Hydrogeologic Report:
Groundwater Mounding Analysis for Proposed Subsurface Disposal System

Site:
Proposed Cascade Development
115 Boston Post Road
Wayland, MA

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EXECUTIVE SUMMARY

This *Hydrogeological Report: Groundwater Mounding Analysis for Proposed Subsurface Disposal System at Cascade Development in Wayland, MA* summarizes the results of hydrogeologic field investigations and two-dimensional groundwater mounding analyses conducted in support of a proposed subsurface disposal system at Cascade Development, Wayland, Massachusetts.

1.0 INTRODUCTION

Geosphere Environmental Management, Inc. (GEOSPHERE) is pleased to submit this Hydrogeological Investigation Report on behalf of Eden Management, Inc., to predict and assess the impacts of a proposed subsurface domestic wastewater disposal system in conjunction with the redevelopment of the former Mahoney Garden Center property located 113 - 119 Boston Post Road, Wayland, Massachusetts. The property is currently occupied by the former buildings of the Garden Center and a separate residential dwelling. A multi-family redevelopment project is proposed.

The proposed disposal system will consist of two leach fields, LF1 and LF2. The design flow for the proposed disposal system is 9,813 gallons per day (gpd) in accordance with Massachusetts Environmental Code Title 5.

This report summarizes the field investigation conducted to collect hydrogeological data in support of a two-dimensional groundwater computer model, developed and calibrated for the site.

The hydrogeologic assessment included: an evaluation of subsurface information collected from test pit excavations (percolation rates, depths to mottling and/or groundwater); installation of groundwater monitoring wells and advancement of soil test borings; review of published geologic information pertinent to the site and area; laboratory permeability testing and sieve analysis of selected soil samples from test borings, and establishing an estimated seasonal high groundwater elevation table (ESHGW) for the site.

Once these pertinent hydrogeologic parameters were identified, a 2-dimensional groundwater flow model was developed to predict potential impacts of the proposed subsurface wastewater disposal system (SSDS) on both ground and surface water, as required by Section L of the Wayland Board of Health regulations for septic systems; including the prediction of groundwater mounding heights during estimated seasonal high groundwater (ESHGW) conditions.

2.0 SITE DESCRIPTION

The 6.4 acre site lies south of Boston Post Road, east of the intersection with Pine Brook Road, see **Figure 1**. The site is bisected by Pine Brook, which flows west, toward the Sudbury River. The portion of the property that is subject to this hydrogeologic study abuts Boston Post Road (Route 20) and lies to the north of Pine Brook, see **Figure 2**. The area of the property south of Pine Brook is undeveloped, and will remain so under the Cascade proposal.

The site is comprised of two adjoining lots, Wayland Assessor's Map 30, Lots 70 and 71. The easternmost parcel is a 1.265 acre lot (Map 30, Lot 70) currently occupied by a two-story wood framed private residence and two-story barn. The buildings are located in the northeastern part of the site. The western parcel is a 5.217 acre lot (Map 30, Lot 71) currently occupied by buildings that previously served as the garden center's retail showroom and green houses. Existing utilities at the site include publicly-supplied subsurface water lines, overhead electricity and subsurface natural gas. On-site septic leach fields served the former garden center and residence. An on-site irrigation well served the garden center since 2003.

A multi-family residential development is planned for the site. The redevelopment project proposes disposing of domestic wastewater in two on-site leach fields, LF1 and LF2, to be located in the central-east portion of the site. The two proposed leach fields will encompass approximately 0.46 acre, and are located approximately 120 feet north Pine Brook, as shown on **Figure 3**. Pine Brook is classified as a MA DEP cold water fishery headwater which flows westerly toward the Sudbury River.

3.0 SITE TOPOGRAPHY

The site topography generally slopes gently from east to west. Ground elevations in this area range between 180 and 148 feet NAVD88. Topography across the proposed LF1 and LF2 area also slopes from east to west, with an elevation change of approximately 10 feet, see **Figure 3**.

4.0 SUBSURFACE INVESTIGATION

4.1 Test Pit Excavations

In December 2016, January 2017, and November 2017, Onsite Engineering of Franklin, MA and a representative from the Town of Wayland Board of Health supervised the excavation of a series of 29 exploratory test pits on site. These test pits were performed to obtain subsurface soil and hydrologic information; specifically, to measure soil percolation rates for the SSDS design. The locations of all test pits completed at the site are depicted on **Figure 3.**

The ground elevation, redoximorphic ("mottling") depth and elevation, and total depth of each of the test pits are summarized in **Table 1**. Logs of 23 test pits (OSE-TP-1 through OSE TP-23) are documented on DEP Form 11, which can be found in **Appendix A** of this report. Six test pits (TP-1A, 1B, TP-2 through TP-5) were exploratory and were not formally documented. Percolation test results including date completed, total depth, percolation test results, and permeability test results are documented on DEP Form 12, which can also be found in **Appendix A** of this report.

4.2 Soil Borings and Observation/Monitoring Well Installation

In order to gain more information about the subsurface soils, on November 29, 2017 GEOSPHERE supervised the advancement of nine (9) soil borings at the site. The location of the soil borings and subsequent monitoring wells were reviewed and approved by the Wayland Board of Health. Seven of these soil borings were converted into permanent groundwater monitoring wells. The borings were drilled and monitoring wells were installed by Crawford Drilling Services of Westminster, Massachusetts using direct push/GeoProbe equipment. As a result of difficulty advancing the GeoProbe equipment at B-3, Crawford returned to the site with a hollow stem auger drill rig to complete that borehole and monitoring well. Boring logs can be found in **Appendix B**. The locations of the soil borings and wells completed on site are shown on **Figure 2** and **Figure 3**.

GEOSPHERE's on-site geologist visually characterized soil samples and selected nine representative samples to be submitted for sieve testing (particle size distribution analysis) and hydraulic permeability analysis by GeoTesting Express of Acton, MA. A summary of sample IDs, depths, and permeability test results can be found in **Table 2**. Lab reports for all soil samples submitted for permeability and grain size analysis can be found in **Appendix C**. Refusal in dense silt was encountered at 12 to 22 feet below ground surface (bgs). Locations, ground surface elevations, groundwater elevations, and refusal elevations for each boring are summarized in **Table 3**.

Five of the soil borings were completed as groundwater monitoring wells using 2-inch diameter PVC slotted screen and riser. Monitoring wells MW-1, MW-3, MW-4, MW-5 and MW-7 were installed in test borings B-1, B-3, B-4, B-5 and B-7, respectively.

4.3 Site Stratigraphy and Hydrogeologic Characterization

During monitoring well installation activities, soil samples were collected and visually characterized by a GEOSPHERE geologist. At the completion of the drilling program, boring logs and well installation diagrams were prepared based on the visual soil descriptions. Boring logs can be found in **Appendix B**.

The subsurface materials encountered in the boreholes were described as 7 to 20 ft. of sand and gravel. A layer of very compact, cohesive silt was encountered below the sand and gravel at borings in the eastern portion of the site, at B-1, B-3, B-4, B-5 and B-6. The top of the silt unit was encountered at elevations between 156 and 160 ft. NAV88. Each of the borings was advanced until conditions became too dense for the equipment to advance, referred to here as 'refusal'. The thickness of the silt layer was not penetrated by the GeoProbe at any of the borings. Bedrock was not encountered in any of the borings. The silt unit was not identified at test boring B-2 or B-9, located in the northeastern portion of the site; these borings encountered refusal prior to reaching the elevation (156 ft.) at which silt was encountered at B-1. The homogeneous silt unit encountered in the eastern portion of the site was not encountered at B-7, in the western portion of the site; which met refusal at 146 ft. The dense sandy silt and gravel encountered at the bottom of B-8 at 142.6 ft. was conservatively modeled as the lower transmissivity silt unit observed elsewhere; see Soil Boring Logs in **Appendix B.**

A 2003 well drillers log, completed by TJ Ogden, Inc. when an irrigation well was installed at the garden center, in the area of OSE-TP-14, reports that silt was encountered to a depth of about 20 ft. bgs, and was underlain by bedrock at 20 ft. bgs, see **Appendix B**.

This data was extrapolated to construct a groundwater mounding model (described below) which presumes a dense silt unit of very low transmissivity separates bedrock and the unconsolidated sand & gravel deposit across the site. For a summary of lithology encountered during test borings, see **Table 4.**

5.0 GROUNDWATER FLOW

The depth to groundwater was measured in each of the monitoring wells by GEOSPHERE on December 12, 2017. Groundwater levels were observed to range from 3.2 ft. bgs at MW-6 to 9.50 ft. bgs at MW-3. Water levels were further collected on two additional dates: on March 21, 2018 and April 6, 2018. The highest water levels were observed in April, ranging from 1.65 ft. bgs in MW-4 to 4.30 ft. bgs in MW-3.

Top of casing and ground elevations at monitoring wells were surveyed by Beals and Thomas, Inc. of Southborough, MA in feet relative to North American Vertical Datum of 1988 (NAVD88). Using these elevations, depth to groundwater measurements collected on April 4, 2018 were converted to groundwater elevation data and groundwater contours are plotted on **Figure 4**. As shown on **Figure 4**, groundwater measurements indicate flow in a westerly direction in the overburden aquifer under a relatively uniform hydraulic gradient of 0.028, measured between MW-3 and MW-7 (an elevation change of 14.33 feet over a distance of 520 feet).

6.0 ESTIMATED SEASONAL HIGH GROUNDWATER CONDITIONS

Groundwater table elevations at each of the on-site monitoring wells were measured three times between December 2017 and April 2018 by GEOSPHERE. The depth to groundwater measurements and groundwater elevation calculations were integrated with data from soil borings and test pit observations to construct a two-dimensional, finite difference (MODFLOW) computer model, described in further detail below. Technical details of the groundwater model are included in **Appendix D.**

The model was constructed to predict groundwater elevations during seasonal high water table conditions under the influence of the proposed wastewater discharge. The highest of the three sets of groundwater level elevations, collected in April 2018, was used to calibrate the model to simulate seasonal high groundwater table conditions.

A simulated Estimated Seasonal High Groundwater (ESHGW) Contour Map, **Figure 5** (and **Appendix D**, **Figure 5)** representing the observed ESHGW elevation was produced by the model for the study area. The map depicts a groundwater table that exceeds GEOSPHERE's observed estimated seasonal high groundwater elevations at the area of LF1, near B-4, and along the western model boundary.

7.0 NUMERICAL MODELING USING MODFLOW

A two-dimensional groundwater model was developed on the MODFLOW platform using the groundwater and subsurface data collected at the site. The model was designed to:

- Estimate seasonal high groundwater (ESHGW);
- Predict the effects of the proposed subsurface disposal system on groundwater height (i.e., "90-day mound height") during seasonal high groundwater conditions;
- Evaluate the potential for breakout;
- Estimate flow path direction, and;
- Assess the potential effects of the proposed Cascade SSDS on Pine Brook.

Initially, soil redoximorphic ("mottling") elevations measured in the test pit were used to calibrate the model for ESHGW elevation. However, actual groundwater table data collected in April 2018 were *higher* than the test pit mottling observations. Therefore, the model was re-calibrated to affect the simulated ESHGW elevations to *meet or exceed nearly all of the observed elevations from both sets of data*, see Summary Table of ESHGW Values in **Appendix D**.

This is considered a conservative method of predicting simulated ESHGW conditions for the site. It does not assume an estimated SSDS discharge superimposed over ambient groundwater conditions, but instead integrates field data collected during seasonal high groundwater conditions.

Simulated ESHGW

The calibrated model resulted in simulated ESHGW in the LF1 area near B-4/MW-4 to be 0.99 ft. higher than the measured groundwater table at B-4/MW-4 in April 2018. Simulated ESHGW levels at the along the western boundary of the model are 1 to 5 feet higher than ground surface elevations, as shown in **Figure 5** of **Appendix D**. However, with only information from B-7 for support, insufficient data was available to define that boundary more precisely; the general head boundary values of the model were set to be higher than necessary in the immediate vicinity of the stream. This resulted in a significantly higher modeled groundwater level where the stream exits the western boundary compared with ground surface. Field observations in April 2018 revealed no flooding of this area. This local error in the model does not impact negatively on the

predicted behavior near the proposed infiltration basins or the simulated interaction between the mound and the stream, see **Appendix D**.

Hydraulic Conductivity
As described in Section 4.3, subsurface soils are generally described as: a sand and gravel layer approximately 7-20 feet thick underlain by a silt layer with very low permeability. To re-create this digitally, the model was constructed of two layers that represent the two distinct hydrogeologic zones. The top of Layer 1 was set to the ground surface elevation; the bottom of Layer 1 was interpolated based on the sand and gravel/silt interface observed during drilling activities. The hydraulic conductivity for each layer was based on an averaging of the results of laboratory-derived values from soil sample analyses, see **Table 2.** The hydraulic conductivity (K) of the sand and gravel layer was set to 90 ft/day, which is conservative when compared with laboratory values, see **Table 2.** The K of the silt layer was set to 1 x 10^{-3} ft/day. As a result, of the silt layer's low conductivity, the model acts as a one-layer, two-dimensional model.

Groundwater Mounding Simulation
Following calibration under steady state conditions, a transient simulation was executed to model effects from infiltration of a 7,850 gallons per day (gpd) (1,049 ft^3/day) of domestic wastewater distributed proportionately between the two leach fields. The simulation modeled infiltration over a continuous 90 day period to predict the mounding height during maximum monthly flow conditions. Maximum monthly flow is defined as 80% of the design flow (9,813 gpd) based on the Title 5 calculations, in accordance with Massachusetts Department of Environmental Protection (Mass DEP) guidance.

The mounding simulation resulted in a maximum mound height of 0.29 feet located near the center of LF1, near B-4; see **Figure 6** (and Figure 6 in **Appendix D**). Model results were then superimposed over the ESHGW surface to determine the mound elevation under ESHGW conditions. The simulated mound elevation exceeded the existing ground surface elevation in some areas within leaching field LF1 by less than one foot. The breakout area predicted at LF1 near MW-4 is also the area where the calibrated ESHGW exceeded the observed groundwater level by approximately 1 foot, indicating that the model overestimates groundwater elevations in that region of the site. The thickness of the mound height exceeding ground surface elevation, therefore, is conservatively predicted to be no greater than one foot, see **Figure 5**, **Figure 6** and **Appendix D**. **Figure 7** illustrates the depth from ground surface to the predicted infiltration mound.

The conservative model also predicts mound breakthrough at discrete locations southwest of the leach fields along the Pine Brook drain cells of the model. Breakthrough of less than 0.1 ft. (1.5 inches) is predicted by the model; see **Figure 6** and **Appendix D**.

In both cases we believe the conservative ESHGW calibration is generating higher predicted groundwater elevations than we expect will occur.

Mass Balance Evaluation
The groundwater model was used to predict Mass Balance effects from the proposed SSDS. To assess the changes in ambient groundwater flow in the vicinity of the leach fields, a water budget was calculated for a (rectangular) zone which occupies the majority of the site area northeast of and including Pine Brook (see **Figure 6** and **Appendix D**). Mass balance predictions were calculated under both ESHGW and ESHGW + proposed infiltration scenarios, summarized in the **Table** below.

According to the model, the simulated mound from the proposed SSDS infiltration of 7,850 gpd (1,049 ft^3/day) would divert a small percentage of ambient groundwater flow from entering the polygon from the north and east. Groundwater flow comes primarily (84%) from the eastern boundary; due to the predicted effects of mounding, ambient groundwater flow from the east into the polygon is expected to be reduced by 2% (240 ft^3/day). The flow regime from the north, estimated at 1,899 ft^3/day during ESHGW, is predicted

to be about 13% of total inflow into the model. Due to the diversion from the mound, flow from the north is predicted to be reduced to about 1,658 ft^3/day – a 14% decrease

Description	ESHGW			90 day w/ infiltration			Difference
	Inflow	Outflow	Net (ft^3/day)	Inflow	Outflow	Net (ft^3/day)	Relative
West	--	11691	(11,691)	--	11,823	(11,823)	1%
East	11,874	370	11,504	11,634	404	11,230	-2%
North	1,899	37	1,862	683	64	1,594	-14%
South	333	930	(597)	160	945	(609)	2%
Infiltration			--	1,049		1,049	n/a
Stream		1,079	(1,079)		1,440	(1,440)	33%

The impact from the proposed infiltration at the SSDSs to fluxes across the southern and western zone boundaries (2% and 1%, respectively of inflow at ESHGW) is predicted to be negligible - a slight increase in outflow (15 ft^3/day at the southern boundary and 132 ft^3/day at the western boundary) is predicted by the model.

The influence of the mound is predicted to divert some ambient groundwater flow (2%) from the east around the mound to the south, which inhibits the infiltrated volume from the SSDS from reaching the stream to the south of the leach fields.

The model the volume of water discharged into the stream is predicted to increase by 33% from the 1,079 ft^3/day predicted under ESHGW conditions to 1,440 ft^3/day with the addition of the proposed SSDS infiltration under Title 5 rules.

The increase in the discharge to the stream can be attributed to modeled increase in the hydraulic heads between the leaching fields and the stream due to the infiltration.

