced above.

Proposed Construction

The proposed equestrian facility will consist of a wood-framed building addition (barn addition) that will extend about 90 feet off the north side of the existing barn building and an approximate 70-foot by 216-foot steel-framed prefabricated riding arena off the east side of the barn addition. The lowest level of the barn addition will coincide with the lowest level of the existing barn building located at about Elevation +108. The lowest level within the riding arena will be located at about Elevation +98 and the north end of the riding arena will be benched into the sloping site. A ramp structure will be located at the northern end of the riding arena which will provide access from the barn addition down and onto the riding arena.

The floor of the barn addition will consist of a concrete floor slab and the floor within the riding area building will consist of a natural soil/gravel surface. No below grade space is planned as part of the proposed building additions.

Subsurface Exploration Program

On March 7, 2017, ten (10) machine-excavated test pits were conducted by Dooley Construction Company, Inc. of Waltham, Massachusetts, under contract to McPhail. Approximate locations of the test pits are as indicated on the enclosed Subsurface Exploration Plan, **Figure 2**.

The test pits were performed using a rubber-tired backhoe and were terminated at depths ranging from 5 to 7 feet below the existing ground surface within the natural glacial till deposit. Test pit logs prepared by McPhail are presented in **Appendix B**.

The explorations were monitored by personnel of McPhail who prepared field logs, obtained and visually classified soil samples, monitored groundwater conditions in the completed explorations, and determined the required depth of the explorations based upon actual subsurface conditions encountered.

Field locations of the test pits were determined by taping from existing site features and the existing ground surface elevation at each exploration location was determined by a level survey performed by our field staff utilizing vertical control information indicated on the existing conditions site plan referenced above.

Subsurface Conditions

A description of the subsurface conditions encountered in the explorations is documented on the test pit logs contained in **Appendix B**. Based on the explorations performed at the site, the following is a description of the generalized subsurface conditions encountered.

With the exception of test pit TP-8, the existing ground surface at the test pit locations was observed to be underlain by a topsoil layer the varied from about 0.5 to 1-foot in thickness. In general, the topsoil layer varied from a loose to compact dark brown to black, silty sand with some gravel containing roots. At test pit TP-8, the ground surface was observed to be underlain by an approximate 4-foot thick fill layer that varied from a compact to dense brown to red-brown silty sand with some gravel, to a sand with some silt and trace gravel. Based on our observations, the fill material observed within test pit TP-8 is considered to represent reworked glacial till.

Underling the topsoil and fill material, a natural glacial till deposit was encountered. In general, the glacial till was observed to vary from a compact to dense, light brown to red-brown to gray, silty sand with some gravel, to a sand and gravel with trace to some silt. Each of the test pit explorations were terminated within the glacial till deposit at depths ranging from about 5 to 7 feet below the existing ground surface.

Groundwater was observed within test pits TP-1, TP-2 and TP-9 at depths between 6 and 6.5 feet below ground surface, corresponding to levels ranging from about Elevation +83.7 to Elevation +87.0. It is anticipated that future groundwater levels across the site may vary from those reported herein due to factors such as normal seasonal changes, runoff particularly during or following periods of heavy precipitation, and alterations of existing drainage patterns or may become perched on the relatively impervious glacial till deposit.

Existing Foundation Conditions

Based on our observations from within test pit TP-1, the existing barn foundation consists of approximate 12-inch diameter concrete pier footings located at about 6 feet on-center. The concrete pier footing appear to be connected at the top with an approximate 1.1-foot thick concrete slab or beam located from about 0.6 to 1.7 feet below the existing ground surface.

The concrete pier footing encountered in test pit TP-1, extends about 4 feet below the existing ground surface and bears directly on the natural glacial till deposit.

Foundation Design Recommendations

Based upon the subsurface conditions encountered at the site, it is recommended that the proposed building additions be founded on conventional footing foundations bearing directly on the undisturbed, natural glacial till deposit or on compacted structural fill that is placed directly on the undisturbed natural glacial till deposit. The footings should be proportioned utilizing an allowable design bearing pressure of two (2) tons per square foot. It is recommended that wall footings have a minimum width of 2.5 feet, and that column footings have a minimum width of 3 feet. All foundations should be designed in accordance with the Code.

Following the removal of the topsoil layer, the surface of the glacial till deposit at the eastern end of the riding arena will be located below the proposed bottom of footing design elevation. Structural fill should be placed and compacted from the surface of the glacial till deposit up to the proposed design bottom of footing elevations. The lateral limits of placement of compacted structural fill should extend beyond the bottom perimeter edges of the footings, in all plan directions, a distance equal the thickness of the structural fill below the footing plus two feet.

All structural fill placed for support of the slab-on-grade and footings should be placed in maximum 6-inch lift thicknesses and be compacted to a minimum of 95 percent of its maximum Modified Proctor dry density.

Perimeter foundations and interior foundations below unheated areas should be provided with a minimum 4-foot thickness of soil cover as frost protection. Interior foundations below heated areas should be located such that the top of foundation concrete is a minimum of 6 inches below the underside of the lowest level slab.

All foundations should be located such that they are below a theoretical line drawn upward and outward at a 2 to 1 (horizontal to vertical) angle from the bottom exterior edge of all adjacent footings, structures and utilities. Proposed foundations located immediately adjacent to existing barn foundations should be founded at the same level as the existing foundations or a minimum of 4 feet below the existing ground surface whichever is deeper.

It is recommended that the lowest level slab located within the barn addition be designed as conventional soil-supported slab-on-grade which is poured over a minimum 6-inch thick layer of gravel fill. The gravel fill should consist of a well-graded sand and gravel from a naturally-occurring off-site source with less than eight percent passing the Number 200 sieve. The gravel fill should be installed over subgrade with has been proof compacted with a minimum of 6-passes of a vibratory compactor having a minimum operating weight of 5,000 pounds. All soft of weaving areas detected during the proof compaction process should be removed and replaced with compacted gravel fil.

It is understood that no floor slab will be constructed within the riding arena portion of the building addition, however, it is recommended that prior to the placement of the specified fill materials associated with the construction of the arena ground floor riding surface that the subgrade be proof compacted as indicated above.

No below grade space is planned as part of the proposed barn and riding arena building additions, however, portions of the northern end of the riding arena will be benched into the sloping site. Therefore, areas of the riding arena which are located below the adjacent exterior ground surface grades and below the finish floor level of the barn addition should be provided with perimeter foundation drainage to protect the riding arena from groundwater intrusion. The perimeter foundation drainage system should be installed along the north face of the foundation wall which separates the barn addition from the riding arena and continue down the east and west sides of the riding arena where the exterior ground surface is located above the surface of the riding arena. Furthermore, the exterior ground surface should be pitched downward and away from the proposed building additions to promote surface runoff away from the buildings.

The perimeter foundation drainage system should consist of a prefabricated drainage board which is installed onto the north face of the foundation wall which separates the barn addition from the riding arena and continue onto the exterior face of the east and west perimeter foundations of the riding arena where the exterior ground surface is located above the surface of the riding arena. The drainage board should extend from about 6 inches below the ground surface and tie into the 6-inch thickness of crushed stone which surrounds a 4-inch diameter perforated PVC pipe with its invert located about 12 inches below the surface of the riding arena. The crushed stone envelope which surrounds the perforated PVC pipe should be wrapped in a layer of nonwoven geotextile fabric such as Mirafi 140, or equal. The perimeter foundation drain pipe should drain by gravity into an onsite groundwater recharge system or to daylight at an on-site location designed by the project Civil Engineer. As an alternative to the perimeter foundation drainage system described herein, the perimeter walls referenced above could be waterproofed. The waterproofing should consist of a sheet applied membrane which is installed by an authorized installer of the waterproofing materials.