For a generalized understanding of hydrodynamics at the site, a particle tracking exercise was performed by applying MODPATH to the model to evaluate the system flow paths and potential interaction with Pine Brook under steady state conditions with constant infiltration at a rate of 7,850 gpd. The output of the model is depicted in **Figure 6** and in **Appendix D**, illustrating most particles passing through the system to the western margin of the model.

8.0 SUMMARY OF FINDINGS

- As shown in **Figure 6**, the simulated groundwater mound beneath leach field LF1 reached a maximum height of 0.29 feet. The simulated groundwater mound was superimposed on top of the ESHGW elevation in **Figure 8** – showing the resultant, simulated groundwater elevations at the site under ESHGW conditions and maximum monthly infiltration.

- Areas where the groundwater table is modeled to exceed existing ground surface elevation under ESHGW conditions are shown in **Figure 7**. The areas in light blue on this plan are categorized distinctly: a) within the LF1 area, where ambient groundwater is shallow, the mound is at its peak, resulting in simulated breakout of less than one foot in this area of the site; and, b) little hydrogeologic information is available to define groundwater table conditions in the area where Pine Brook intercepts the general head boundary at the western margin of the model. During calibration, this resulted in the model predicting groundwater elevations higher than observed in the field. Field observations in April 2018 revealed no flooding of these areas. This erroneous artifact carried through the mounding simulation. This local error in the model does not impact the behavior near the proposed infiltration basins or the simulated interaction between the mound and the stream. Due to the characteristics of the model's ESHGW calibration in comparison to the observed ESHGW – we believe the breakout results are unique to the model.

- Given the conservative nature in which the simulated ESHGW was estimated, and the fact that the hydraulic conductivity parameters are also conservative estimates, the potential breakout conditions shown in **Figures 6 and 7** represent model only worst-case scenarios that are not likely to manifest.

- **Figure 7** depicts the simulated groundwater mound after 90 days of continuous discharge of 7,850 gpd at LF1 and LF2. Ambient groundwater at the site is shallow, ranging from 1.65 to 4.30 ft. bgs during seasonal high water observed in April 2018. Using Title 5 maximum monthly flows (80% of design flows) the top of the groundwater mound breaks out at a small area at LF1, with simulated groundwater mound elevation less than 1 ft. above ground surface. Elsewhere on the area of the site proposed for development, the simulated mound elevation was predicted 2 to 10 ft. below current ground surface elevations during ESHGW. Adequate separation (minimum 4 ft.) between the groundwater mound and ground surface elevations can be achieved through surface re-grading and/or filling in all areas where the simulated mound is less than 4 ft. bgs.

- Groundwater particle flow paths for were simulated under steady state conditions with constant infiltration of 7,850 gpd. **Figure 8** depicts resulting groundwater table elevations from the SSDS mound effect, illustrating that groundwater discharge from the site is weighted to the western boundary of the model.

  Estimated average linear velocity through the sand and gravel aquifer is 10.6 ft/day to 17.6 ft/day. This yields a travel time from the Cascade SSDS to the Pine Brook of 6.8 to 11.3 days. Note that the model flow path exercise predicts that most of the water from the area of the SSDS mound will not discharge at the drain cells of Pine Brook, but exit the model at its western boundary, see **Figure 6** in **Appendix D** and **Figure 8**.

9.0 CONCLUSIONS

The conservative MODFLOW groundwater flow model simulation predicts that the modeled subsurface discharge of 7,850 gpd into leach fields LF1 and LF2 results in a maximum groundwater mounding effect of 0.29 ft. during ESHGW periods. Due to the shallow ambient groundwater table conditions at the site, the two-dimensional model predicted groundwater would break-out at ground surface in the area of LF1. Minimum separation between predicted groundwater mounding and ground surface elevation can be achieved through grading any areas where the predicted groundwater mound is less than 4 feet bgs, as depicted on **Figure 7**.

The conservatively-simulated maximum mound effect at the boundary of Pine Brook is less than 0.1 ft. (1.2 inches) at ESHGW. GEOSPHERE has previously worked on projects where MADEP has approved groundwater discharges creating up to 6 inches of mound effect on nearby surface water bodies. The modeled discharge effects are not considered to pose deleterious effects on streamflow or biota.

Furthermore Mass DEP has indicated temperature effects from sanitary subsurface discharges into conventional septic systems are also not expected to be deleterious, as they will be ameliorated within the leach field, located a distance of over 100 feet from Pine Brook. Temperatures consistent with ambient groundwater temperatures are expected to prevail upon discharges into the aquifer surrounding the leach fields.

TABLES

TABLE 1
Test Pit Data
Cascade Development
115 Boston Post Rd., Wayland, MA

Test Pit ID	Ground Elevation	Test Pit Depth (in)	Test Pit Depth (ft)	Depth to Mottling (in)	Mottling elevation (ft. avd)
OSE-TP 1	-	-	-	-	-
OSE-TP 2	169.2	108	9.00	38	166
OSE-TP 3	164.2	105	8.75	58	159.4
OSE-TP 4	163	106	8.83	55	158.4
OSE-TP 5	159	132	11.00	90	151.5
OSE-TP 6	174.1	108	9.00	39	170.9
OSE-TP 7	169	156	13.00	42	165.5
OSE-TP 8	169	120	10.00	34	166.2
OSE-TP 9	170.7	120	10.00	31	168.1
OSE-TP 10	172.6	45	3.75	>	168.85
OSE-TP 11	171.9	101	8.42	36	168.9
OSE-TP 12	171.9	144	12.00	57	167.2
OSE-TP 13	172.5	125	10.42	54	168
OSE-TP 14	169.7	120	10.00	36	166.7
OSE-TP 15	170.6	120	10.00	60	165.6
OSE-TP 16	177.3	98	8.17	>	169.13
OSE-TP 17	178.2	137	11.42	57	173.5
OSE-TP 18	175	132	11.00	>	164.00
OSE-TP 19	177	120	10.00	42	173.5
OSE-TP 20	168.8	120	10.00	43	165.2
OSE-TP 21	171	84	7.00	36	168
OSE-TP 22	172	72	6.00	72	166
OSE-TP 23	170	96	8.00	36	167
1A	157.5	-	-	42	154
1B	159.6	-	-	42	156.1
2	157.1	-	-	-	-
3	163.6	-	-	-	-
4	166.3	-	-	58	161.5
5	168.2	-	-	-	-

Notes:
AVD = above vertical datum
Elevations in feet (ft) in reference to North American Vertical Datum of 1988 (NAVD88)
Ground elevations surveyed by BEALS AND THOMAS, INC. 144 Turnpike Rd., Southborough, MA, 01772

TABLE 2
Permeability Test Results
Cascade Development
115 Boston Post Road - Wayland, MA
Boring Samples Collected November 29-30, 2017

Boring ID	**B1**	**B3**		**B4**		**B5**		**B8**	**B9**			
Degrees North	42° 21.577'	42° 21.556'		42° 21.570'		42° 21.542'		42.359947°	42.359918°			
Degrees West	71° 20.544'	71° 20.432'		71° 20.465'		71° 20.461'		71.342359°	71.340940°			
Total Depth (ft)	17	22		14.5		18.5		18	12			
Refusal ?	Dense Silt	Dense Silt		Dense Silt		Dense Gravelly Silt		Dense Gravelly Silt	Sand w/Gravel			
Water Encountered (ft. elevation)	159.96	165.42		155.30		157.24		n/a	n/a			
Well Installed?	Yes	Yes		Yes		Yes		No	No			
Permeability Sample ID and Depth (ft)	**S1&S2 4-15 ft**	**S20 0-5 ft**	**S6 5-10 ft**	**S12 5-10 ft**	**S13 10-14.5 ft**	**S9 5-10 ft**	**S10 11-18.5 ft**	**S16 5-13 ft**	**S19 5-12 ft**			
Material Description from Boring Log	Silty Sand w/Gravel	Silty Sand w/Gravel	Silty Sand w/Gravel	Sand w/Gravel	Silt	Sand w/Gravel	Gravely Silt w/Sand	Sand w/Gravel	Sand w/Gravel	Average Hydraulic Conductivity (K) Sand & Gravel (7 Samples)	Hydraulic Conductivity (K) Value Used in MODFLOW Model (Sand & Gravel)	Hydraulic Conductivity (K) Value Used in MODFLOW Model (Silt)
Permeability Result (cm/sec)	1.8×10^{-2}	1.4×10^{-2}	1.1×10^{-1}	1.4×10^{-2}	2.4×10^{-6}	1.1×10^{-2}	9.6×10^{-7}	5.2×10^{-2}	3.8×10^{-2}	3.7×10^{-2}	--	--
k (cm/sec)	0.018	0.014	0.11	0.014	0.0000024	0.011	0.00000096	0.052	0.038	0.036714286	--	--
(0.03281 ft/cm)*(86400 sec/day)	2835	2835	2835	2835	2835	2835	2835	2835	2835	--	--	--
k (ft/day)	51.0	39.7	311.9	39.7	0.0068	31.2	0.0027	147.4	107.7	104	**90 ft/day**	**1×10^{-3} ft/day**
Borehole Avg. k (ft/day)	51	176		40		31		147	108	--	--	--
Total Borehole Avg. k (ft/day) (6 samples)	92									--	--	--

Sieve Analysis results for S-7, S-11, S-15 and S-17 included with permeability results in Appendix C.

TABLE 3

Borehole and Monitoring Well Data including Groundwater Elevations
Cascade Development
115 Boston Post Rd., Wayland, MA

Boring ID	Ground Elevation (ft)	Top of PVC Elevation (ft avd)	Depth to Bottom (ft btpvc)	Elevation of Bottom (ft avd)	Depth to Groundwater 12/12/2017 (ft btpvc)	Groundwater Elevation 12/12/2017 (ft avd)	Depth to Groundwater 3/21/2018 (ft btpvc)	Groundwater Elevation 3/21/2018 (ft avd)	Depth to Groundwater 4/6/2018 (ft btpvc)	Depth to Groundwater 4/6/2018 (ft bgs)	Groundwater Elevation 4/6/2018 (ft avd)
B-1/MW	171.61	171.29	17.0	154.6	5.54	165.75	3.84	167.45	2.52	2.84	168.77
B-2	175.7	-	14.0	161.7	-	-	-	-	-	-	-
B-3/MW	177.32	179.06	22.0	155.3	11.24	167.82	6.03	173.03	6.04	4.30	173.02
B-4/MW	169.35	171.68	14.5	154.9	6.87	164.81	4.09	167.59	3.98	1.65	167.70
B-5/MW	171.25	173.52	18.5	152.8	5.77	167.75	4.52	169.00	4.40	2.13	169.12
B-6/MW	166.77	168.47	13.0	153.8	4.90	163.57	3.49	164.98	3.38	1.68	165.09
B-7/MW	157.86	160.15	12.0	146	6.66	153.49	6.37	153.78	6.31	4.02	153.84
B-8	157.6	-	18.0	140	-	-	-	-	-	-	-
B-9	171.2	-	12.0	159	-	-	-	-	-	-	-

Notes:

- = Not applicable
AVD = above vertical datum
btpvc = Below top of 2" PVC
Elevations in feet (ft) in reference to North American Vertical Datum of 1988 (NAVD88)
Top of PVC and ground elevations surveyed by BEALS AND THOMAS, INC. 144 Turnpike Rd., Southborough, MA, 01772

TABLE 4
Lithology Summary Table - Soil Borings
Cascade Development
115 Boston Post Rd., Wayland, MA

Soil Boring ID	Total Borehole Depth (ft)	Thickness of Topsoil, Fill and S&G Layer	Thickness of Silt Layer (ft)	Sand & Gravel Layer (Top) Elevation (ft avd)	Sand & Gravel Layer (Bottom) Elev. (ft avd)	Silt Layer (Top) Elevation (ft avd)	Depth to Silt Layer (ft bgs)	Silt Layer (Bottom) Elevation (ft avd)	Silt Layer Description	S&G Layer Description
B-1/MW	17	15	2	171.6	156.6	156.6	15	154.6	Silt	Silty Sand with Gravel
B-2	14	14	ne	175.7	161.7	ne	ne	ne	ne	Sandy Silt with Gravel
B-3/MW	22	20	2	177.3	157.3	157.3	20	155.3	Silt	Silty Sand with Gravel
B-4/MW	14.5	10	4.5	169.4	159.4	159.4	10	154.9	Silt	Well graded Sand with Gravel
B-5/MW	18.5	11	7.5	171.3	160.3	160.3	11	152.8	Gravelly Silt w/ Sand	Well graded Sand with Gravel
B-6/MW	13	7	6	166.8	159.8	159.8	7	153.8	Silt	Well graded Sand with Gravel
B-7/MW	12	12	ne	157.9	145.9	ne	ne	ne	ne	Silty Sand and Gravel
B-8	18	15	3	157.6	142.6	142.6	15	139.6	Silty Sand w/ Gravel	Well graded Sand with Gravel
B-9	12	12	ne	171.2	159.2	ne	ne	ne	ne	Well graded Sand with Gravel

Notes:
bgs = below ground surface
avd = above vertical datum
S&G = Sand and gravel
ne = not encountered: the silt layer was not encountered shallower than refusal
- = No data available (not surveyed/no lab analysis conducted)
Elevations in feet (ft) in reference to North American Vertical Datum of 1988 (NAVD88)
Ground elevations surveyed by BEALS AND THOMAS, INC. 144 Turnpike Rd., Southborough, MA, 01772

FIGURES

0 1,000 2,000 4,000 Feet

Approximate Scale: 1 inch = 2,000 feet

N W E S

FIGURE 1 - Site Locus

Cascade Wayland
115 Boston Post Rd
Wayland, MA

LEGEND

Site Parcel

Modified By: MK
Checked By: DN
Project No: 17205
Date: 03/12/2018

Reference: MassGIS Digital Quads (FRAMINGHAM)

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave. - Exeter, NH 03833 - (603) 773-0075

Legend

- Borehole
- Monitoring Well
- Test Pit
- Leachfields
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

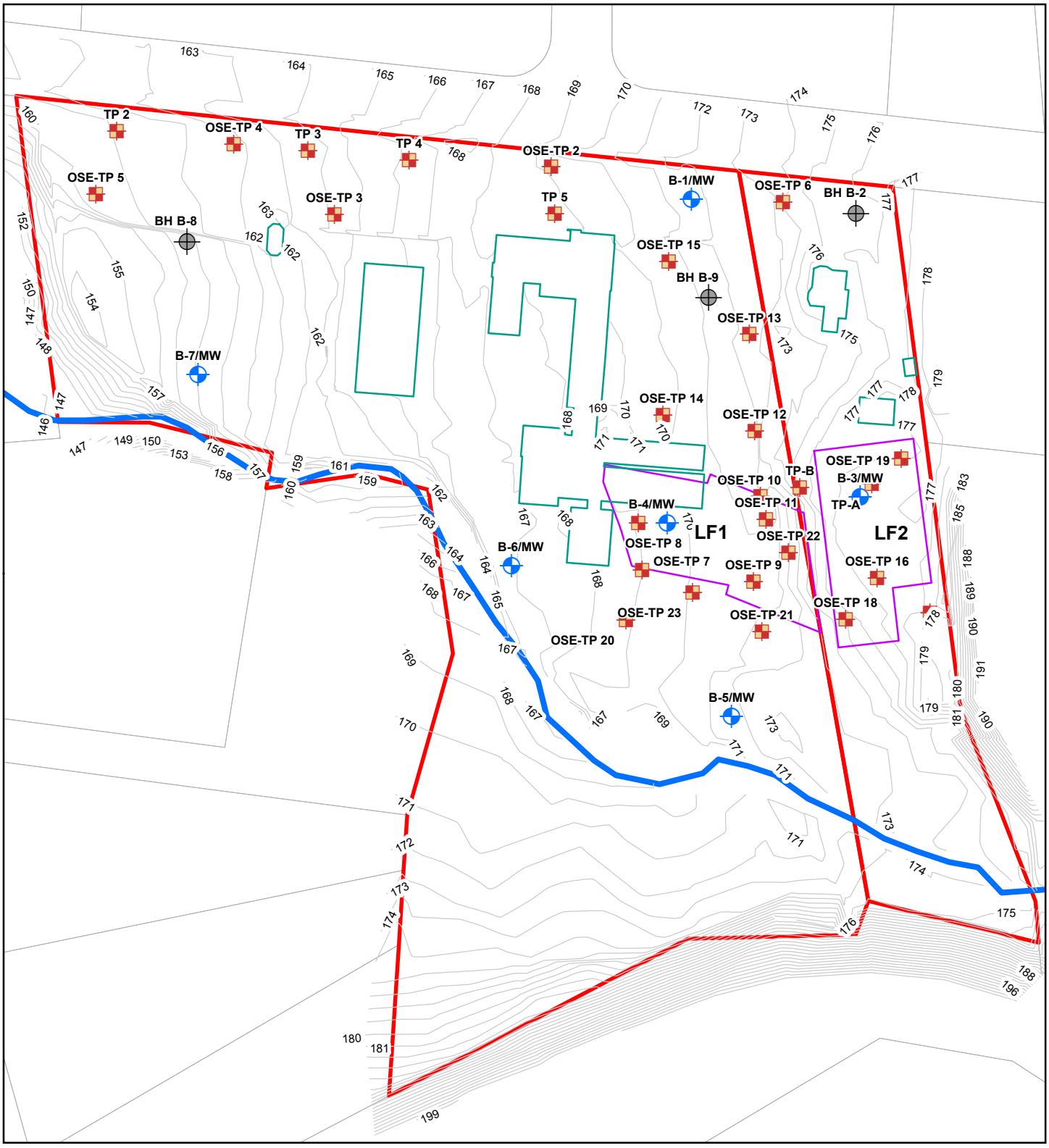
N W E S

GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 2
Aerial Site Plan

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/08/2018	DATE: 06/08/2018	17205\Figures



Legend

- Borehole
- Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- Surface Topography feet AVD
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

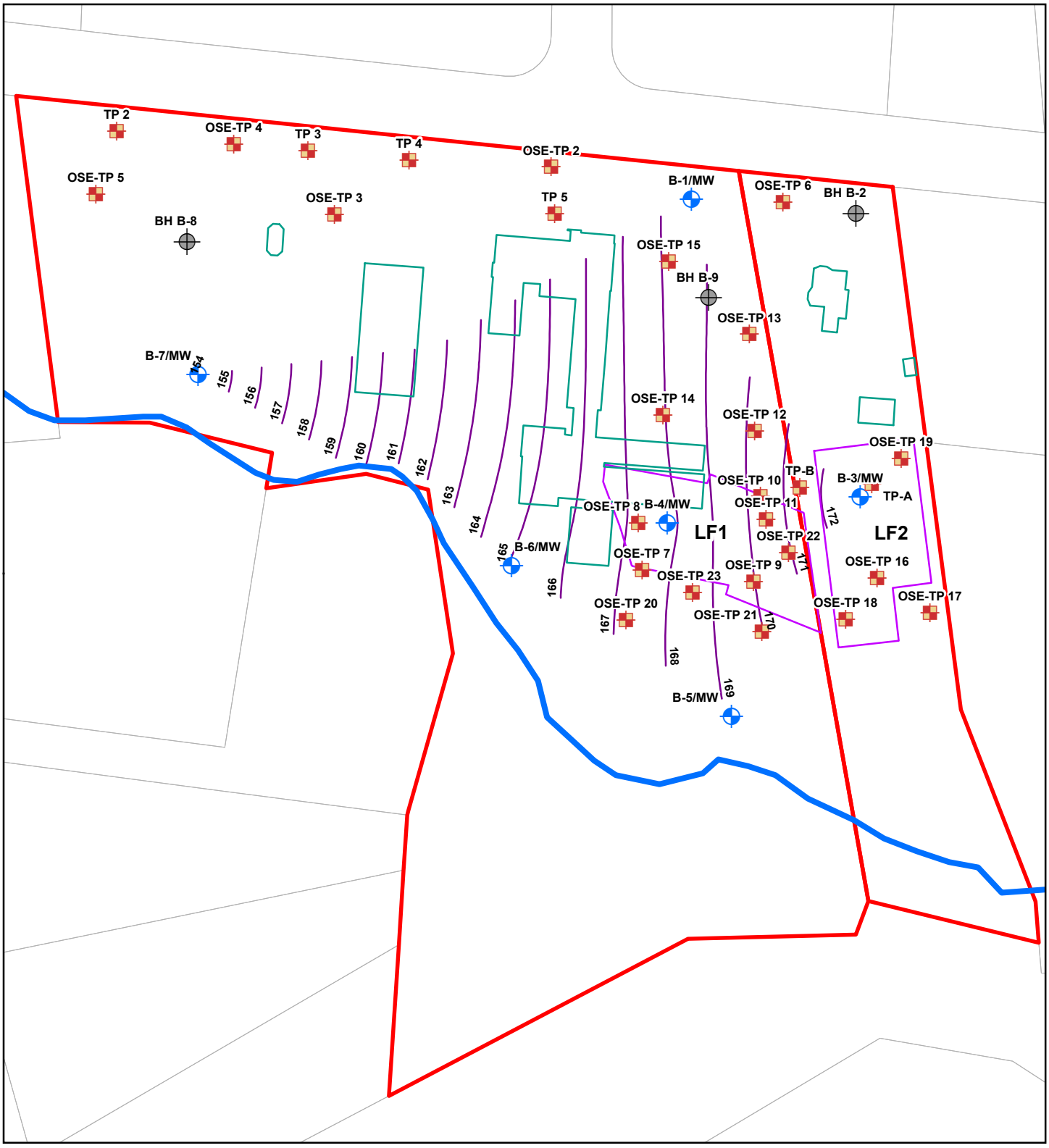
GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 3
Site Plan

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: RT	PROJ. NO: 17205
DATE: 06/08/2018	DATE: 06/08/2018	17205\Figures

Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
AVD = Above vertical datum
All elevations relative to North American Vertical Datum of 1988



Legend

- Borehole
- Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- Groundwater Contours 4/6/2018 feet AVD
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

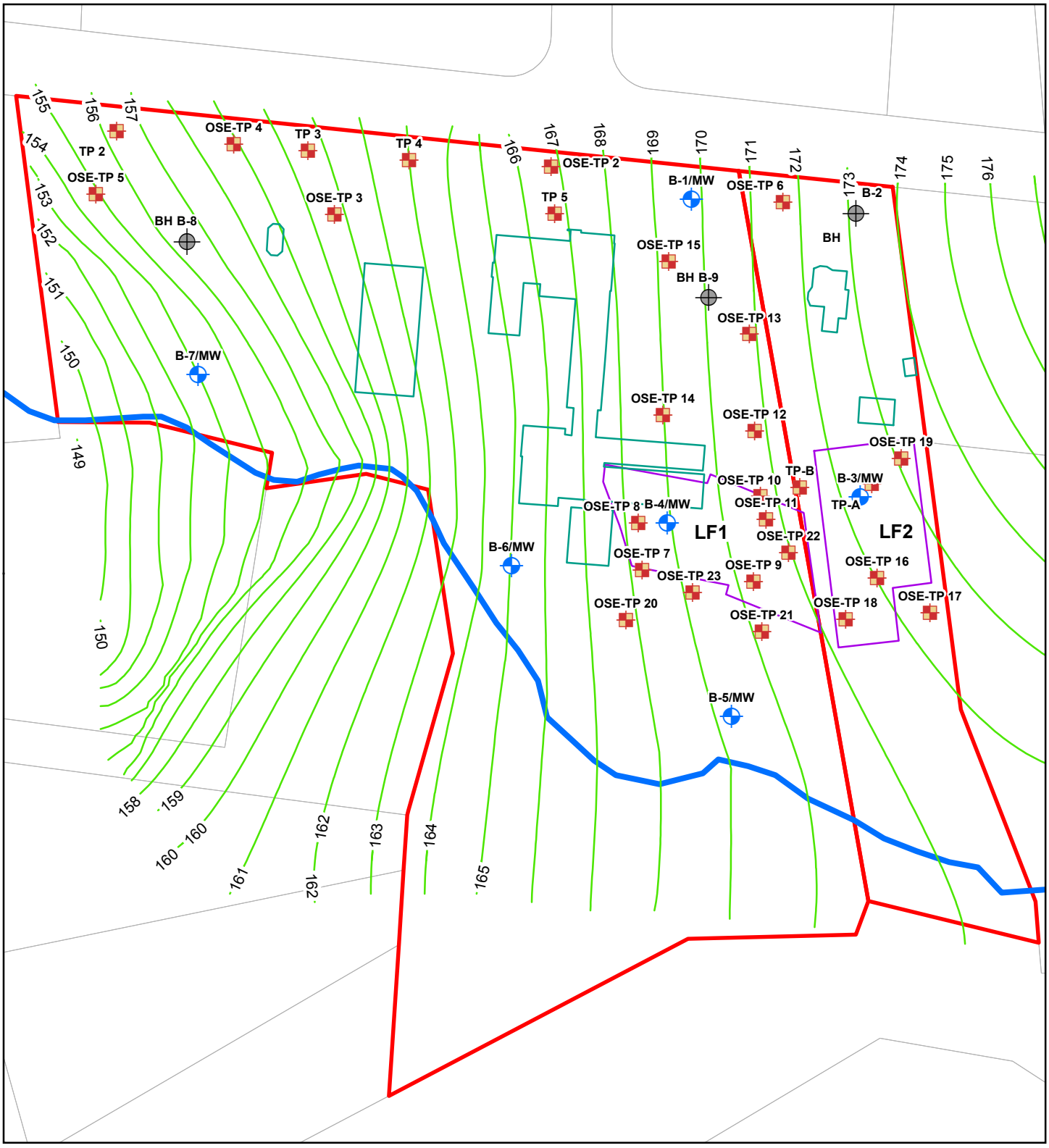
GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 4
Observed Groundwater Contours - April 6, 2018

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/08/2018	DATE: 06/08/2018	17205\Figures

Water level data collected by GEOSPHERE on 4/8/2018
Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
AVD = Above vertical datum
All elevations relative to North American Vertical Datum of 1988



Legend

- Borehole
- Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- ESHGW Contours feet AVD
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

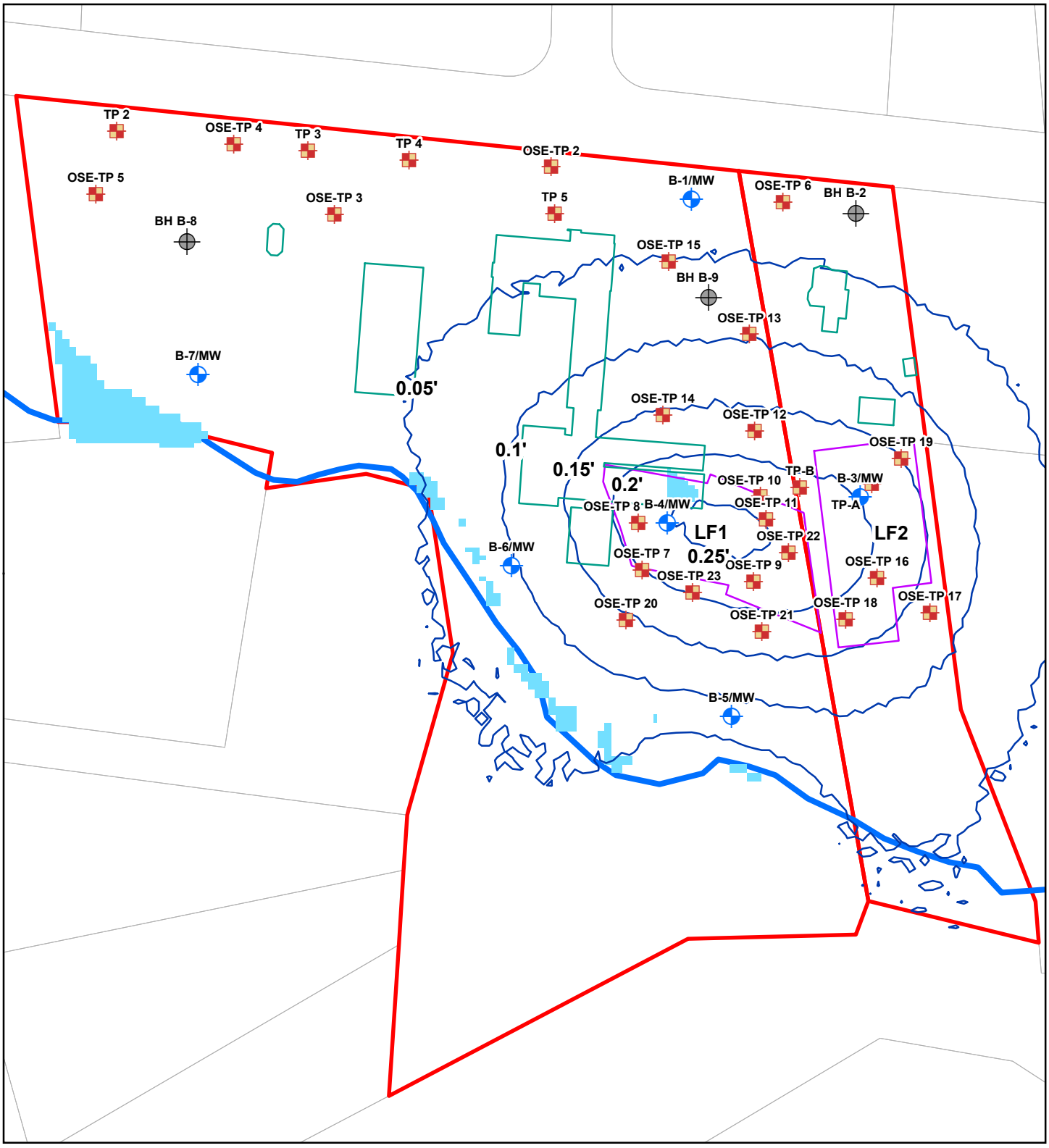
AVD = Above vertical datum
Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
All elevations relative to North American Vertical Datum of 1988

GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 5
Simulated ESHGW Contours

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/26/2018	DATE: 06/26/2018	17205\Figures



Legend

- Borehole
- Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- 90-Day Mound Height feet
- Flooded Cells
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

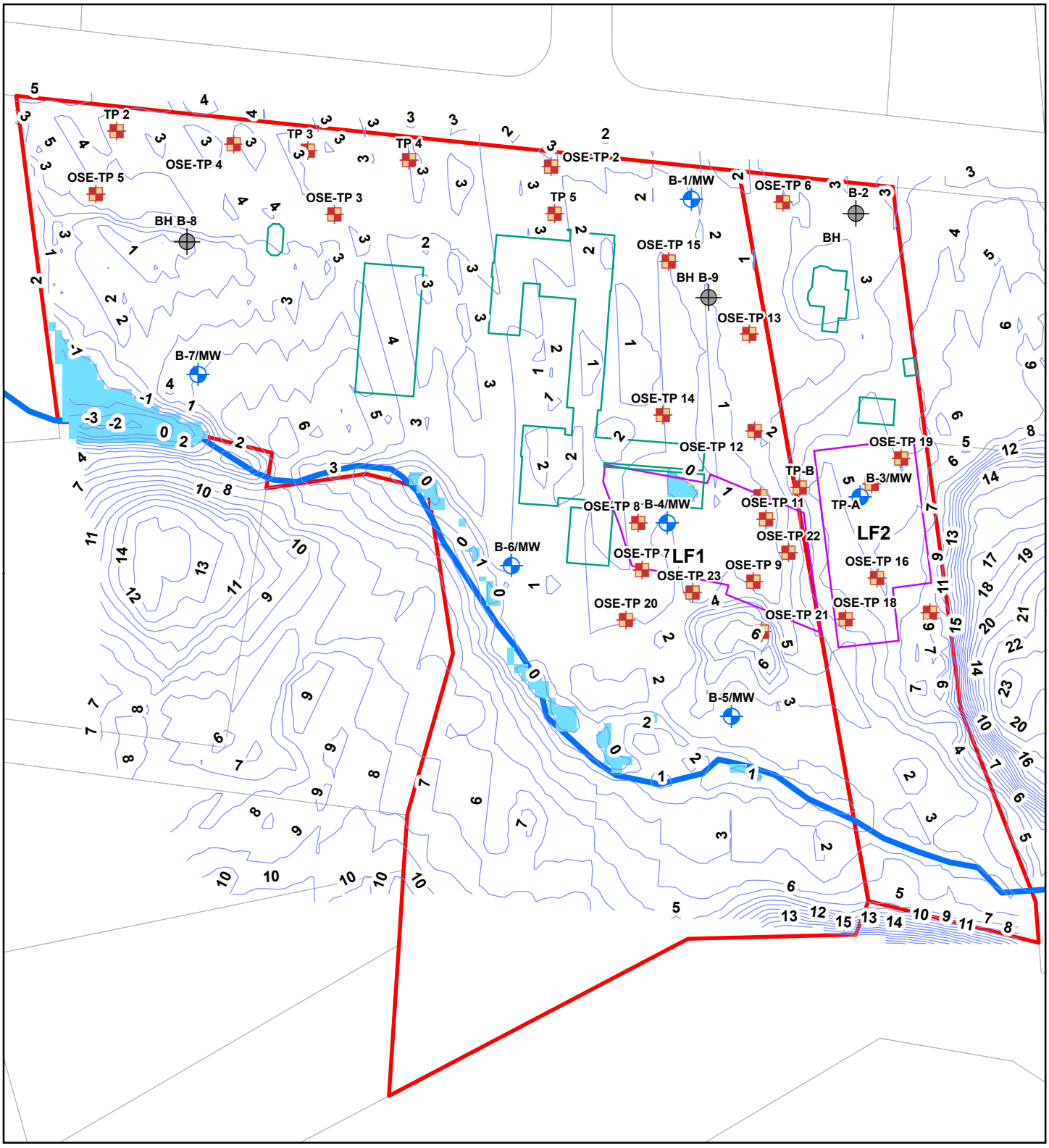
AVD = Above vertical datum
Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
All elevations relative to North American Vertical Datum of 1988

GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 6
Simulated Est. Mound Height & Breakout

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/26/2018	DATE: 06/26/2018	17205\Figures



Legend

- Borehole
- Flooded cells Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- Depth to Mound Contours feet BGS
- Flooded Cells
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