Lateral forces can be transmitted from the structure to the soil by passive pressure on the footings utilizing an equivalent fluid density of 120 pounds per cubic foot providing that these structural elements are designed to resist these pressures. Lateral forces can also be considered to be transmitted from the structure to the soil by friction on the base of the footings using a frictional coefficient of 0.5 to which a factor of safety of 1.5 should be applied. Due to the lateral loading associated with the riding arena structure, perimeter below grade foundation walls which tie into the perimeter footings may be required to for transmitting the lateral building loads from the structure into the soil.

Below-grade foundation walls receiving lateral support at the top and bottom (i.e. restrained walls) should be designed for a lateral earth pressure corresponding to an equivalent fluid density of 60 pounds per cubic-foot (pcf). Cantilevered site retaining walls should be designed utilizing a lateral earth pressure corresponding to an equivalent fluid density of 40

pcf. To these values must be added the pressures attributable to earthquake forces per Section 1610.2 of the Code and any applicable surcharges from adjacent structures. The cantilevered walls should also be backfilled with free-draining gravel fill and be provided with a drain line or weep holes to preclude hydrostatic pressures from acting on the walls.

Should the waterproofing alternative of the foundation walls be utilized, the waterproofed perimeter foundation walls should be designed utilizing a lateral earth pressure corresponding to an equivalent fluid density of 90 pcf up to a design groundwater elevation corresponding the exterior ground surface along the east and west perimeter foundation walls, and up to Elevation +108 along the foundation wall which separates the barn addition from the riding arena.

Seismic Design Considerations

For the purposes of determining parameters for structural seismic design, this site is considered to be a Site Class C as defined in Section 1613 of the Code. Furthermore, the bearing strata on the proposed site is not considered to be subject to liquefaction during an earthquake based on the criterion of Section 1806.4 of the Code.

Foundation Construction Considerations

The primary construction considerations include preparation of the building addition pads and foundation bearing surfaces, reuse of onsite soil and backfiling, construction dewatering, and off-site disposal of excess excavated soil.

Preparation of Building Pad and Footing Bearing Surfaces

All surficial topsoil and fill material should be removed from the footprints of the proposed barn and riding arena additions. The final excavation of the footing bearing surfaces should be accomplished using an excavator that is equipped with smooth-edged bucket to avoid disturbance of the bearing surface. Further, it is recommended that as soon as footing bearing surface is exposed, it be immediately covered with a minimum 3-inch thickness of compacted 3/4-inch crushed stone to prevent disturbance of the subgrade during subsequent forming operations and construction traffic.

Reuse of On-Site Excavated Material and Backfilling

The on-site excavated glacial till material is considered suitable for use as structural fill for support of the proposed footings and where needed to raise the grades within the riding arena building footprint provided that all oversized material (cobbles and boulders) greater than 6 inches are culled out. It is also noted that the glacial till material contains a relatively high percentage of silt and therefore cannot be compacted when it becomes too wet. Hence, it is recommended that all stockpiles of excavated glacial till material intended for reuse be protected against increases in moisture content by securely covering the

stockpiles prior to and during precipitation events. Topsoil is not considered suitable for reuse as structural fill and should be kept segregated from the glacial till soil at all times.

Where the new barn addition foundations abut the existing barn building there is the potential for soil loss from below the concrete slab which is located across the tops of the concrete pier footings. In areas where soil loss is observed, it is recommended that the void space below the concrete slab referenced above be replaced with excavatable flowable fill up to the underside of the concrete slab.

Construction Dewatering

Based on the soil and groundwater conditions encountered in the subsurface explorations, it is not anticipated that groundwater will be encountered during excavation for building subgrades. Should water accumulate during periods of heavy precipitation, it is anticipated that it will be able to be controlled using conventional sumping. Pumped groundwater should be recharged on site.

Off-Site Disposal of Excess Soil

Current Massachusetts Department of Environmental Protection (MA DEP) policies and regulations for off-site disposal of excess excavated soil require environmental characterization of the excess excavated soil prior to its off-site disposal. Based on the premium cost associated with chemical testing and off-site disposal of soil, it is recommended that excess soil be reused on-site to the fullest extent possible.

Final Comments

It is recommended that McPhail be retained to provide design assistance to the design team during the final design phase of this project. The purpose of this involvement would be to review the structural foundation drawings and foundation notes for conformance with the recommendations presented herein and to prepare the earthwork specification section for inclusion into the Contract Documents for construction.

It is recommended that McPhail be retained during the construction period to observe final preparation of the foundation bearing surfaces and to monitor placement and compaction of fill materials in accordance with the provisions of the Code and the provisions of the Contract Documents. Our involvement during the construction phase of the work should minimize costly delays due to unanticipated field problems since our field engineer would be under the direct supervision of our project manager who was responsible for the subsurface exploration program and foundation design recommendations documented herein.

We trust that the above is sufficient for your present requirements. Should you have any questions concerning the foundation design recommendations presented herein, please do not hesitate to call us.