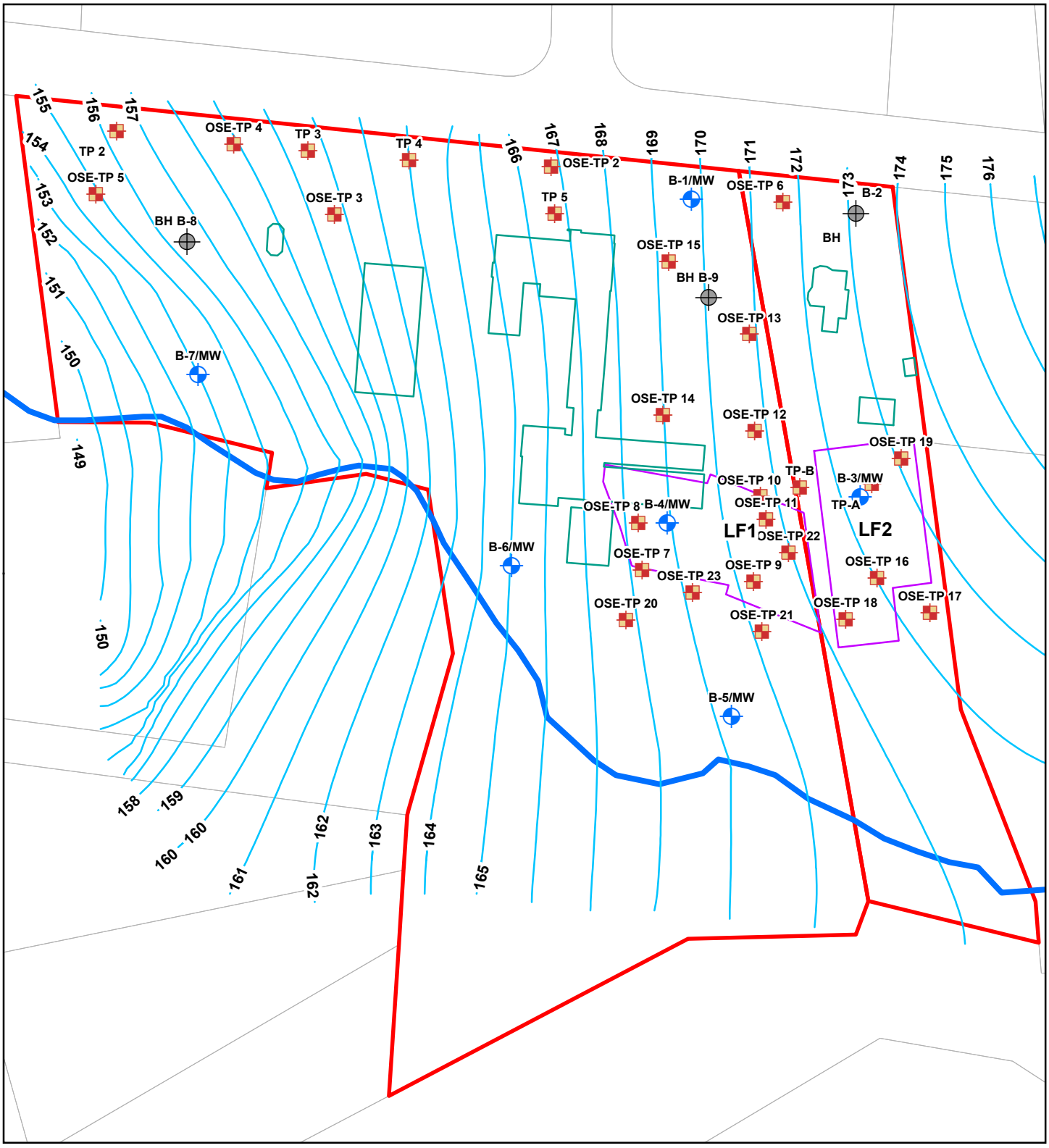
BGS = Below ground surface
Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
All elevations relative to North American Vertical Datum of 1988

GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 7
Depth to Mound Below Ground Surface

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/26/2018	DATE: 06/26/2018	17205\Figures



Legend

- Borehole
- Monitoring Well
- Test Pit
- Building Outlines
- Leachfields
- 90-Day Simulated Head feet AVD
- Pine Brook
- Site Parcel
- Tax Parcels

0 25 50 100 150 200 Feet

1 inch = 100 feet

N W E S

GEOSPHERE ENVIRONMENTAL MANAGEMENT INC.

FIGURE 8
90-Day Simulated Head

Cascade Wayland
115 Boston Post Road
Wayland, MA

CREATED BY: LB	CHECKED BY: DN	PROJ. NO: 17205
DATE: 06/26/2018	DATE: 06/26/2018	17205\Figures

AVD = Above vertical datum
Ground elevation surveyed by Beals & Thomas, Southborough, Massachusetts
All elevations relative to North American Vertical Datum of 1988

Appendix A

Test Pit and Percolation Test Logs
Massachusetts DEP Forms 11 and 12

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Mahoney's Garden Center, LLC
Owner Name

115 Boston Post Road Map/Lot: Map 30, Lot 071
Street Address

Wayland MA 01778
City/Town State Zip Code

B. Site Information

1. (Check one) New Construction ☒ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☒ No ☐ If yes: _____ _____ _
Year Published Publication Scale Soil Map Unit

Haven Urban Land Complex (MassGIS) _____
Soil Name Soil limitations

3. Surficial Geological Report available? Yes ☐ No ☒ If yes: _____ _____ _____
Year Published Publication Scale Map Unit

_____ _____
Geologic Material Landform

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☒ No ☐ Within the 100 year flood boundary? Yes ☐ No ☒

Within the 500 year flood boundary? Yes ☐ No ☒ Within a Velocity Zone? Yes ☐ No ☒

5. Wetland Area: National Wetland Inventory Map _____ _____
Map Unit Name

Wetlands Conservancy Program Map _____ _____
Map Unit Name

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

6. Current Water Resource Conditions (USGS) December 2016 (Month/Year) Range: Above Normal ☐ Normal ☐ Below Normal ☒

7. Other references reviewed: _____

_____

C. On-Site Review (*minimum of two holes required at every proposed primary and reserved disposal area)*

Deep Observation Hole Number: December 13, 2016 (Date) AM (Time) Sunny 30s F (Weather)

1. Location

Ground Elevation at Surface of Hole Varies

Location (Identify on Plan) See Plan

2. Land Use: Nursery (e.g. woodland, agricultural field, vacant lot, etc.) None (Surface Stones) 3-8% (Slope (%))

Disturbed (Vegetation) Moraine (Landform) _____ (Position on landscape (attach sheet))

3. Distances from: Open Water Body > 100 feet Drainage Way > 100 feet Possible Wet Area > 100 feet

Property Line >10 feet Drinking Water Well > 100 feet Other _____

4. Parent Material: Ice Contact Outwash Unsuitable Materials Present: Yes ☒ No ☐

If Yes: Disturbed Soil☐ Fill Material☒ Impervious Layer(s) ☐ Weathered/Fractured Rock☐ Bedrock ☒

5. Groundwater Observed: Yes ☒ No ☐

If Yes: Depth Weeping from Pit Varies Depth Standing Water in Hole Varies

Estimated Depth to High Groundwater: Varies (see Testpits) inches _____ elevation

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-1

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			

Additional Notes Excavation within buried foundation

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-2

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-42	Fill		38”								
42-60	C_1	2.5 Y 7/6				Very Fine Sand			Single Grain	Loose	
60-108	C_2	2.5 Y 6/6				Sandy Loam			Massive	Friable	

Additional Notes Water Weeping @ 78”, ESHGW = 38”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-3

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-22	Fill										
22-33	A	10 YR 3/2				Sandy Loam			Massive	Friable	
33-105	C_1	2.5 Y 6/6	58”			Loamy Sand			Single Grain	Loose	

Additional Notes Water Weeping @ 74”, ESHGW=58”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-4

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-50	Fill										
50-57	A	10 YR 3/2	55”			Sandy Loam			Massive	Friable	
57-72	C_1	2.5 Y 6/3				Coarse Sand			Single Grain	Loose	
72-106	C_2	2.5 Y 6/3				Very Fine Loamy Sand			Single Grain	Loose	

Additional Notes Water Weeping @ 72”, ESHGW=55”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-5

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-90	Fill										
90-101	A	10 YR 3/2	90”			Sandy Loam			Massive	Friable	
101-132	C	2.5 Y 5/6				Very Fine Loamy Sand			Single Grain	Loose	

Additional Notes Water Standing @ 112”, ESHGW=90”

Commonwealth of Massachusetts
City/Town of Wayland Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-6

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-13	Fill										
13-24	A	10 YR 3/2				Sandy Loam			Massive	Friable	
24-48	Bw	10 YR 5/6	39”			Sandy Loam			Massive	Friable	
48-108	C_1	2.5 Y 6/6				Sandy Loam			Massive	Friable	

Additional Notes ESHGW=39”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:
   - ☒ Depth observed standing water in observation hole — A. Varies (inches) B. _____ (inches)
   - ☒ Depth weeping from side of observation hole — A. Varies (inches) B. _____ (inches)
   - ☒ Depth to soil redoximorphic features (mottles) — A. Varies (inches) B. _____ (inches)
   - ☐ Groundwater adjustment (USGS methodology) — A. _____ (inches) B. _____ (inches)

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☐ No ☐

   b. If yes, at what depth was it observed? Upper boundary: Varies (inches) Lower boundary: Varies (inches)

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

_____ 2/13/2017
Signature of Soil Evaluator — Date

Raymond Willis, P.E., SE2612
Typed or Printed Name of Soil Evaluator/License Number

May 1996
*Date of Soil Evaluator Exam

Darren MacCaughey
Name of Board of Health Witness

Town of Wayland
Board of Health

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

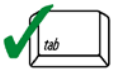
Use this sheet for field diagrams:

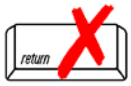
See Attached Plans

Commonwealth of Massachusetts
City/Town of Wayland
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.





A. Site Information

Mahoney's Nursery
Owner Name

115 Boston Post Road
Street Address or Lot #

Wayland	MA	01778
City/Town	State	Zip Code

Contact Person (if different from Owner) | Telephone Number

B. Test Results

	12/13/2016 Date	AM Time	12/13/2016 Date	PM Time
Observation Hole #	OSE-TP-3		OSE-TP-6	
Depth of Perc	40"-58"		51"-69"	
Start Pre-Soak	9:59 AM		1:43 PM	
End Pre-Soak	10:15 AM		1:59 PM	
Time at 12”	10:15 AM		1:59 PM	
Time at 9”	10:23 AM		2:25 PM	
Time at 6”	10:34 AM		2:57 PM	
Time (9”-6”)	11 minutes		32 minutes	
Rate (Min./Inch)	4 mpi		11 mpi	
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Raymond Willis, P.E.
Test Performed By:

Darren MacCaughey
Witnessed By:

Comments:

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Mahoney's Garden Center, LLC
Owner Name

115 Boston Post Road Map/Lot: Map 30, Lot 071
Street Address

Wayland MA 01778
City/Town State Zip Code

B. Site Information

1. (Check one) New Construction ☒ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☒ No ☐ If yes: _____ _____ _
Year Published Publication Scale Soil Map Unit

Haven Urban Land Complex (MassGIS) _____
Soil Name Soil limitations

3. Surficial Geological Report available? Yes ☐ No ☒ If yes: _____ _____ _____
Year Published Publication Scale Map Unit

_____ _____
Geologic Material Landform

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☒ No ☐ Within the 100 year flood boundary? Yes ☐ No ☒

Within the 500 year flood boundary? Yes ☐ No ☒ Within a Velocity Zone? Yes ☐ No ☒

5. Wetland Area: National Wetland Inventory Map _____ _____
Map Unit Name

Wetlands Conservancy Program Map _____ _____
Map Unit Name

Commonwealth of Massachusetts
City/Town of Wayland Massachusetts
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

6. Current Water Resource Conditions (USGS) January 2017 (Month/Year) Range: Above Normal ☐ Normal ☐ Below Normal ☒

7. Other references reviewed: _____

_____

C. On-Site Review (*minimum of two holes required at every proposed primary and reserved disposal area)*

Deep Observation Hole Number: January 12, 2017 (Date) AM (Time) Overcast-Sunny 50s F (Weather)

1. Location

Ground Elevation at Surface of Hole Varies

Location (Identify on Plan) See Plan

2. Land Use: Nursery (e.g. woodland, agricultural field, vacant lot, etc.) None (Surface Stones) 3-8% (Slope (%))

Disturbed (Vegetation) Moraine (Landform) _____ (Position on landscape (attach sheet))

3. Distances from: Open Water Body > 100 feet Drainage Way > 100 feet Possible Wet Area > 100 feet

Property Line >10 feet Drinking Water Well > 100 feet Other _____

4. Parent Material: Ice Contact Outwash Unsuitable Materials Present: Yes ☒ No ☐

If Yes: Disturbed Soil☐ Fill Material☒ Impervious Layer(s) ☐ Weathered/Fractured Rock☐ Bedrock ☒

5. Groundwater Observed: Yes ☒ No ☐

If Yes: Depth Weeping from Pit Varies Depth Standing Water in Hole Varies

Estimated Depth to High Groundwater: Varies (see Testpits) (inches) _____ (elevation)

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-7

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-24	Fill										
24-36	C_1	2.5 Y 7/6				Coarse Sand &Gravel		>5%	Single Grain	Loose	Gravel
36-156	C_2	2.5 Y 7/4	42”			Coarse Sand &Gravel		>5%	Single Grain	Loose	Gravel

Additional Notes Water Standing @ 53”, ESHGW @ 42”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-8

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-44	Fill		34”								
44-66	C_1	2.5 Y 7/4				Coarse Sand & Gravel		>5%	Single Grain	Loose	Gravel
66-120	C_2	2.5 Y 6/4				Medium Sand			Single Grain	Loose	

Additional Notes Water Standing @ 54”, ESHGW = 34”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-9

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	Fill										
12-24	C_1	2.5 Y 7/6				Medium Sand			Single Grain	Loose	
24-120	C_2	2.5 Y 7/4	31”			Coarse Sand & Gravel		>5%	Single Grain	Loose	Gravel

Additional Notes Water Standing @ 53”, ESHGW=31”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-10

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-25	Fill										
25-45	C_1	2.5 Y 7/4				Coarse Sand & Gravel			Single Grain	Loose	
45	R										

Additional Notes No Water, No Mottles

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-11

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-15	Fill										
15-55	C_1	10 YR 5/6	36”			Loamy Sand			Single Grain	Loose	
55-101	C_2	2.5 Y 6/4				Coarse Sand & Gravel		>5%	Single Grain	Loose	Gravel, Caving

Additional Notes Water Standing @ 60”, ESHGW=36”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-12

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-32	Fill										
32-82	C_1	2.5 Y 6/6	57”			Sandy Loam			Single Grain	Loose	
82-144	C_2	2.5 Y 6/6				Sandy Loam		>5%	Single Grain	Loose	Gravel
144	R										Rock or Large Boulder

Additional Notes Water Weeping @ 77”, ESHGW=57”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-13

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-34	Fill										
34-54	C_1	2.5 Y 7/4	54”			Very Fine Loamy Sand			Single Grain	Loose	
54-125	C_2	2.5 Y 6/6				Sandy Loam			Massive	Friable	
125	R										

Additional Notes Water Weeping @ 96”, ESHGW=54”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-14

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-30	Fill										
30-120	C_1	2.5 Y 7/4	36”			Very Fine Loamy Sand			Single Grain	Loose	

Additional Notes Water Standing @ 58”, ESHGW=36”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-15

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-65	Fill		60”								
65-72	C_1	2.5 Y 7/4				Very Fine Loamy Sand			Single Grain	Loose	
72-120	C_2	2.5 Y 6/4				Coarse Sand & Gravel		>5%	Single Grain	Loose	Gravel

Additional Notes Water Standing @ 65”, ESHGW=60”

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: OSE-TP-16

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-39	Fill										
39-98	C_1	2.5 Y 6/6				Sandy Loam			Massive	Friable	

Additional Notes No water, west side of hole has 57" of fill.

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:
   - ☒ Depth observed standing water in observation hole — A. Varies inches B. _ inches
   - ☒ Depth weeping from side of observation hole — A. Varies inches B. _ inches
   - ☒ Depth to soil redoximorphic features (mottles) — A. Varies inches B. _ inches
   - ☐ Groundwater adjustment (USGS methodology) — A. _____ inches B. _____ inches

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☒ No ☐

   b. If yes, at what depth was it observed? Upper boundary: Varies inches Lower boundary: Varies inches

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

_____ 2/13/2017
Signature of Soil Evaluator — Date

Raymond Willis, P.E.; SE2612 — May 1996
Typed or Printed Name of Soil Evaluator/License Number — *Date of Soil Evaluator Exam

Darren MacCaughey — Town of Wayland
Name of Board of Health Witness — Board of Health

Commonwealth of Massachusetts
City/Town of Wayland, Massachusetts

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

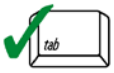
Use this sheet for field diagrams:

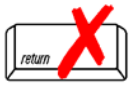
See Attached Plans

Commonwealth of Massachusetts
City/Town of Wayland
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.





A. Site Information

Mahoney's Nursery
Owner Name

115 Boston Post Road
Street Address or Lot #

Wayland	MA	01778
City/Town	State	Zip Code

Contact Person (if different from Owner) | Telephone Number

B. Test Results

	1/12/2017 Date / AM Time	1/12/2017 Date / PM Time
Observation Hole #	OSE-TP-9	OSE-TP-11
Depth of Perc	24"-52"	17"-35"
Start Pre-Soak	11:59 AM	12:04 PM
End Pre-Soak		12:22 PM
Time at 12”		12:22 PM
Time at 9”		12:26 PM
Time at 6”		12:33 PM @ 5.5"
Time (9”-6”)		7 minutes
Rate (Min./Inch)	<2 mpi	2 mpi
	Test Passed: ☒ Test Failed: ☐	Test Passed: ☒ Test Failed: ☐

Raymond Willis, P.E.
Test Performed By:

Darren MacCaughey
Witnessed By:

Comments:

TP-9 - 24 gallons passed in less than 15 minutes

Commonwealth of Massachusetts
City/Town of Wayland
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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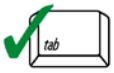
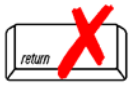




A. Site Information

Mahoney's Nursery
Owner Name

115 Boston Post Road
Street Address or Lot #

Wayland	MA	01778
City/Town	State	Zip Code

Contact Person (if different from Owner) | Telephone Number

B. Test Results

	1/12/2017 Date / AM Time	1/12/2017 Date / PM Time
Observation Hole #	OSE-TP-12	OSE-TP-14
Depth of Perc	53"-71"	30"-48"
Start Pre-Soak	11:29 AM	2:45 PM
End Pre-Soak	11:44 AM	3:02 PM
Time at 12"	11:44 AM	3:02 PM
Time at 9"	12:11 PM	3:24 PM
Time at 6"	12:50 PM	4:00 PM
Time (9"-6")	39 minutes	36 minutes
Rate (Min./Inch)	13 mpi	12 mpi
	Test Passed: ☒ Test Failed: ☐	Test Passed: ☒ Test Failed: ☐

Raymond Willis, P.E.
Test Performed By:

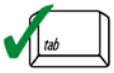
Darren MacCaughey
Witnessed By:

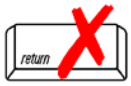
Comments:

Commonwealth of Massachusetts
City/Town of Wayland
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.





A. Site Information

Mahoney's Nursery
Owner Name

115 Boston Post Road
Street Address or Lot #

Wayland	MA	01778
City/Town	State	Zip Code

Contact Person (if different from Owner) | Telephone Number

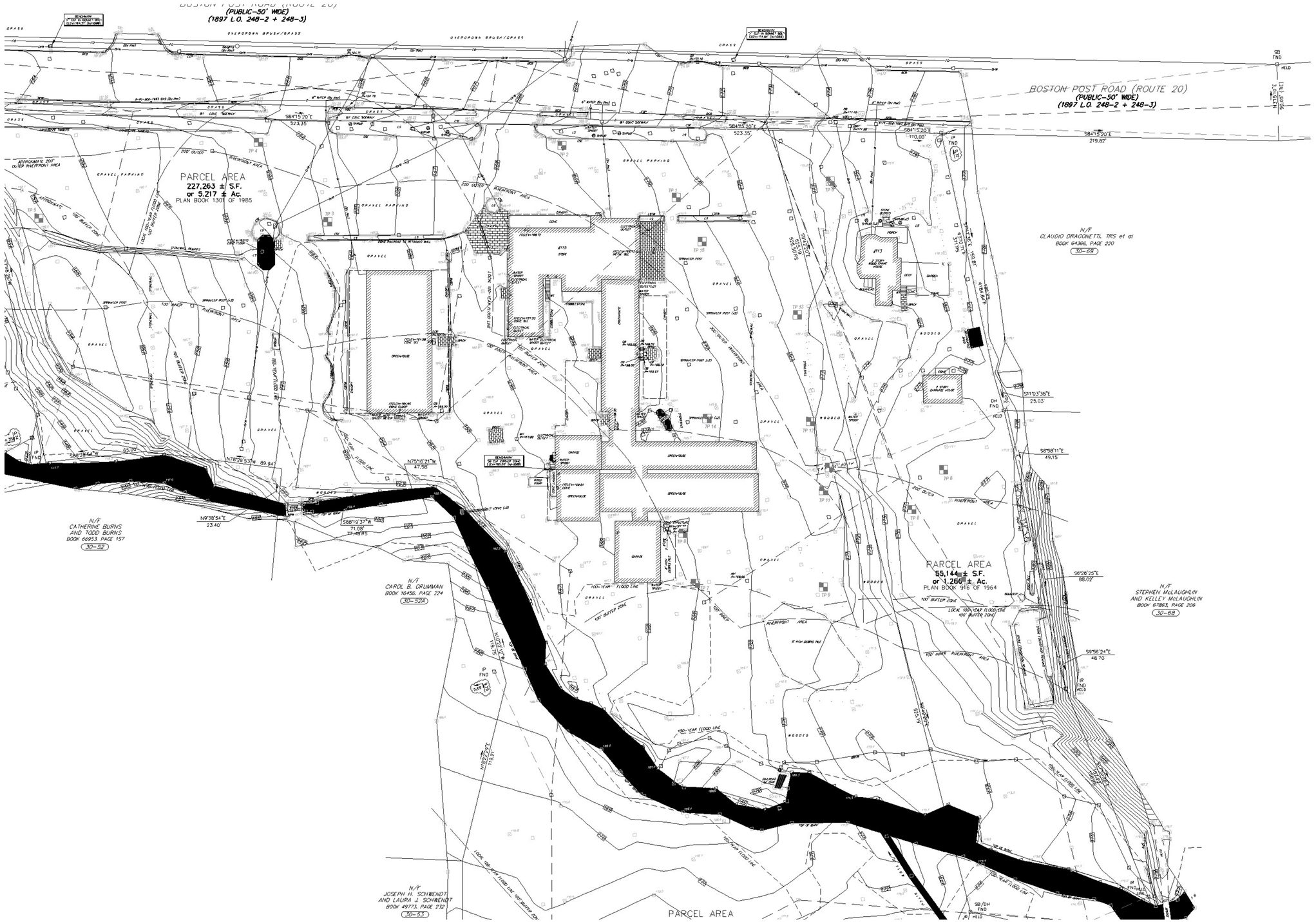
B. Test Results

	Date	Time	Date	Time
	1/12/2017	AM		
Observation Hole #	OSE-TP-16			
Depth of Perc	46"-64"			
Start Pre-Soak	2:22 PM			
End Pre-Soak	2:37 PM			
Time at 12”	2:37 PM			
Time at 9”	3:15 PM @ 8.75"			
Time at 6”	4:02 PM @ 5.75"			
Time (9”-6”)	47 minutes			
Rate (Min./Inch)	16 mpi			
	Test Passed: ☒		Test Passed: ☐	
	Test Failed: ☐		Test Failed: ☐	

Raymond Willis, P.E.
Test Performed By:

Darren MacCaughey
Witnessed By:

Comments:



ONSITE ENGINEERING
Water, Wastewater and Stormwater Specialists
279 East Central Street
Franklin, MA 02038
508-553-0616
www.onsite-eng.com

BROOKSIDE WAYLAND
115 BOSTON POST ROAD

TEST PIT LOCATION PLAN

REV DATE DESCRIPTION

PROJECT NO.: 01380
DATE: .2-13-17
SCALE: 1"=30'
SHEET: 1 of 1

DRAWN BY: DESIGNED BY:
CHECKED BY: APPROVED BY:

Fig 1

Appendix B

Soil Boring/Monitoring Well Construction Logs
TJ Ogden Well Driller's Log – Irrigation Well (2003)

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-1/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-1/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
ft / m		Ground Surface						
0 / 0		***Silty Sand with Gravel*** Light to dark brown fine to coarse Sand (40-50%), Gravel (20-40%), Fines (10-20%). Loose, dry. (0'-15')	B1-1		60"	41"		4" diameter flush mount road box -Concrete 0-1' -Silica sand backfill 1'-3' -Bentonite seal 3'-5'
6 / 2			B1-2	S1	60"	18"		-Screen 6'-16' -Silica sand filter pack 5'-16'
12 / 4			B1-3	S2	60"	14"		
16 / 5		***Silt*** Tan fines, dense, non-plastic, non-cohesive, wet. (15'-17')	B1-4		24"	13"		Well set at 16'
18 / 6		***End of Boring/Refusal = 17'***						End of Boring/Refusal at 17'

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: 5.54' btpvc

Driller: Crawford Drilling Services Well Casing Diameter: 2" PVC Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-2

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-2

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
0 / 0		Ground Surface						
0		***Topsoil/Organics*** (0'-1')						
1		***Sandy Silt with Gravel*** Light brown to gray Fines (60%), fine Sand (15-25%), and Gravel (10-15%). Wet at 14'. (1'-14')	B2-1		60"	39"		No well set.
2 / 4				S4 2'-5'				
6 / 2			B2-2	S3 5'-7'	60"	44"		
8				S5-2 5'-9'				
10								
12 / 4			B2-3	S5 9'-14'	48"	32"		
14		***End of Boring/Refusal at 14'***						End of Boring/Refusal at 14'
16								
18								
20 / 6								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: N/A

Driller: Crawford Drilling Services Well Casing Diameter: N/A Date of Static GW Level: N/A

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

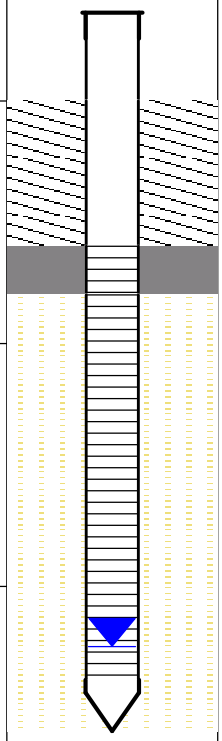
Log of Borehole/MW: B-3/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-3/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
0		Ground Surface						4" diameter riser stick-up 1.8' ags
0		***Silty Sand with Gravel*** Brown to dark brown fine to coarse Sand (50-60%), Gravel (25-30%), Fines (15-20%). Loose 0'-5', compact to very compact 5'-20'. Moist at 9', wet at 11'. (0'-20')	B3-1	S20 0'-5'	60"	40"		-Concrete seal 0-3'
4								-Bentonite seal 3'-4'
6 / 2			B3-2	S6 5'-10'	60"	47"		-Silica sand filter pack 4'-13' Screen 3'-13'
12 / 4			B3-3	S7 10'-14'	60"	38"		Well set at 13'
16			B3-4	S8 14'-22'	60"	13"		
20 / 6		***Silt*** Gray fines (90%), Gravel (10%). Very compact. Wet. (20'-22')	B3-5		24"	12"		
22		***End of Boring/Refusal = 22'***						End of Boring/Refusal at 22'
24								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: 11.24' btpvc

Driller: Crawford Drilling Services Well Casing Diameter: 2" PVC Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-4/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-4/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
-3 / -1		Ground Surface					4" diameter riser stick-up 2.3' ags	
1 / 3		***Well graded Sand with Gravel*** Brown fine to coarse sand (50-60%), Gravel (40-50%). Loose & dry 0-3', to compact, wet at 6'. (0'-10')	B4-1	S21 1.5'-2.5'	60"	24"	-Concrete seal 0'-1' -Bentonite seal 1'-1.5' -Sand backfill 1.5'-2.5'	
5 / 2			B4-2	S12 5'-10'	60"	20"	-Native fill 2.5'-14.5' Well screen 4.5'-14.5'	
11 / 4		***Silt*** Brown/gray fines (90%), Gravel (10%). Very compact, cohesive, non-plastic, wet. (10'-14.5')	B4-3	S13 1 0'-14.5'	12"	9"		
15		***End of Boring/Refusal at 14.5'***					Well set at 14.5'	

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: 6.87' btpvc

Driller: Crawford Drilling Services Well Casing Diameter: 2" PVC Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-5/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-5/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
ft / m		Ground Surface						4" diameter riser stick-up 2.25' ags
0		***Well graded Sand with Gravel*** Brown to gray fine to coarse Sand (50-60%) and Gravel (40-50%). Wet at 3'. (0'-10')	B5-1	S9 5'-10'	120"	41"		-Concrete seal -Bentonite seal 0.5'-1'
2								-Silica sand filter pack 1'-15'
4								
6								
8								Screen 2'-15'
10		***Poorly graded Sand*** Brown/orange medium Sand (90%) and Gravel (10%). Wet. (10'-11')		S9-2 10'-11'				
12		***Gravelly Silt with Sand*** Tan fines (50%), Sand (20%) and Gravel (30%). Very compact, non-cohesive, non-plastic, wet. (11'-18.5')	B5-2	S10/ S11 11'-18.5'	60"	34"		
14								Well set at 15'
16			B5-3		30"	24"		
18		***End of Boring/Refusal at 18.5'***						End of Boring/Refusal at 18.5'
20								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: 5.77' btpvc

Driller: Crawford Drilling Services Well Casing Diameter: 2" PVC Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-6/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-6/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
0		Ground Surface					4" diameter riser stick-up 1.6' ags	
0		***Well graded Sand with Gravel*** Tan fine to medium Sand (50-60%) and Gravel (40-50%). Moist at 5', wet at 7' (0'-7')	B6-1		60"	13"	-Concrete seal 0'-1'	
2							-Bentonite seal 1'-2'	
4							-Silica sand filter pack 2'-13'	
6 / 2			B6-2	S14 5'-7'	60"	21"		
8		***Silt*** Fines (100%) gray, wet, very compact. (7'-13')					Screen 3'-13'	
10				S14-2 7'-13'				
12			B6-3		24"	5"	Well set at 13'	
4 / 14		***End of Boring/Refusal at 13'***						End of Boring/Refusal at 13'
16								
18								
20 / 6								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe Sampler Diameter: 2" Depth to GW: 4.90' btpvc

Driller: Crawford Drilling Services Well Casing Diameter: 2" PVC Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

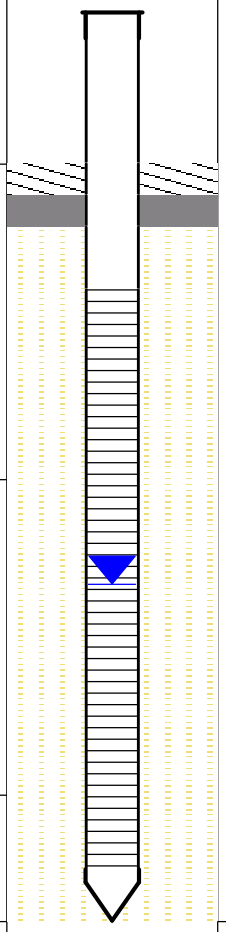
Log of Borehole/MW: B-7/MW

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-7/MW

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
-3 / -1		Ground Surface						4" diameter riser stick up 2.4'
1 / 3		***Fill*** (no sample collected) (0'-5')	B7-1		60"	6"		-Concrete seal 0'-0.5' -Bentonite seal 0.5'-1' -Silica sand filter pack 1'-12'
5 / 7 / 9 / 11 / 2		***Silty Gravel with Sand*** Light brown Fines (20%), medium to coarse Sand (40%) and Gravel (50%). Very compact, dry. (5'-12')	B7-2	S15	60"	27"		Screen 2'-12'
			B7-3		24"	No Rec.		Well set at 12'
13 / 15 / 17 / 4		***End of Boring/Refusal at 12'***						End of boring/Refusal at 12'

Drill Date: 11/29/2017 Borehole Diameter: 7" Ground Elevation: 0

Drill Method: Geoprobe/Auger Sampler Diameter: 2" Depth to GW: 6.66

Driller: Crawford Drilling Services Well Casing Diameter: N/A Date of Static GW Level: 12/12/2017

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-8

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B-8

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
ft / m		Ground Surface						
0 / 0		***Fill*** (no sample collected) Moist at 4'. (0'-4')	B8-1		60"	22"		No well set.
4		***Well graded Sand with Gravel*** Light brown medium to coarse Sand (50-60%), and Gravel (40-50%). Moist at 7', wet at 13', mottling at 12'. Very compact 5-15'. (4'-15')	B8-2	S16 5'-13'	60"	32"		
10			B8-3		60"	24"		
14		***Silty Sand with Gravel*** Dark brown fines (50-60%), Sand (25-30%), and Gravel (25%). Very compact, wet. (15'-18')	B8-4	S17 13'-18'	36"	24"		
18		***End of Boring/Refusal at 18'***						
20 / 6								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Hollow Stem Auger Sampler Diameter: 2" Depth to GW: N/A

Driller: Crawford Drilling Services Well Casing Diameter: N/A Date of Static GW Level: N/A

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
51 Portsmouth Ave.
Exeter, NH 03833
(603)773-0075

Log of Borehole/MW: B-9

Project No.: 17205

Site: Mahoney Garden Center Borehole Location: B9

Address: 115 Boston Post Road

Client: Eden Management Geologist: MK/LB

SUBSURFACE PROFILE			SAMPLE					
Depth	Symbol	Description	Core ID	Sample ID	Pen (ft)	Rec (ft)	Well Data	Comments
ft m		Ground Surface						
0 0		***Well graded Sand with Gravel*** Gray/brown to dark brown fine to medium Sand (60-80%), Gravel (20-40%). Trace fines. Moist at 4', mottling at 4'. (0'-12')	B9-1	S18 2'-5'	60"	19"		No well set.
2								
4								
6 2			B9-2	S19 5'-12'	60"	6"		
8								
10			B9-3		24"	12"		
12 4		***End of boring/refusal at 12'***						Refusal at 12'
14								
16								
18								
20 6								