Very truly yours,

McPHAIL ASSOCIATES, LLC

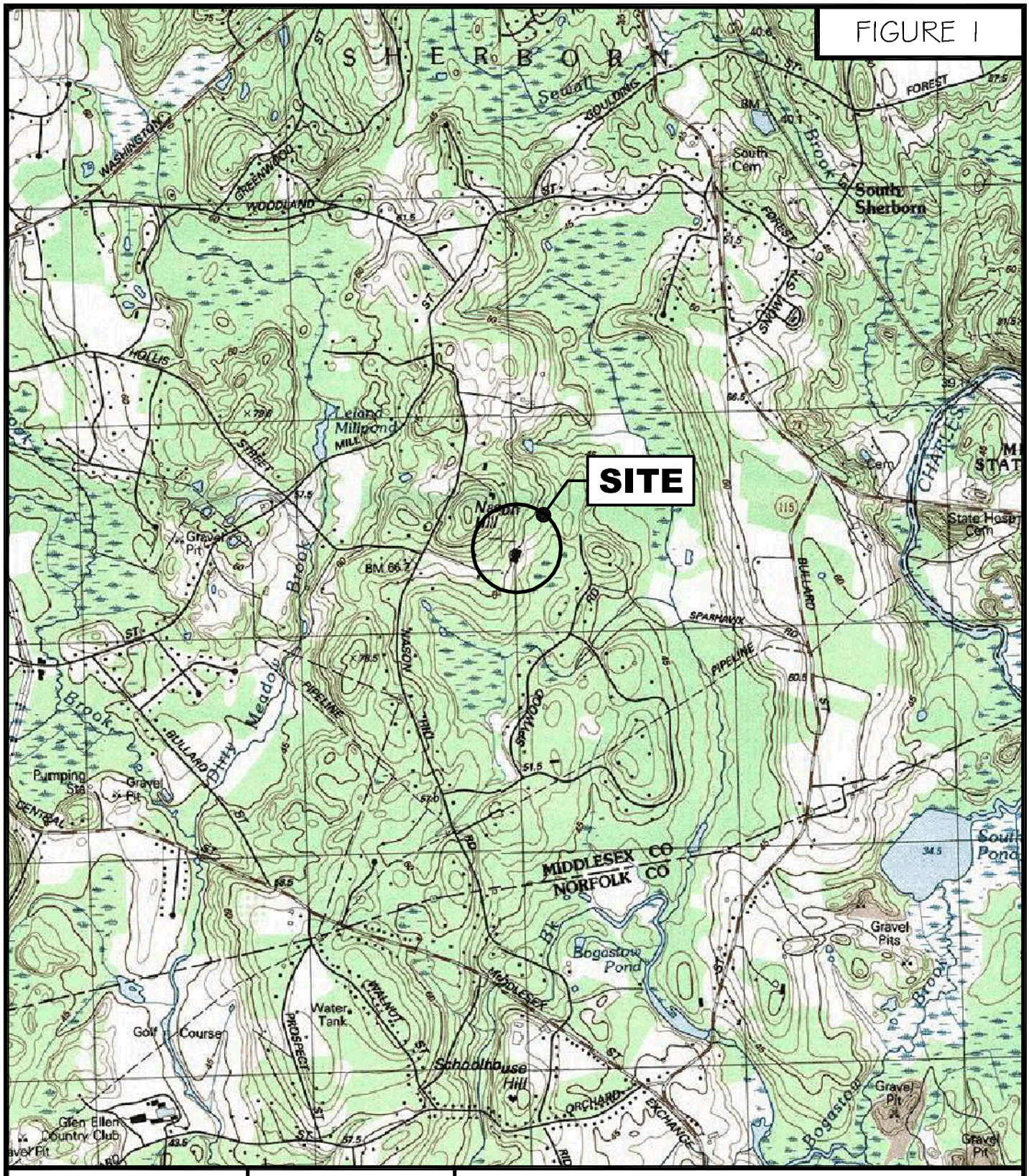
Harry J. Berlis

Jonathan W. Patch, P.E.

N:\Working Documents\Reports\6351-F_032417.docx

HJB/jwp

FIGURE 1



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SCALE 1:25,000

PROJECT LOCATION PLAN

16 NASON HILL LANE

SHERBORN MASSACHUSETTS

FIGURE 2

NORTH

LEGEND

— APPROXIMATE LOCATION OF TEST PIT PERFORMED BY DOOLEY CONSTRUCTION, INC. ON MARCH 7, 2017 FOR MCPHAIL ASSOCIATES, LLC

REFERENCE: THIS PLAN WAS PREPARED FROM A 40-SCALE DRAWING ENTITLED, "EXISTING CONDITIONS PLAN' DATED AUGUST 26, 2016 PREPARED BY GLM ENGINEERING CONSULTANTS, INC.

APPROXIMATE LIMITS OF PROPOSED BUILDING

TP-1 TP-2 TP-3 TP-4 TP-5 TP-6 TP-7 TP-8 TP-9 TP-10

LL SLAB EL.+108±

LL EL.+98±

EXISTING DWELLING #16 T.C.=101.42

BARN

PATIO

DECK

INGROUND POOL

POOL HOUSE

TENNIS COURT

LAWN

BLUESTONE

STONE WALL

CONC.

GRAVEL

5' WALK

RET. WALL

BENCHMARK COR. STONE STEP ELEV.=95.32

100' WETLAND BUFFER

50' WETLAND BUFFER

B.V.W.

S43°49'03"W 166.52'

S55°27'01"W 71.54'

S19°54'04"W 25.14'

S29°25'21"W 80.47'

S28°57'14"W 60.19'

S31°20'39"W 38.76'

S36°08'46"W 209.12'

S55°56'34"E 70.14'

S71°30'27"E 22.04'

S59°19'07"E 206.77'

S53°25'33"E 79.82'

S68°01'39"E 50.38'

S57°04'13"E 78.18'

S35°46'18"E

S35°55'E 111.83'

GRAPHIC SCALE

60 0 60 120

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16 NASON HILL LANE

SHERBORN MASSACHUSETTS

SUBSURFACE EXPLORATION PLAN

FOR

MR. MICHAEL NEWMAN

BY

McPHAIL ASSOCIATES, LLC

Date: MARCH 2017	Dwn: M.B.S.	Chkd: H.J.B.	Scale: 1" = 60'
Project No: 6351			

FILE NAME: N:\Acad\JOBS\6351\6351-F02.dwg

APPENDIX A:

LIMITATIONS

LIMITATIONS

This report has been prepared on behalf of and for the exclusive use of Mr. Michael Newman for specific application to the proposed equestrian facility to be located at 16 Nason Hill Lane in Sherborn, Massachusetts in accordance with generally accepted soil and geotechnical engineering practices. No other warranty, expressed or implied, is made.

In the event that any changes in nature or design of the proposed construction are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by McPhail Associates.

The analyses and recommendations presented in this report are based upon the data obtained from the subsurface explorations performed at the approximate locations indicated on the enclosed plan. If variations in the nature and extent of subsurface conditions between the widely spaced explorations become evident during the course of construction, it will be necessary for a re-evaluation of the recommendations of this report to be made after performing on-site observations during the construction period and noting the characteristics of any variations.

APPENDIX B:

MCPHAIL ASSOCIATES, LLC

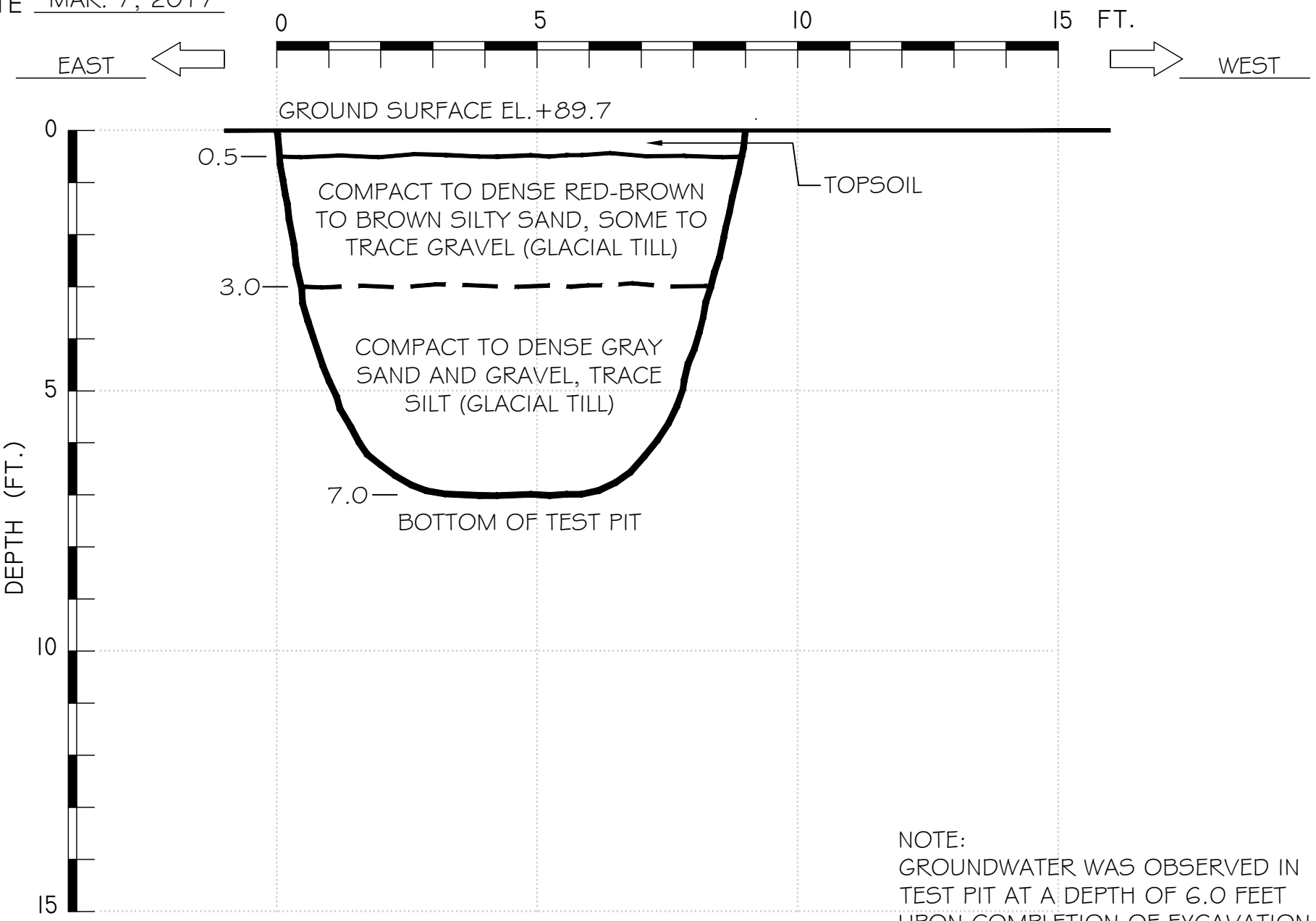
TEST PIT LOGS
TP-1 THROUGH TP-10

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 1



McPHAIL ASSOCIATES, LLC

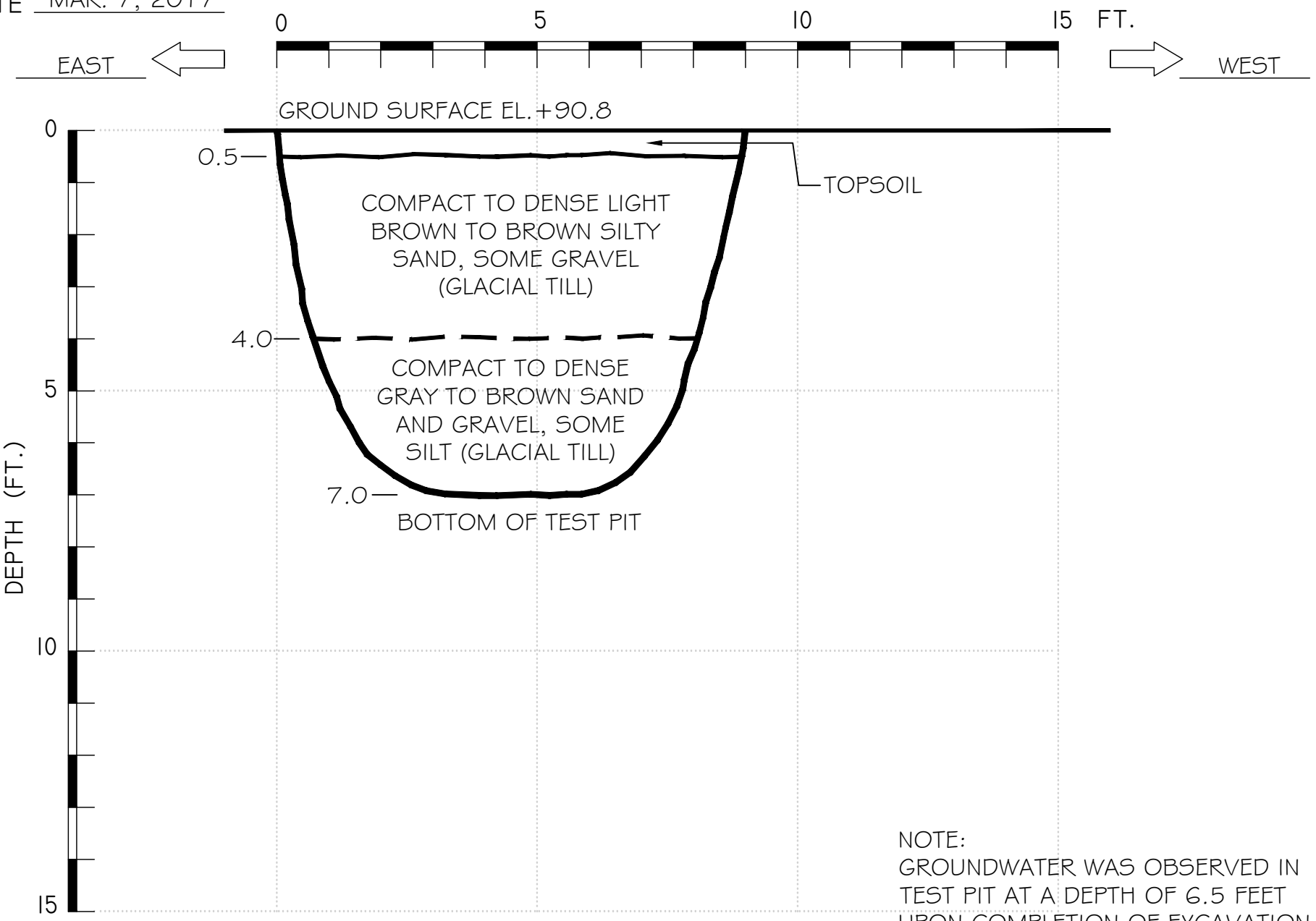
NOTE:
GROUNDWATER WAS OBSERVED IN TEST PIT AT A DEPTH OF 6.0 FEET UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 2



McPHAIL ASSOCIATES, LLC

NOTE:
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JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