Drill Date: 11/29/2017 Borehole Diameter: 2.5" Ground Elevation: 0

Drill Method: Geoprobe/Auger Sampler Diameter: 2" Depth to GW: N/A

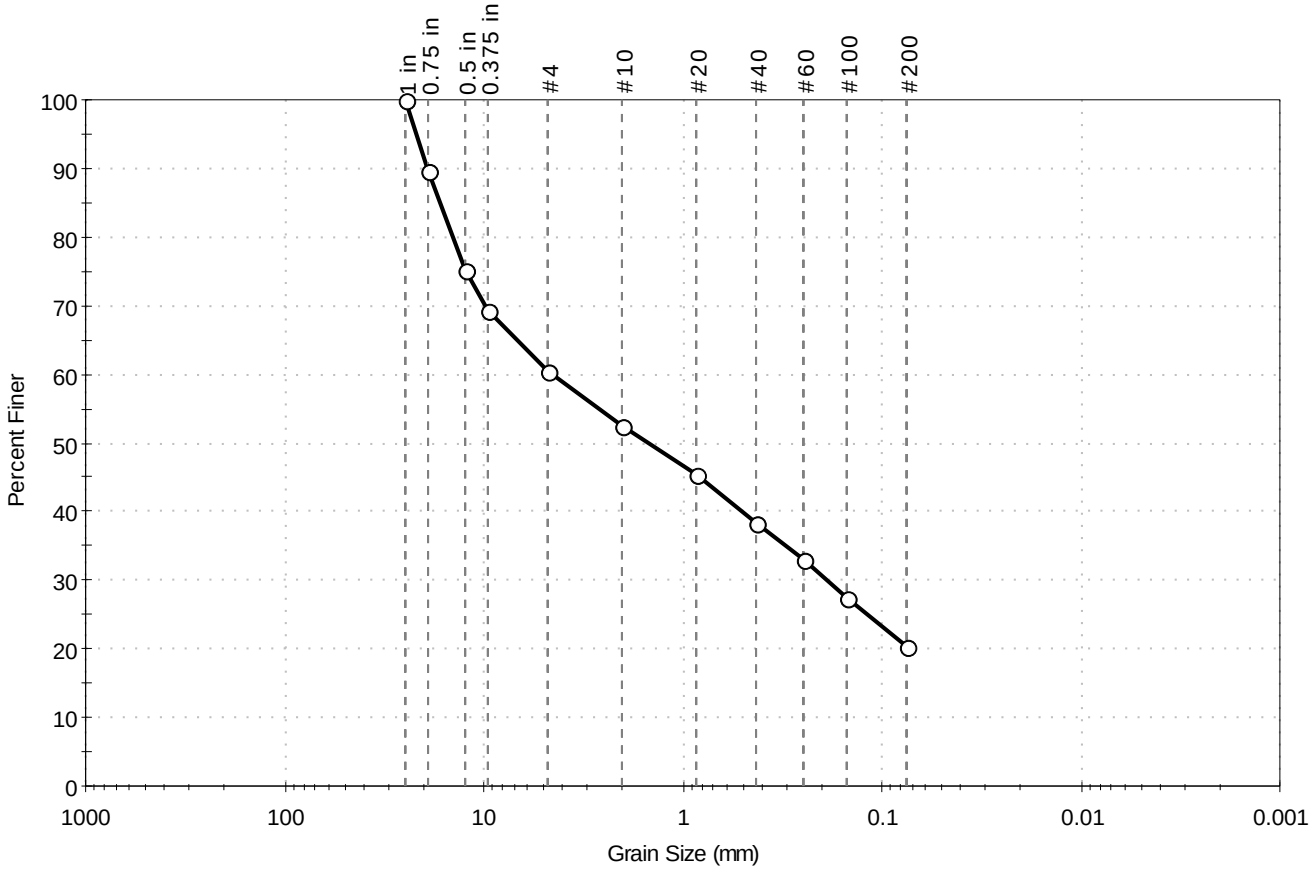
Driller: Crawford Drilling Services Well Casing Diameter: N/A Date of Static GW Level: N/A

Appendix C

Geotechnical Testing Laboratory Permeability Test Results

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1/S2	Test Date:	01/05/18	Checked By:	emm
Depth :	---	Test Id:	438665		
Test Comment:	---				
Visual Description:	Moist, greenish gray silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	39.6	40.0	20.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	90		
0.5 in	12.50	75		
0.375 in	9.50	69		
#4	4.75	60		
#10	2.00	52		
#20	0.85	45		
#40	0.42	38		
#60	0.25	33		
#100	0.15	27		
#200	0.075	20		

Coefficients

D_{85} = 16.6118 mm	D_{30} = 0.1885 mm
D_{60} = 4.5508 mm	D_{15} = N/A
D_{50} = 1.4844 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

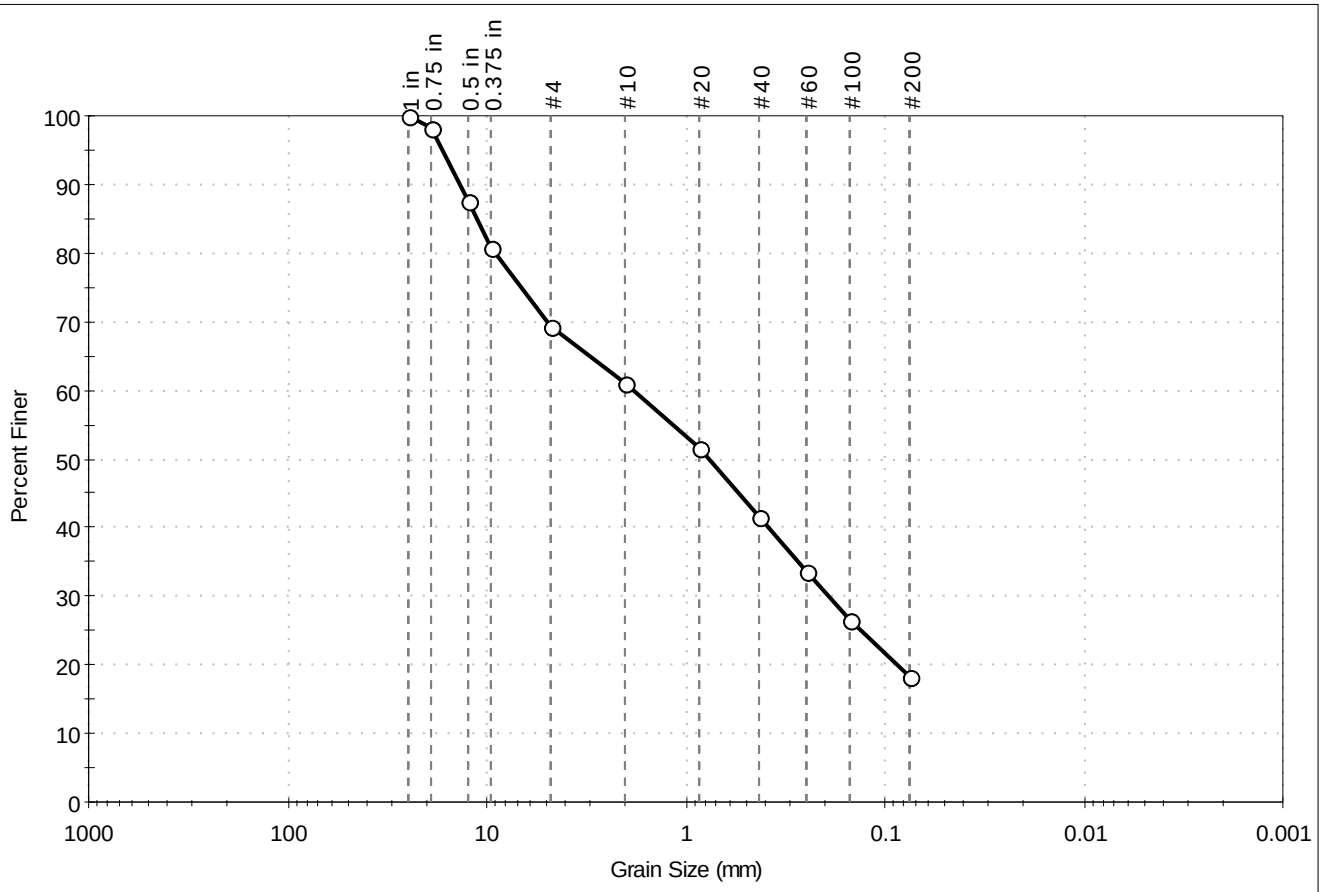
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S7	Test Date:	01/03/18	Checked By:	emm
Depth :	---	Test Id:	438666		
Test Comment:	---				
Visual Description:	Moist, gray silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	30.5	51.1	18.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	98		
0.5 in	12.50	88		
0.375 in	9.50	81		
#4	4.75	69		
#10	2.00	61		
#20	0.85	52		
#40	0.42	42		
#60	0.25	34		
#100	0.15	26		
#200	0.075	18		

Coefficients

D_{85} = 11.2567 mm	D_{30} = 0.1935 mm
D_{60} = 1.8251 mm	D_{15} = N/A
D_{50} = 0.7553 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

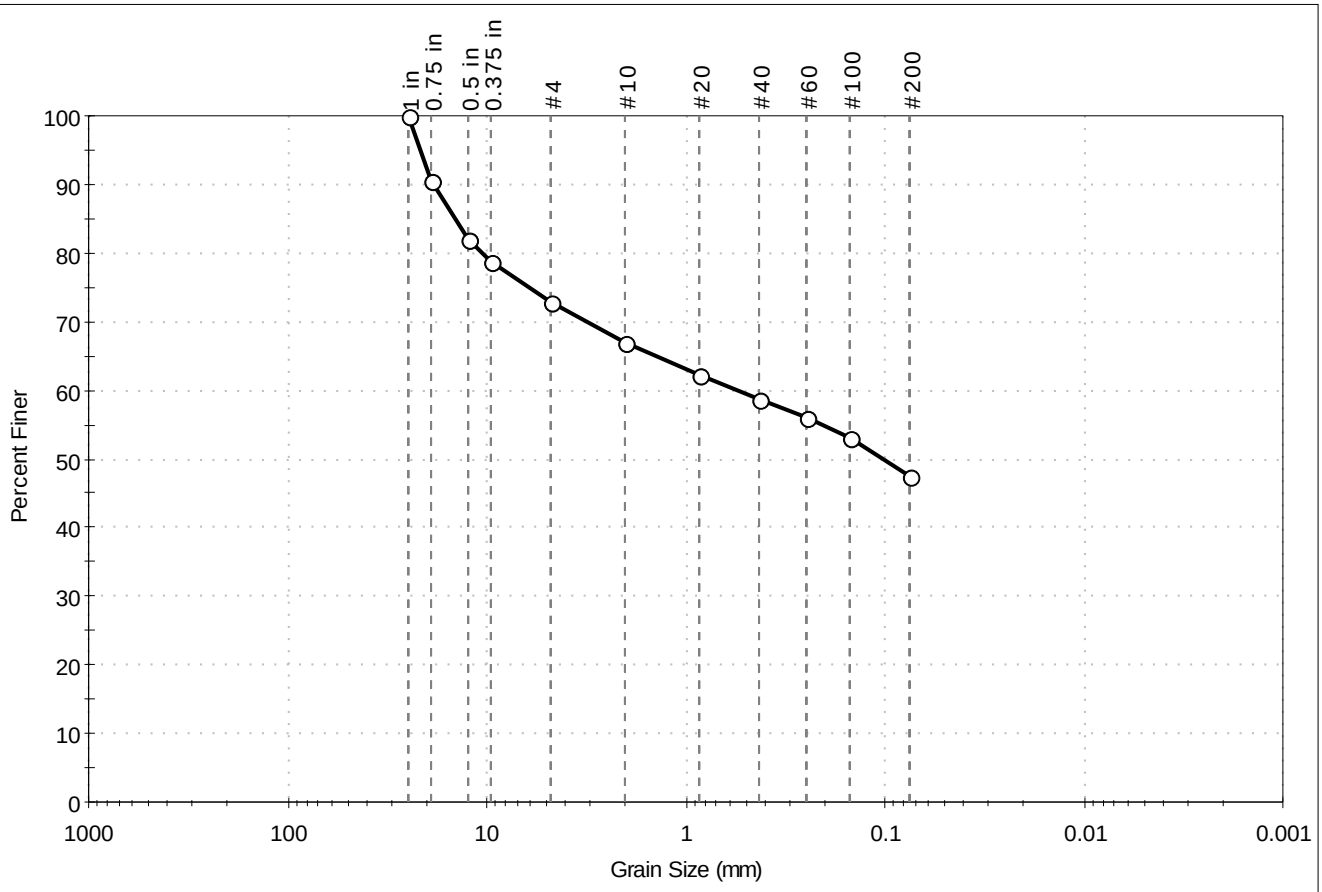
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S11	Test Date:	01/03/18	Checked By:	emm
Depth :	---	Test Id:	438667		
Test Comment:	---				
Visual Description:	Moist, brown clayey gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	27.0	25.4	47.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	91		
0.5 in	12.50	82		
0.375 in	9.50	79		
#4	4.75	73		
#10	2.00	67		
#20	0.85	62		
#40	0.42	59		
#60	0.25	56		
#100	0.15	53		
#200	0.075	48		

Coefficients

D_{85} = 14.4990 mm D_{30} = N/A

D_{60} = 0.5494 mm D_{15} = N/A

D_{50} = 0.1021 mm D_{10} = N/A

C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

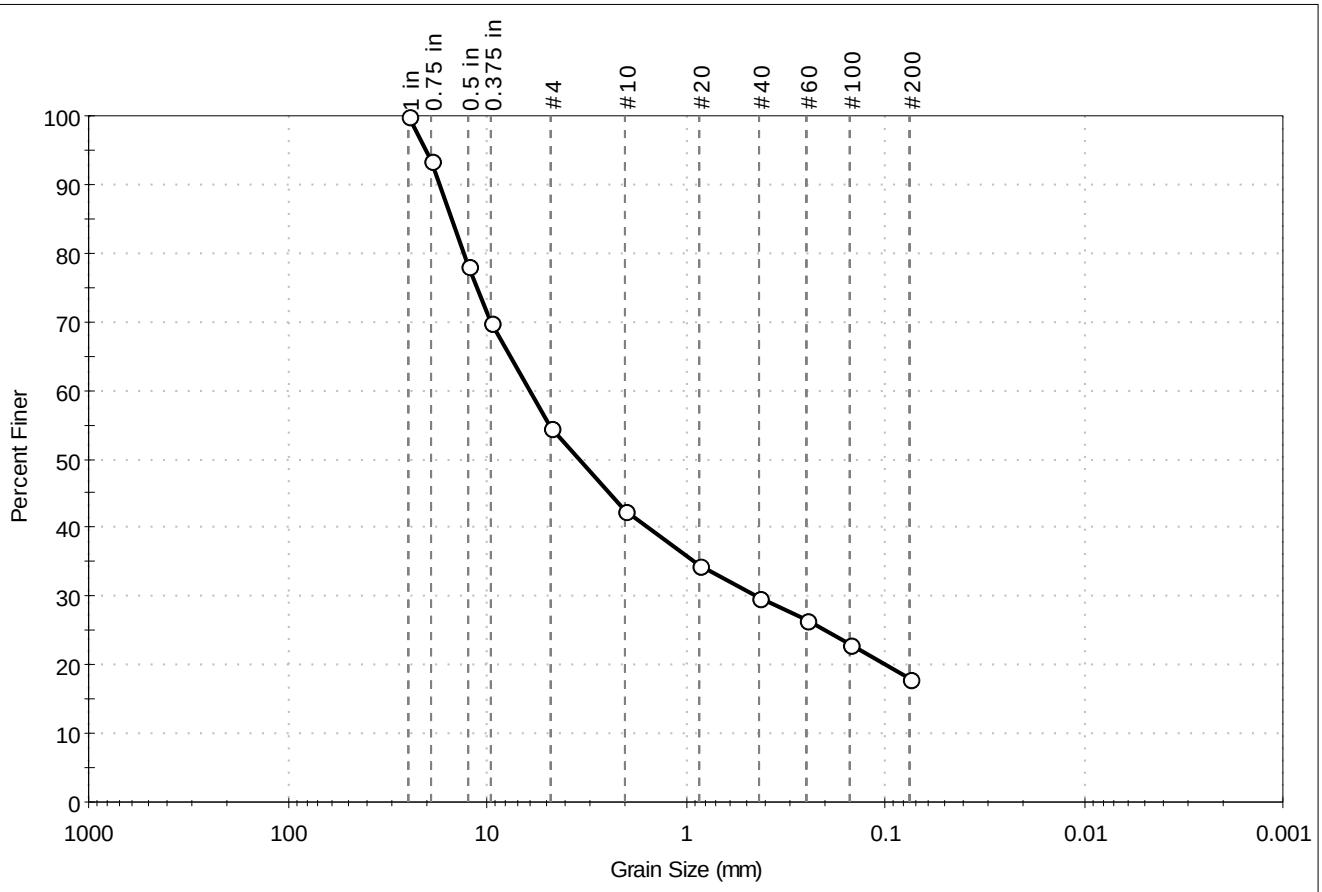
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S15	Test Date:	01/03/18	Checked By:	emm
Depth :	---	Test Id:	438668		
Test Comment:	---				
Visual Description:	Moist, gray silty gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	45.4	36.7	17.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	93		
0.5 in	12.50	78		
0.375 in	9.50	70		
#4	4.75	55		
#10	2.00	43		
#20	0.85	34		
#40	0.42	30		
#60	0.25	26		
#100	0.15	23		
#200	0.075	18		