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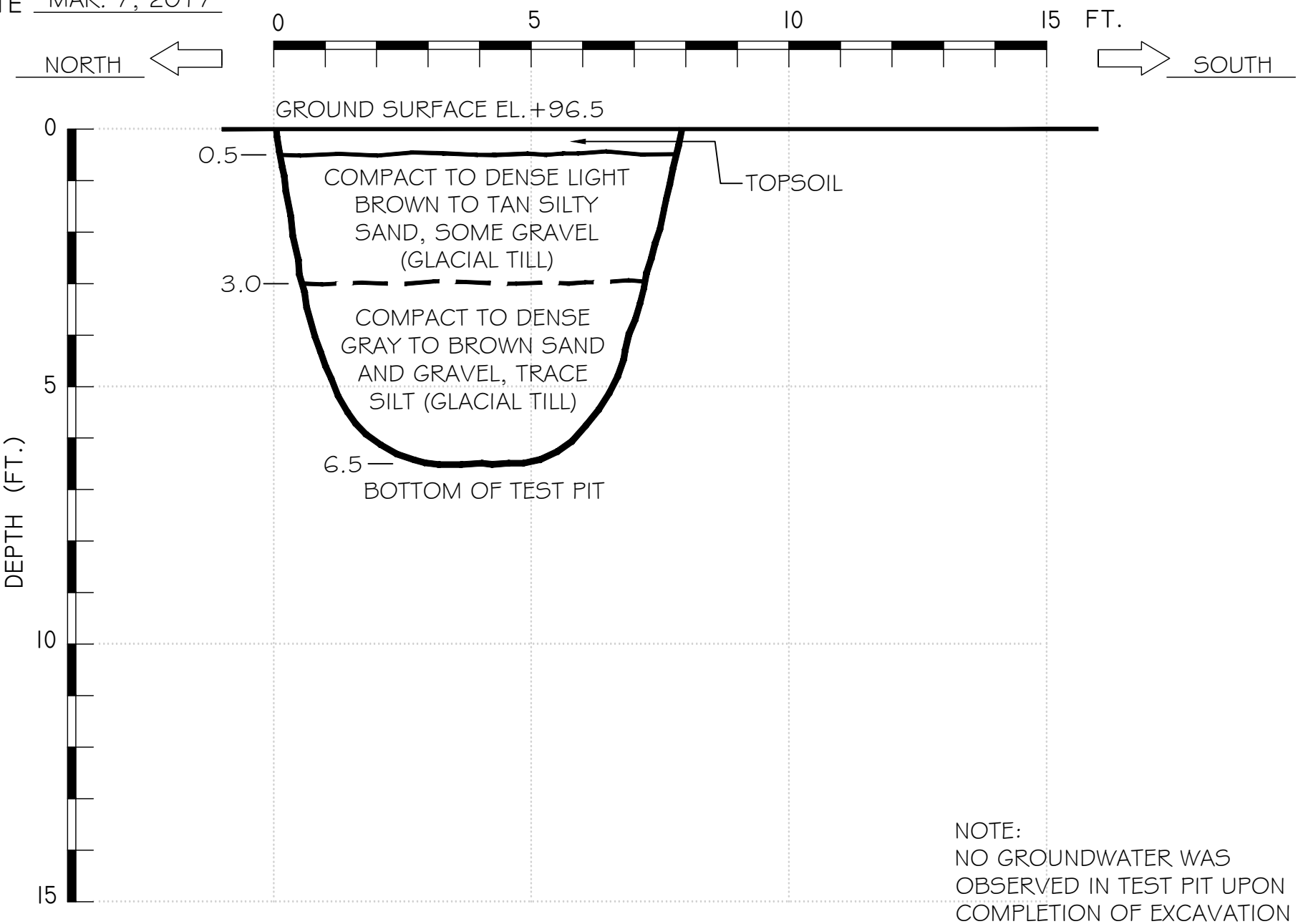

McPHAIL ASSOCIATES, LLC

NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

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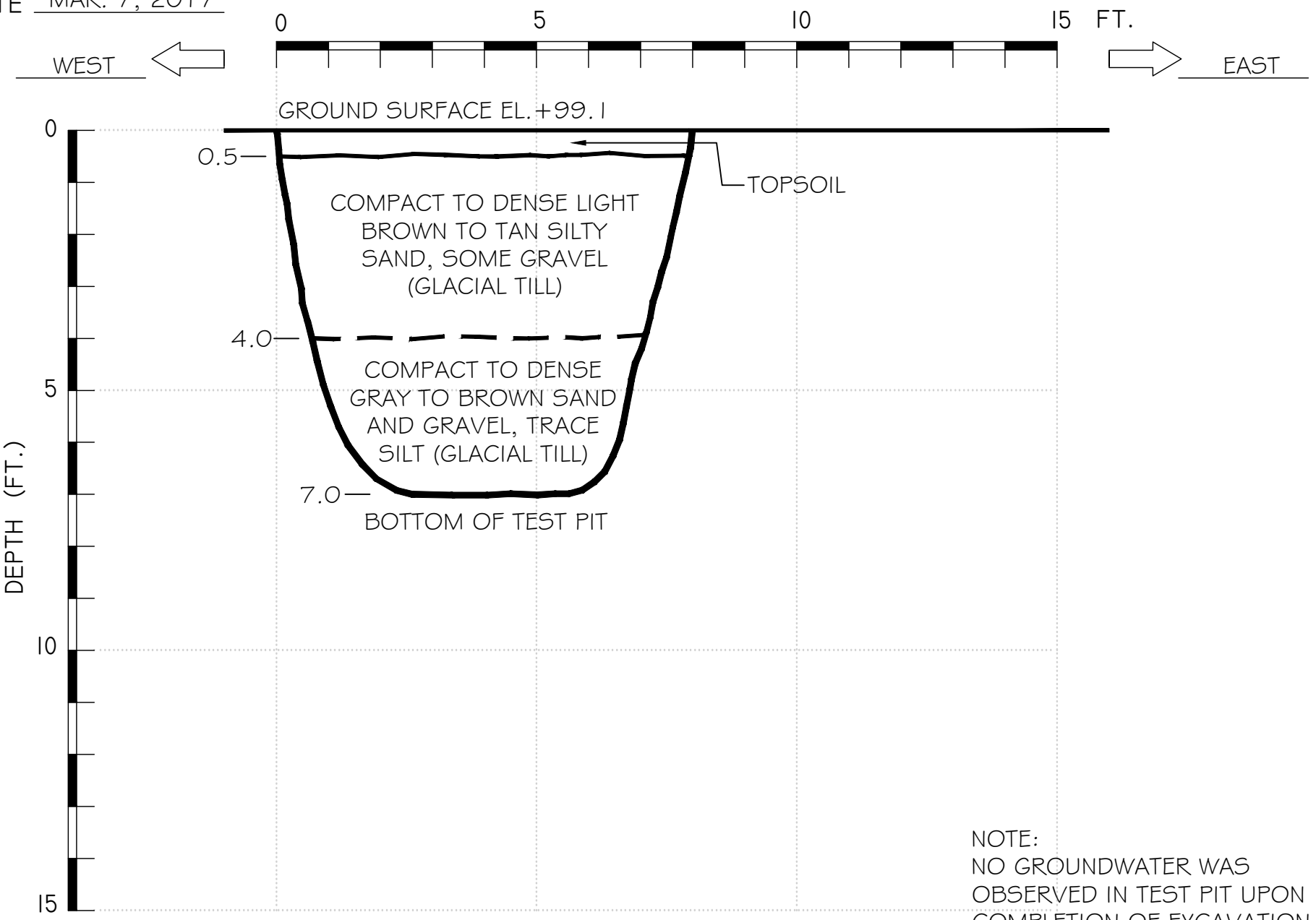

McPHAIL ASSOCIATES, LLC

NOTE:
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JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

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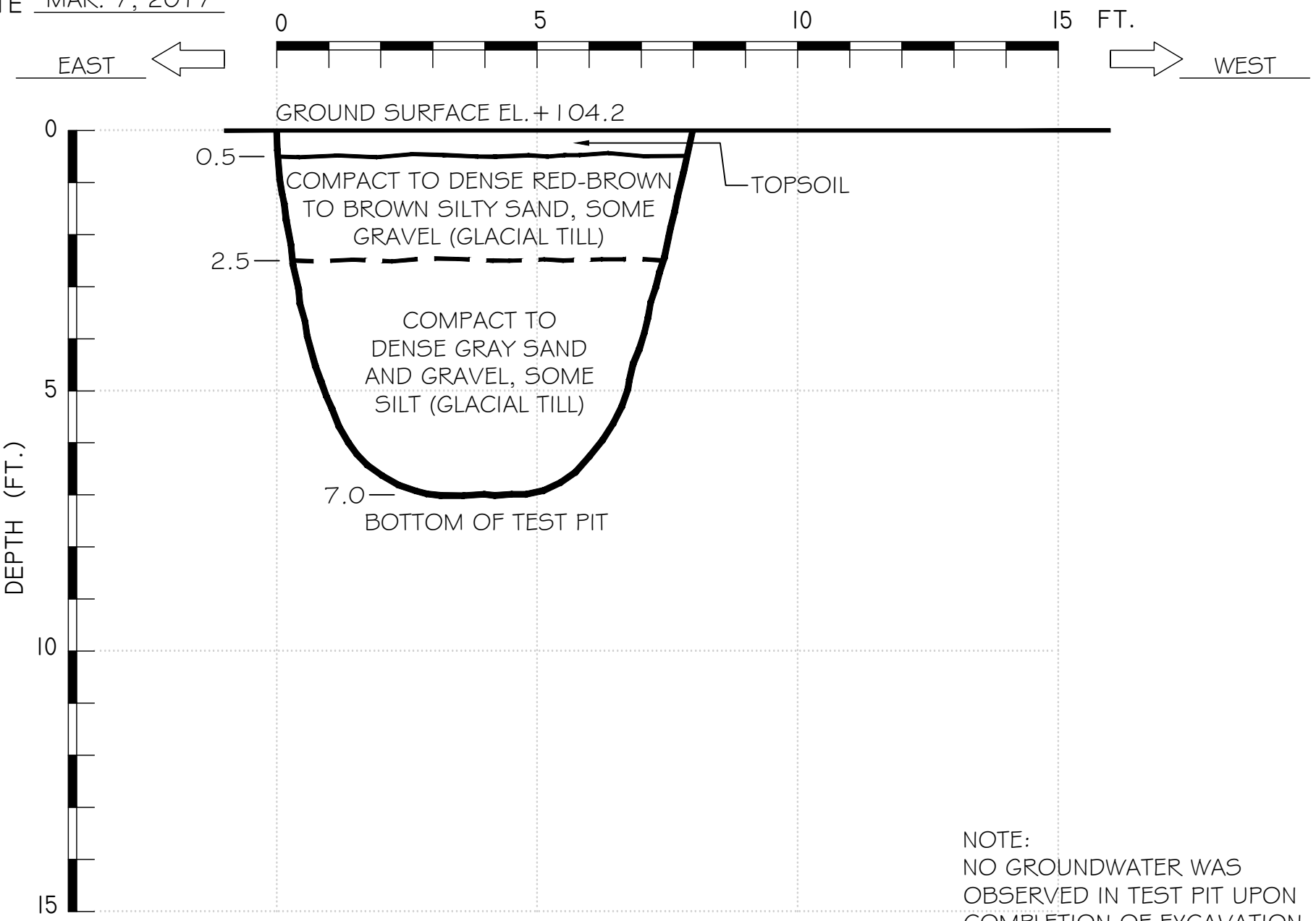


McPHAIL ASSOCIATES, LLC

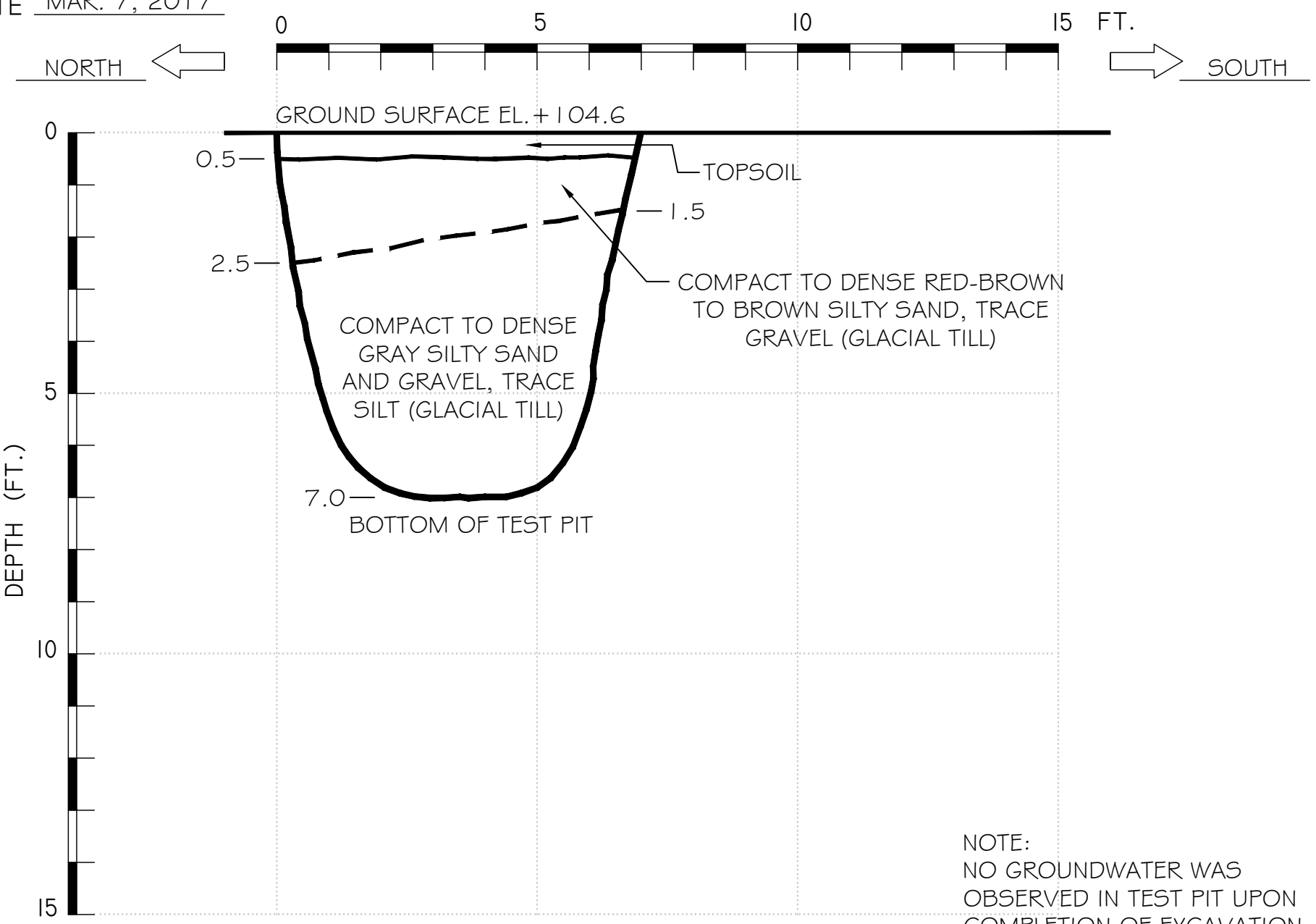
NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 6