Coefficients

D_{85} = 15.0857 mm	D_{30} = 0.4425 mm
D_{60} = 6.0615 mm	D_{15} = N/A
D_{50} = 3.4205 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

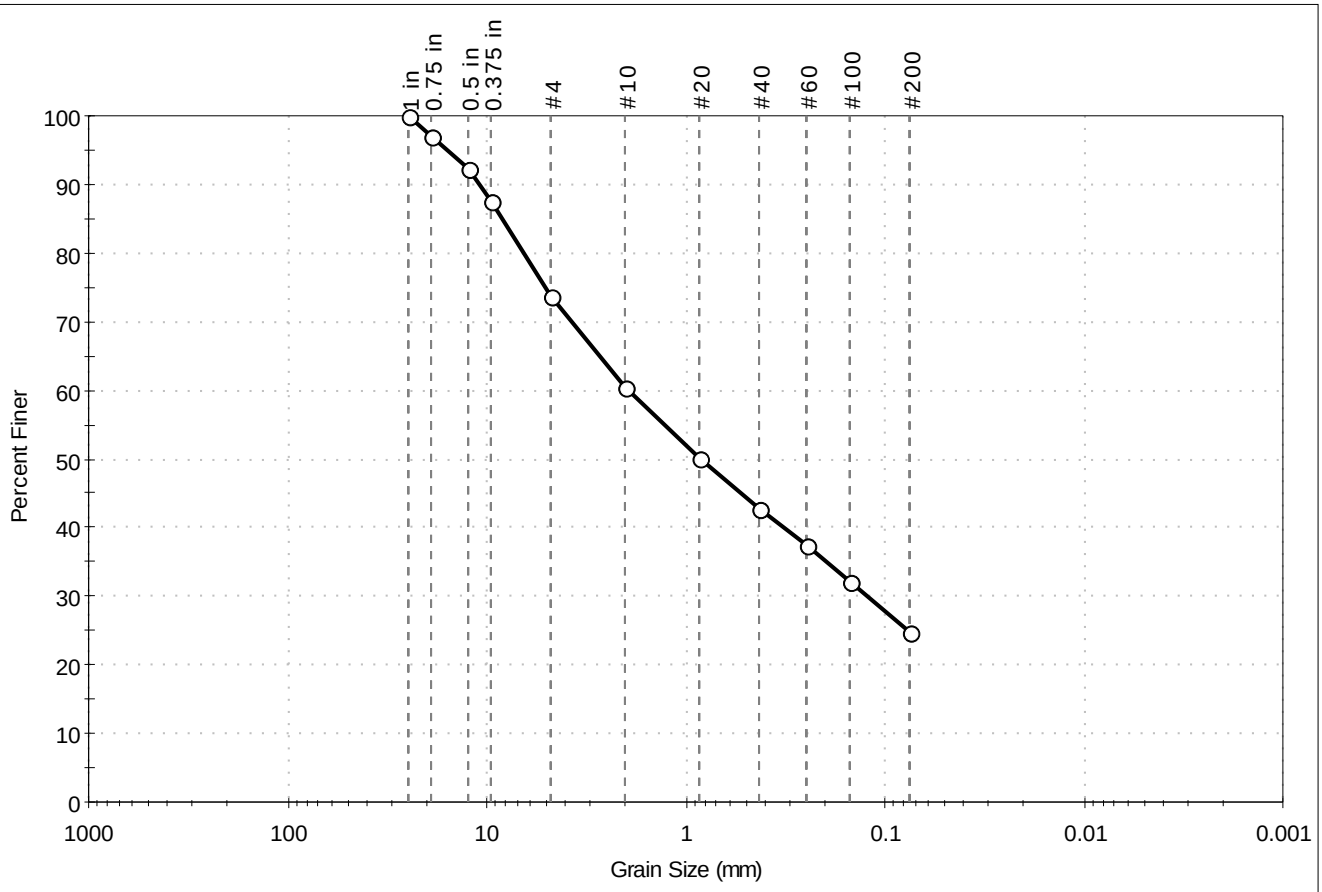
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S17	Test Date:	01/03/18	Checked By:	emm
Depth :	---	Test Id:	438669		
Test Comment:	---				
Visual Description:	Moist, dark brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	26.1	49.2	24.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	97		
0.5 in	12.50	92		
0.375 in	9.50	88		
#4	4.75	74		
#10	2.00	60		
#20	0.85	50		
#40	0.42	43		
#60	0.25	38		
#100	0.15	32		
#200	0.075	25		

Coefficients

D_{85} = 8.3075 mm	D_{30} = 0.1229 mm
D_{60} = 1.9333 mm	D_{15} = N/A
D_{50} = 0.8355 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

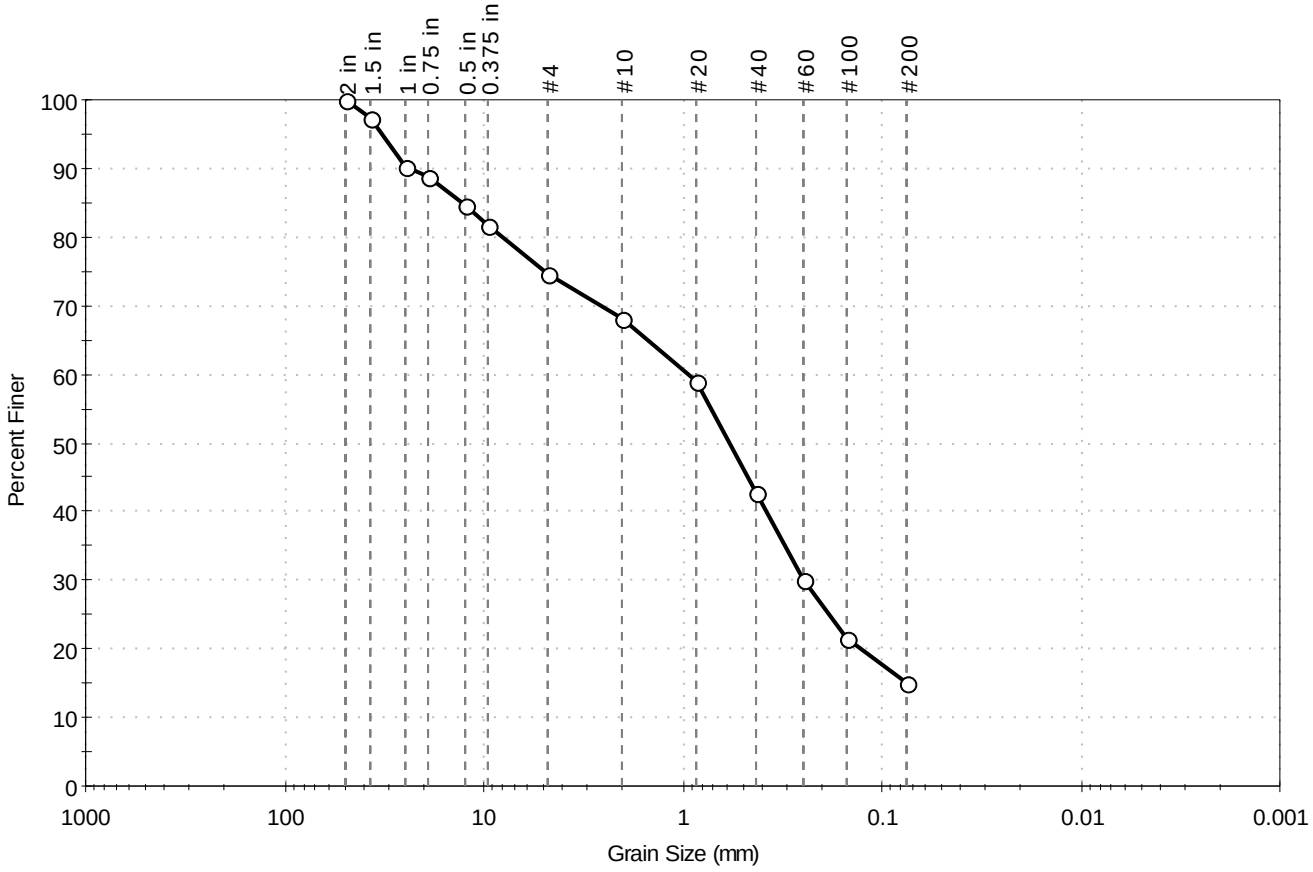
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management				
Project:	Wayland				
Location:				Project No:	GTX-307448
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	S20	Test Date:	01/05/18	Checked By:	emm
Depth :	---	Test Id:	438670		
Test Comment:	---				
Visual Description:	Moist, dark brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	25.2	59.8	15.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	97		
1 in	25.00	90		
0.75 in	19.00	89		
0.5 in	12.50	85		
0.375 in	9.50	82		
#4	4.75	75		
#10	2.00	68		
#20	0.85	59		
#40	0.42	43		
#60	0.25	30		
#100	0.15	22		
#200	0.075	15		

Coefficients

D_{85} = 13.0232 mm
D_{30} = 0.2499 mm
D_{60} = 0.9285 mm
D_{15} = 0.0753 mm
D_{50} = 0.5772 mm
D_{10} = N/A
C_u = N/A
C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	12/28/2017	Tested By:	eec/trm
End Date:	1/9/2018	Checked By:	emm
Boring #:	---		
Sample #:	S-10		
Depth:	---		
Visual Description:	Moist, grayish brown silt with sand		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084

Constant Volume

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	---

Sample Preparation: Test specimen compacted with moderate effort at as-received moisture content. Material >3/8-inch removed from sample prior to testing. Trimmings moisture content = 22.6%

Assumed Specific Gravity: 2.70

Parameter	Initial	Final
Height, in	2.55	2.35
Diameter, in	2.96	2.80
Area, in^2	6.88	6.16
Volume, in^3	17.5	14.5
Mass, g	512.7	498.4
Bulk Density, pcf	111.1	130.9
Moisture Content, %	22.6	19.2
Dry Density, pcf	90.6	109.8
Degree of Saturation, %	71	97

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.68	Increased Cell Pressure, psi:	95.90	Cell Pressure Increment, psi:	5.22
Sample Pressure, psi:	85.08	Corresponding Sample Pressure, psi:	90.17	Sample Pressure Increment, psi:	5.09
				B Coefficient:	0.98

FLOW DATA

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time,	Gradient	Permeability K,	Temp,		Permeability K @ 20 °C,
		Cell	Sample	Z_1	Z_2	Z_1-Z_2	sec		cm/sec	°C	R_t	cm/sec
1/3	1	90.7	85.1	11.5	10.5	1.0	38	24.3	9.0E-07	19.7	1.008	9.1E-07
1/3	2	90.7	85.1	11.5	10.5	1.0	35	24.3	9.8E-07	19.7	1.008	9.8E-07
1/3	3	90.7	85.1	11.5	10.5	1.0	34	24.3	1.0E-06	19.7	1.008	1.0E-06
1/3	4	90.7	85.1	11.5	10.5	1.0	36	24.3	9.5E-07	19.7	1.008	9.6E-07

PERMEABILITY AT 20° C: 9.6 x 10^{-7} cm/sec (@ 5 psi effective stress)

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	12/27/2017	Tested By:	eec/trm
End Date:	1/8/2018	Checked By:	emm
Boring #:	---		
Sample #:	S-13		
Depth:	---		
Visual Description:	Moist, pale brown silt		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084

Constant Volume

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	---

Sample Preparation: Test specimen compacted with moderate effort at as-received moisture content. Material >3/8-inch removed from sample prior to testing. Trimmings moisture content = 17.6%

Assumed Specific Gravity: 2.70

Parameter	Initial	Final
Height, in	2.10	2.08
Diameter, in	2.81	2.79
Area, in^2	6.20	6.11
Volume, in^3	13.0	12.7
Mass, g	461.7	458.3
Bulk Density, pcf	134.8	137.0
Moisture Content, %	16.4	15.5
Dry Density, pcf	115.8	118.6
Degree of Saturation, %	97	99

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.32	Increased Cell Pressure, psi:	95.00	Cell Pressure Increment, psi:	4.68
Sample Pressure, psi:	84.73	Corresponding Sample Pressure, psi:	89.32	Sample Pressure Increment, psi:	4.59
				B Coefficient:	0.98

FLOW DATA

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time,	Gradient	Permeability K,	Temp,		Permeability K @ 20 °C,
		Cell	Sample	Z_1	Z_2	Z_1-Z_2	sec		cm/sec	°C	R_t	cm/sec
	1	90.3	84.7	23.0	18.0	5.0	34	54.9	2.4E-06	19.7	1.008	2.4E-06
1/0	2	90.3	84.7	23.0	18.0	5.0	36	54.9	2.3E-06	19.7	1.008	2.3E-06
1/0	3	90.3	84.7	23.0	18.0	5.0	33	54.9	2.5E-06	19.7	1.008	2.5E-06
1/0	4	90.3	84.7	23.0	18.0	5.0	36	54.9	2.3E-06	19.7	1.008	2.3E-06

PERMEABILITY AT 20° C: 2.4 x 10^{-6} cm/sec (@ 5 psi effective stress)

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/15/18	Tested By:	eec
End Date:	01/15/18	Checked By:	emm
Boring #:	---		
Sample #:	S12		
Depth:	---		
Visual Description:	Moist, olive brown sand with silt and gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

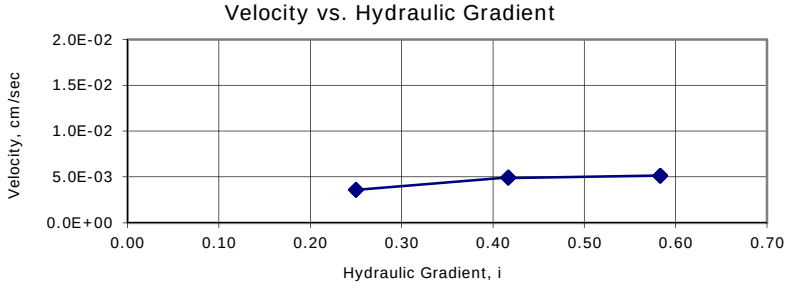
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	1.20	1.20
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	15.1	15.1
Mass, g	419	506
Bulk Density, pcf	105.9	127.8
Moisture Content, %	0.5	19.8
Dry Density, pcf	105.3	106.7
Degree of Saturation, %	---	95.4
Void Ratio, e	---	0.55

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/15	1	2.9	10	0.29	0.25	1.4E-02	14.2	1.163	1.7E-02
1/15	2	2.9	10	0.29	0.25	1.4E-02	14.2	1.163	1.7E-02
1/15	3	2.9	10	0.29	0.25	1.4E-02	14.2	1.163	1.7E-02
1/15	4	4.0	10	0.40	0.42	1.2E-02	14.2	1.163	1.4E-02
1/15	5	4.0	10	0.40	0.42	1.2E-02	14.2	1.163	1.4E-02
1/15	6	4.0	10	0.40	0.42	1.2E-02	14.2	1.163	1.4E-02
1/15	7	4.2	10	0.42	0.58	8.8E-03	14.2	1.163	1.0E-02
1/15	8	4.1	10	0.41	0.58	8.8E-03	14.2	1.163	1.0E-02
1/15	9	4.2	10	0.42	0.58	8.8E-03	14.2	1.163	1.0E-02



PERMEABILITY @ 20 °C = 1.4×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/11/18	Tested By:	eec
End Date:	01/12/18	Checked By:	emm
Boring #:	---		
Sample #:	S6		
Depth:	---		
Visual Description:	Moist, gray silty sand with gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

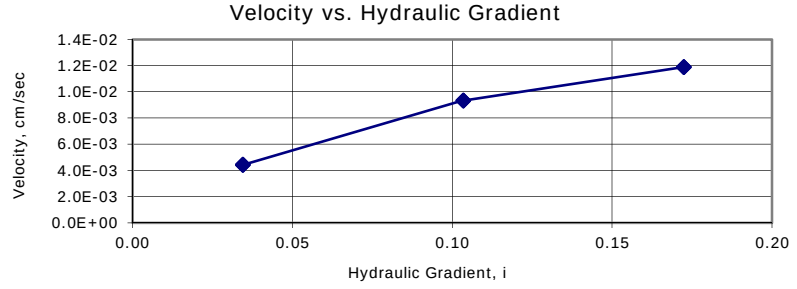
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	3.00	2.90
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	37.7	36.4
Mass, g	934.0	1180.0
Bulk Density, pcf	94.4	123.4
Moisture Content, %	0.6	24.6
Dry Density, pcf	93.8	99.0
Degree of Saturation, %	---	97.2
Void Ratio, e	---	0.67