McPHAIL ASSOCIATES, LLC

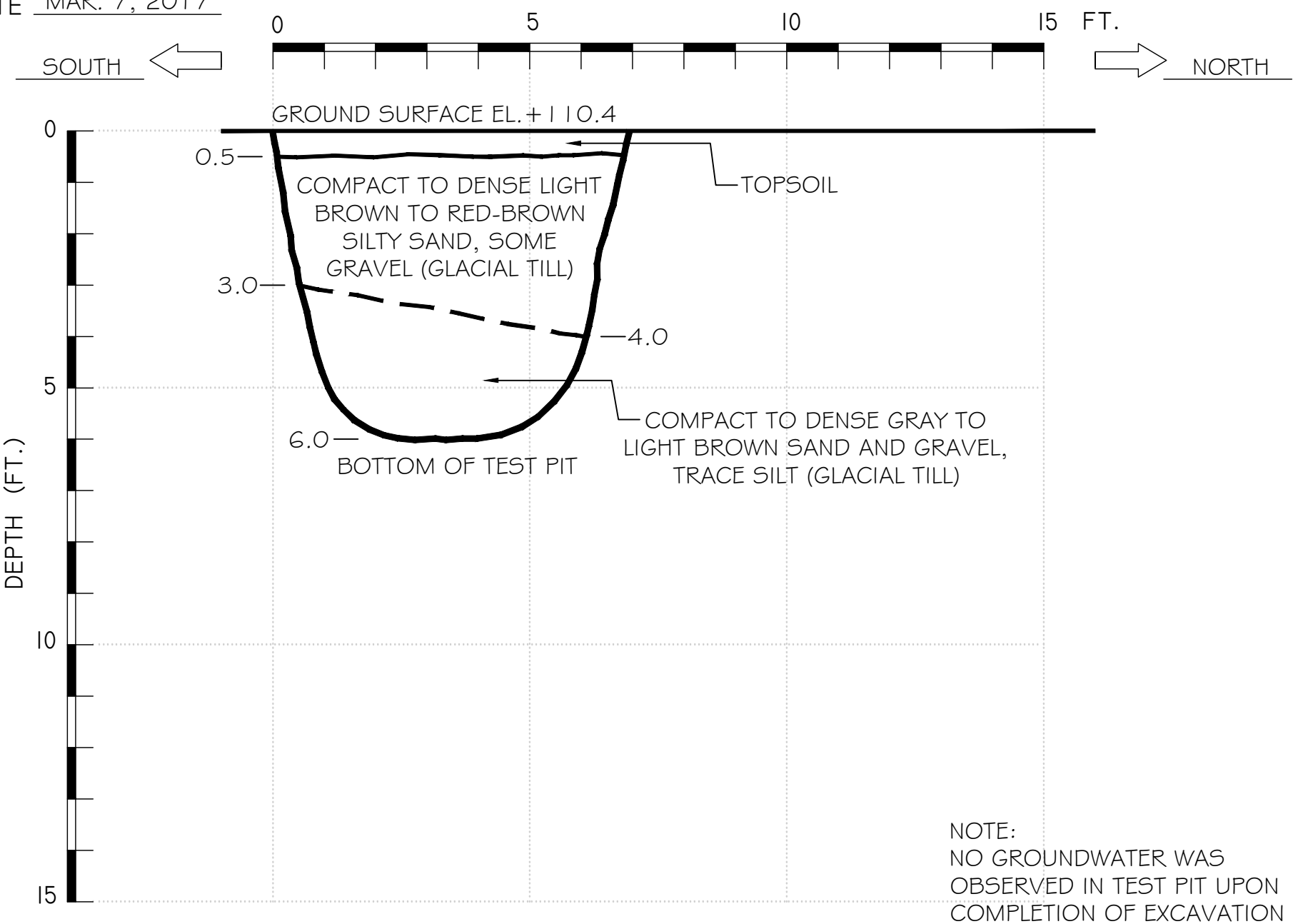
NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 7



McPHAIL ASSOCIATES, LLC

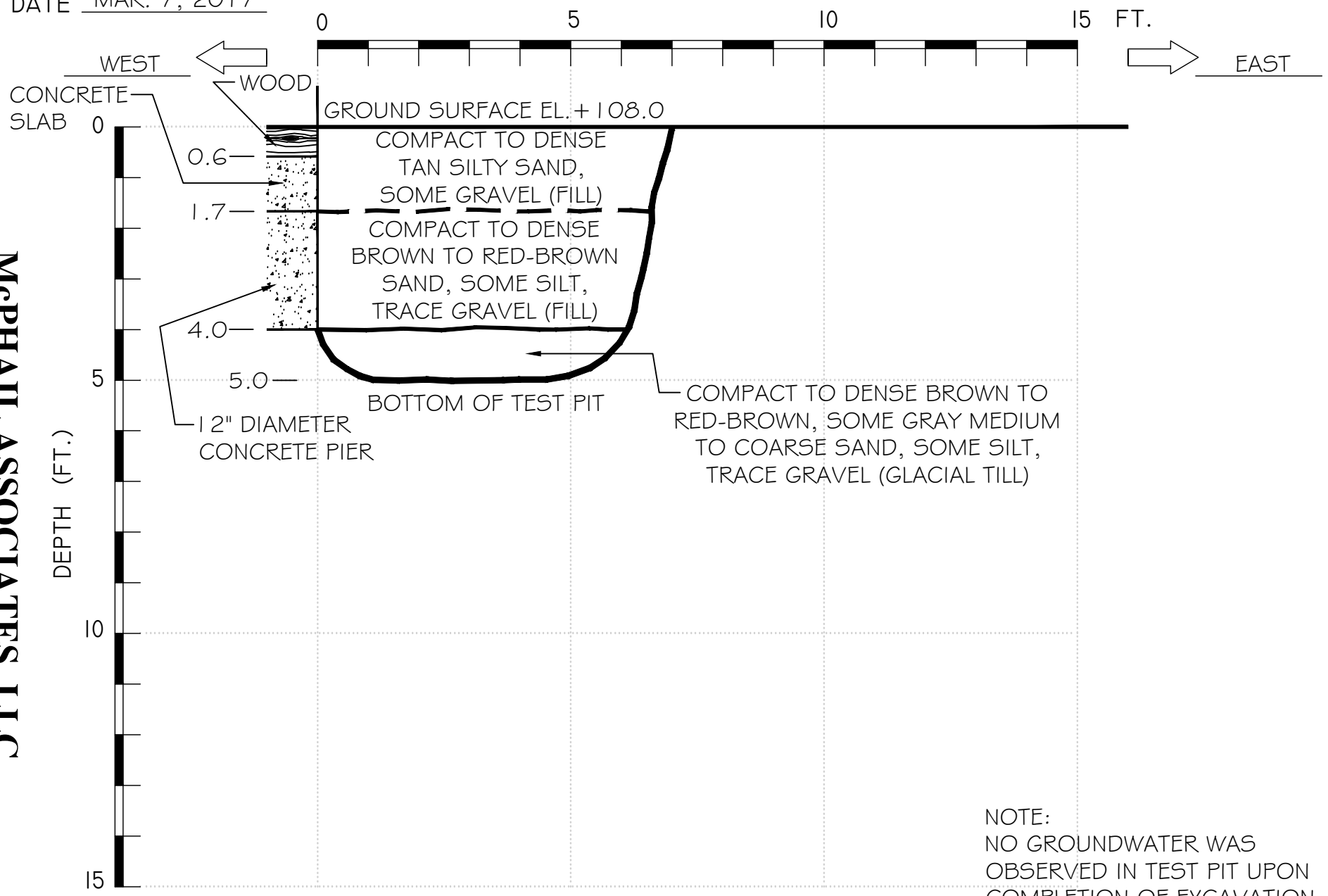
NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 8



McPHAIL ASSOCIATES, LLC

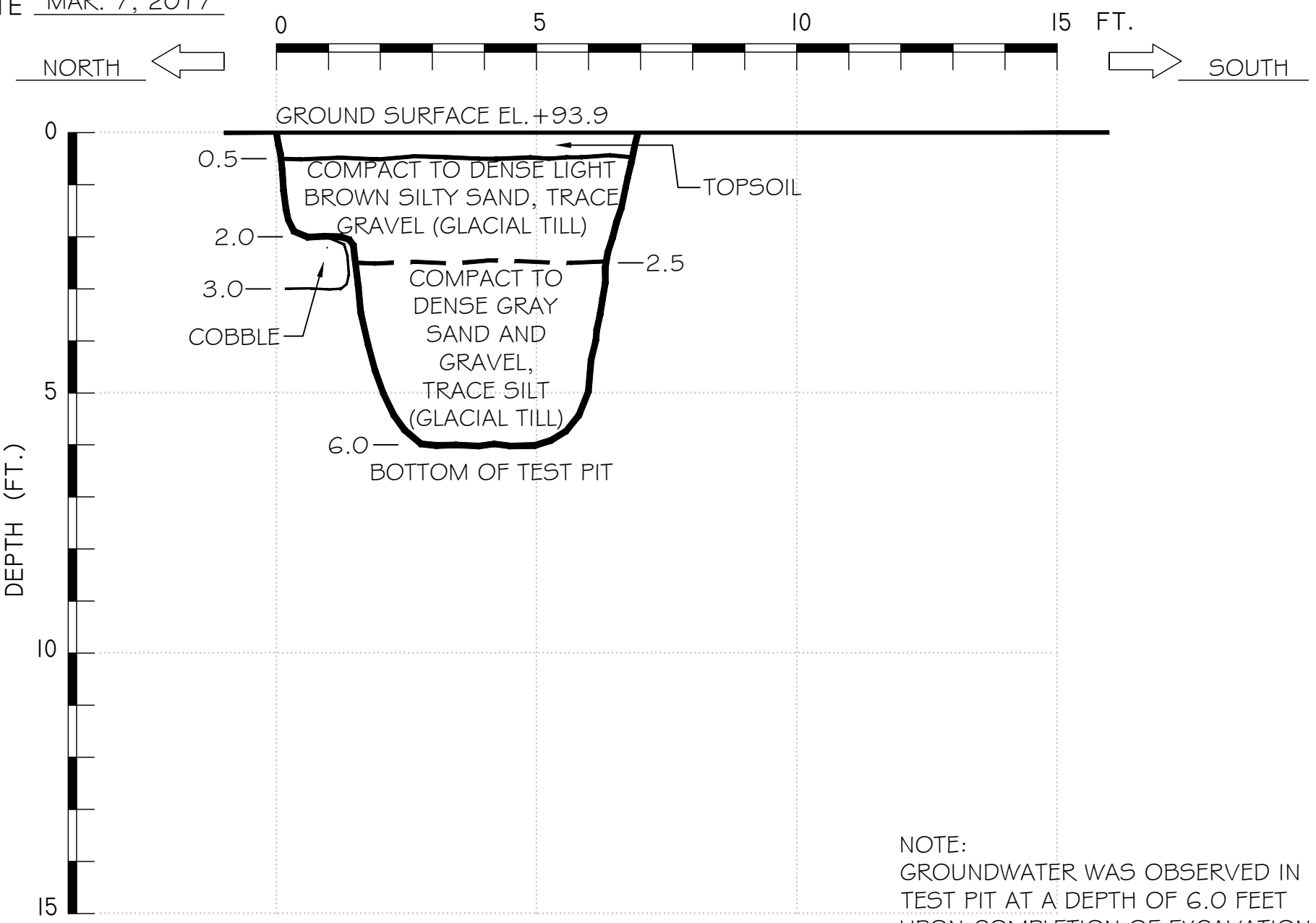
NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 9



McPHAIL ASSOCIATES, LLC

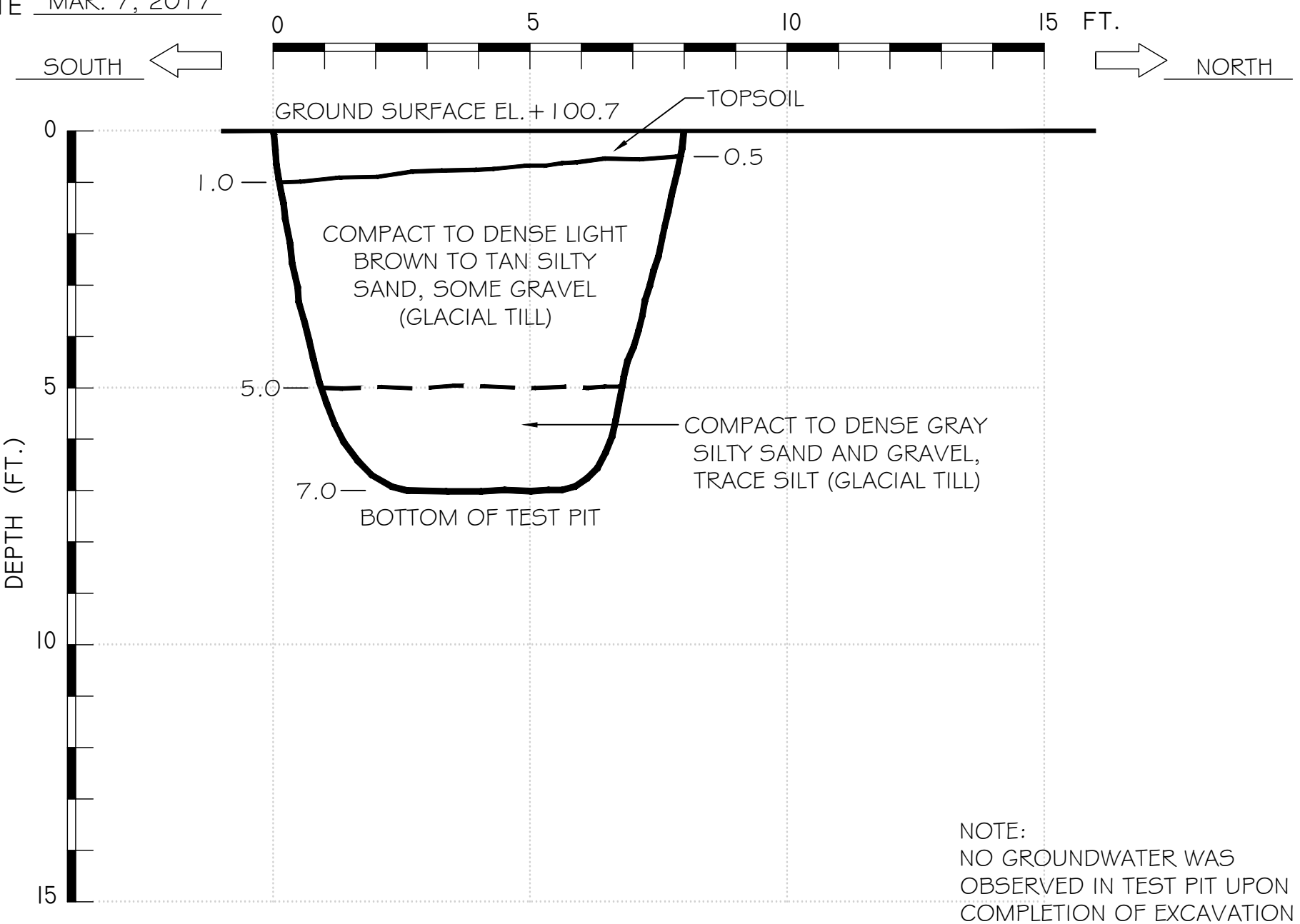
NOTE:
GROUNDWATER WAS OBSERVED IN TEST PIT AT A DEPTH OF 6.0 FEET UPON COMPLETION OF EXCAVATION

JOB NO. 6351

DATE MAR. 7, 2017

TEST PIT LOG

TEST PIT NO. 10



McPHAIL ASSOCIATES, LLC

NOTE:
NO GROUNDWATER WAS OBSERVED IN TEST PIT UPON COMPLETION OF EXCAVATION