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/12	1	3.6	10	0.36	0.03	1.3E-01	13.9	1.173	1.5E-01
1/12	2	3.6	10	0.36	0.03	1.3E-01	13.9	1.173	1.5E-01
1/12	3	3.6	10	0.36	0.03	1.3E-01	13.9	1.173	1.5E-01
1/12	4	7.6	10	0.76	0.10	9.0E-02	13.9	1.173	1.1E-01
1/12	5	7.6	10	0.76	0.10	9.0E-02	13.9	1.173	1.1E-01
1/12	6	7.6	10	0.76	0.10	9.0E-02	13.9	1.173	1.1E-01
1/12	7	9.6	10	0.96	0.17	6.9E-02	13.9	1.173	8.1E-02
1/12	8	9.7	10	0.97	0.17	6.9E-02	13.9	1.173	8.1E-02
1/12	9	9.6	10	0.96	0.17	6.9E-02	13.9	1.173	8.1E-02



PERMEABILITY @ 20 °C = 1.1×10^{-1} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/11/18	Tested By:	eec
End Date:	01/12/18	Checked By:	emm
Boring #:	---		
Sample #:	S9		
Depth:	---		
Visual Description:	Moist, gray silty sand with gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

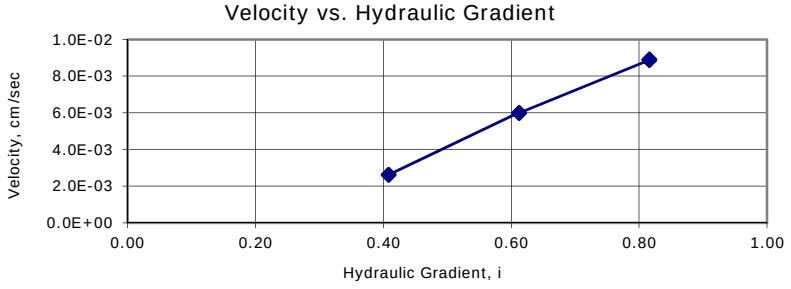
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	1.00	0.98
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	12.6	12.3
Mass, g	325.9	410.0
Bulk Density, pcf	98.8	126.8
Moisture Content, %	0.2	21.8
Dry Density, pcf	98.6	104.1
Degree of Saturation, %	---	98.1
Void Ratio, e	---	0.59

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/11	1	2.1	10	0.21	0.41	6.4E-03	13.7	1.179	7.6E-03
1/11	2	2.1	10	0.21	0.41	6.4E-03	13.7	1.179	7.5E-03
1/11	3	2.1	10	0.21	0.41	6.4E-03	13.7	1.179	7.6E-03
1/11	4	4.9	10	0.49	0.61	9.8E-03	13.7	1.179	1.2E-02
1/11	5	4.9	10	0.49	0.61	9.8E-03	13.7	1.179	1.2E-02
1/11	6	4.8	10	0.48	0.61	9.8E-03	13.7	1.179	1.2E-02
1/11	7	7.2	10	0.72	0.82	1.1E-02	13.7	1.179	1.3E-02
1/11	8	7.2	10	0.72	0.82	1.1E-02	13.7	1.179	1.3E-02
1/11	9	7.2	10	0.72	0.82	1.1E-02	13.7	1.179	1.3E-02



PERMEABILITY @ 20 °C = 1.1×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/12/18	Tested By:	eec
End Date:	01/12/18	Checked By:	emm
Boring #:	---		
Sample #:	S-16		
Depth:	---		
Visual Description:	Moist, gray silty gravel with sand		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

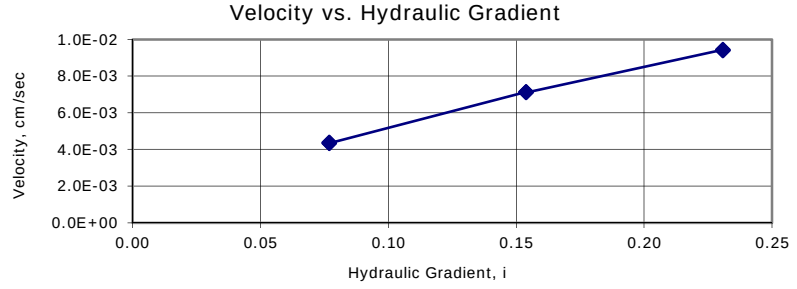
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	2.80	2.60
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	35.2	32.7
Mass, g	902.0	1100.0
Bulk Density, pcf	97.7	128.3
Moisture Content, %	0.5	20.9
Dry Density, pcf	97.1	106.0
Degree of Saturation, %	---	99.1
Void Ratio, e	---	0.56

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/12	1	3.5	10	0.35	0.08	5.6E-02	17.0	1.079	6.1E-02
1/12	2	3.6	10	0.36	0.08	5.7E-02	17.0	1.079	6.1E-02
1/12	3	3.5	10	0.35	0.08	5.7E-02	17.0	1.079	6.1E-02
1/12	4	5.8	10	0.58	0.15	4.6E-02	17.0	1.079	5.0E-02
1/12	5	5.8	10	0.58	0.15	4.6E-02	17.0	1.079	5.0E-02
1/12	6	5.8	10	0.58	0.15	4.6E-02	17.0	1.079	5.0E-02
1/12	7	7.6	10	0.76	0.23	4.1E-02	17.0	1.079	4.4E-02
1/12	8	7.6	10	0.76	0.23	4.1E-02	17.0	1.079	4.4E-02
1/12	9	7.6	10	0.76	0.23	4.1E-02	17.0	1.079	4.4E-02



PERMEABILITY @ 20 °C = 5.2×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/11/18	Tested By:	eec
End Date:	01/12/18	Checked By:	emm
Boring #:	---		
Sample #:	S20		
Depth:	---		
Visual Description:	Moist, dark brown silty sand with gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

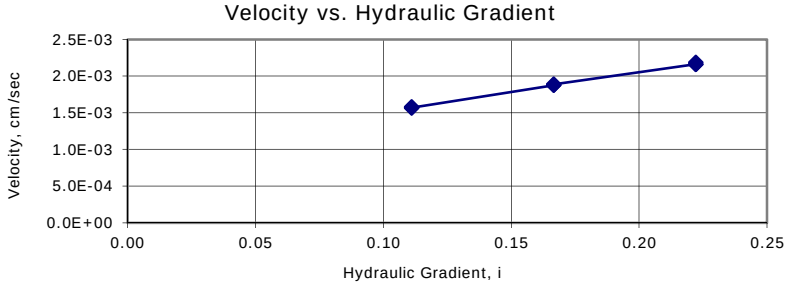
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	3.70	3.60
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	46.5	45.2
Mass, g	1100	1420
Bulk Density, pcf	90.1	119.6
Moisture Content, %	0.9	27.5
Dry Density, pcf	89.3	93.8
Degree of Saturation, %	---	95.5
Void Ratio, e	---	0.76

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/10	1	1.3	10	0.13	0.11	1.4E-02	13.6	1.183	1.7E-02
1/10	2	1.3	10	0.13	0.11	1.4E-02	13.6	1.183	1.7E-02
1/10	3	1.3	10	0.13	0.11	1.4E-02	13.6	1.183	1.7E-02
1/10	4	1.5	10	0.15	0.17	1.1E-02	13.6	1.183	1.3E-02
1/10	5	1.5	10	0.15	0.17	1.1E-02	13.6	1.183	1.3E-02
1/10	6	1.5	10	0.15	0.17	1.1E-02	13.6	1.183	1.3E-02
1/10	7	1.8	10	0.18	0.22	9.7E-03	13.6	1.183	1.1E-02
1/10	8	1.8	10	0.18	0.22	9.7E-03	13.6	1.183	1.1E-02
1/10	9	1.8	10	0.18	0.22	9.8E-03	13.6	1.183	1.2E-02



PERMEABILITY @ 20 °C = 1.4×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/15/18	Tested By:	eec
End Date:	01/16/18	Checked By:	emm
Boring #:	---		
Sample #:	S1/S2		
Depth:	---		
Visual Description:	Moist, olive gray sand with silt and gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

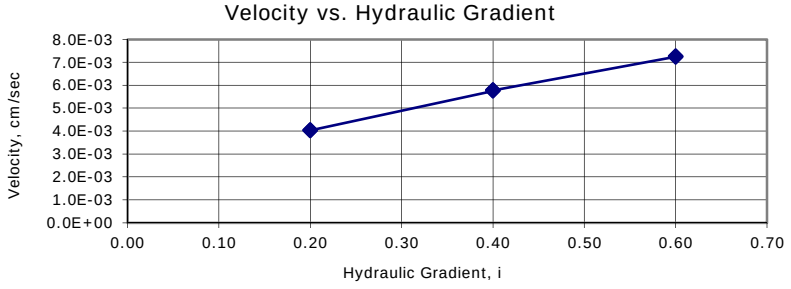
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	1.10	1.00
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	13.8	12.6
Mass, g	380.0	436.0
Bulk Density, pcf	104.7	132.2
Moisture Content, %	0.3	17.8
Dry Density, pcf	104.4	112.2
Degree of Saturation, %	---	99.4
Void Ratio, e	---	0.47

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/15	1	3.3	10	0.33	0.20	2.0E-02	14.2	1.163	2.3E-02
1/15	2	3.3	10	0.33	0.20	2.0E-02	14.2	1.163	2.4E-02
1/15	3	3.3	10	0.33	0.20	2.0E-02	14.2	1.163	2.3E-02
1/15	4	4.7	10	0.47	0.40	1.4E-02	14.2	1.163	1.7E-02
1/15	5	4.7	10	0.47	0.40	1.4E-02	14.2	1.163	1.7E-02
1/15	6	4.7	10	0.47	0.40	1.4E-02	14.2	1.163	1.7E-02
1/15	7	5.9	10	0.59	0.60	1.2E-02	14.2	1.163	1.4E-02
1/15	8	5.9	10	0.59	0.60	1.2E-02	14.2	1.163	1.4E-02
1/15	9	5.9	10	0.59	0.60	1.2E-02	14.2	1.163	1.4E-02



PERMEABILITY @ 20 °C = 1.8×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Geosphere Env. Management		
Project Name:	Wayland		
Project Location:	---		
GTX #:	307448		
Start Date:	01/15/18	Tested By:	eec
End Date:	01/16/18	Checked By:	emm
Boring #:	---		
Sample #:	S19		
Depth:	---		
Visual Description:	Moist, olive brown sand with silt and gravel		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

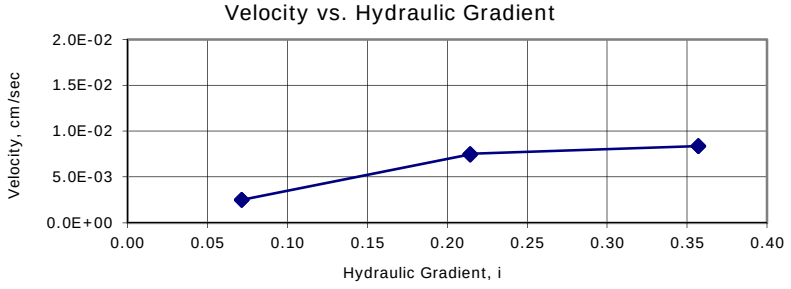
Sample Information:

Maximum Dry Density:	--- pcf
Optimum Moisture Content:	--- %
Compaction Test Method:	---
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Test specimen compacted with moderate effort at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing.

Parameter	Initial	Final
Height, in	1.50	1.40
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	18.8	17.6
Mass, g	451.0	565.0
Bulk Density, pcf	91.1	122.3
Moisture Content, %	0.5	25.4
Dry Density, pcf	90.7	97.6
Degree of Saturation, %	---	96.7
Void Ratio, e	---	0.70

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
1/15	1	2.0	10	0.20	0.07	3.5E-02	12.7	1.214	4.2E-02
1/15	2	2.1	10	0.21	0.07	3.5E-02	12.7	1.214	4.3E-02
1/15	3	2.0	10	0.20	0.07	3.5E-02	12.7	1.214	4.2E-02
1/15	4	6.1	10	0.61	0.21	3.5E-02	12.7	1.214	4.2E-02
1/15	5	6.0	10	0.60	0.21	3.5E-02	12.7	1.214	4.2E-02
1/15	6	6.1	10	0.61	0.21	3.5E-02	12.7	1.214	4.3E-02
1/15	7	6.8	10	0.68	0.36	2.3E-02	12.7	1.214	2.8E-02
1/15	8	6.8	10	0.68	0.36	2.3E-02	12.7	1.214	2.9E-02
1/15	9	6.8	10	0.68	0.36	2.3E-02	12.7	1.214	2.8E-02



PERMEABILITY @ 20 °C = 3.8×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

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a subsidiary of Geocomp Corporation

SOIL CHAIN OF CUSTODY & TEST REQUEST

CLIENT	
Company: GEOSPHERE	
Address: 51 PORTSMOUTH AVE	
City, State, Zip: EXETER, NH 03833	
Contact: DAVID NIEMEYER	E-mail: dniemeyer@
Phone: 603-773-0075 x12	Fax: geosphere nh.com

PROJECT	
Project Name: WAYLAND	
Address:	Client Project #: 17205
City, State, Zip:	
On-site Contact:	E-mail:
Phone:	Fax:

GeoTesting Express, Inc.
1145 Massachusetts Avenue
Boxborough, MA 01719
800 434 1062 Toll Free
978 635 0266 Fax

2662 Holcomb Bridge Road, Suite 310
Alpharetta, GA 30022
770 645 6575 Tel
770 645 6570 Fax

www.geotesting.com

INVOICE (complete if different from client)	
Company:	
Address:	
City, State, Zip:	
Contact:	E-mail:
Phone:	Fax:

GENERAL		
Purchase Order #: 17205	GTX Sales Order #:	
Shipped By:	Date Shipped:	
Mode of Shipment:	Requested Turnaround:	
Send Results To:	☒ CLIENT OFFICE	☐ PROJECT OFFICE
Send Results Via:	☒ E-MAIL ☐ FAX	☐ VERBAL ☐ HARD COPY

	SOIL *please include boring # and depth if known — Sample ID	Atterberg Limits (ASTM D 4318)	California Bearing Ratio (ASTM D 1883) *specify conditions below	USCS – Classification (ASTM D 2487)	Density (ASTM D 2937)	Direct Shear (ASTM D 3080) *specify conditions below	Direct Simple Shear (ASTM D 6528) *specify conditions below	Electrical Resistivity (ASTM G 57)	Grain Size (ASTM D 422) Sieve Only / Sieve & Hydrometer please circle one	Incremental Consolidation (ASTM D 2435)	Moisture Content (ASTM D 2216)	Organic Content (ASTM D 2974)	Permeability/ Hydraulic Conductivity (Fixed Wall – ASTM D 2434) (Flexible Wall – ASTM D 5084) please circle one	Ph (ASTM D 4972)	Proctor Compaction (Standard – ASTM D 698) (Modified – ASTM D 1557) please circle one	Specific Gravity (ASTM D 854)	Triaxial Shear (UU – ASTM D 2850) (CU – ASTM D 4767) (CD – US COE EM1110) *specify conditions below please circle one	Unconfined Compression (ASTM D 2166)	Other:	Other:
1	Combine S1																			
2	S2			X					X				X							
3	S3																			
4	S4																			
5	S5																			
6	S6												X							
7	S7			X					X											

*Specify Test Conditions (Undisturbed or Remolded, Density and moisture, Test Normal Loads, Test Confining Stresses, etc.):
Desired Tests: 1) Permeability, moderate compaction (Proctor); Sieve (no hydrometer)
Call to discuss need for Atterberg Limits, Hydrometer for classification, and compositing.

AUTHORIZE BY SIGNING AND DATING:
SIGNATURE: [signature] PRINT NAME: DAVID NIEMEYER DATE: 12/12/17

P1/3

Relinquished By: Matthew W. Ruof	DATE: 12/13/17 2:41pm	Received By: [signature]	DATE: 12/13/17
	TIME:		TIME: 2:40PM
Relinquished By:	DATE:	Received By:	DATE:
	TIME:		TIME:

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SOIL CHAIN OF CUSTODY & TEST REQUEST

CLIENT			
Company:	GEOSPHERE		
Address:	51 PORTSMOUTH AVE		
City, State, Zip:	EXETER, NH 03833		
Contact:	DAVID NIEMEYER	E-mail:	dniemeyer@
Phone:	603-773-0075 x12	Fax:	geosphere.nh.com

PROJECT			
Project Name:	WAYLAND		
Address:		Client Project #:	17205
City, State, Zip:			
On-site Contact:		E-mail:	
Phone:		Fax:	

GeoTesting Express, Inc.
1145 Massachusetts Avenue
Boxborough, MA 01719
800 434 1062 Toll Free
978 635 0266 Fax

2662 Holcomb Bridge Road, Suite 310
Alpharetta, GA 30022
770 645 6575 Tel
770 645 6570 Fax

www.geotesting.com

INVOICE (complete if different from client)			
Company:			
Address:			
City, State, Zip:			
Contact:		E-mail:	
Phone:		Fax:	

GENERAL			
Purchase Order #:	17205	GTX Sales Order #:	
Shipped By:		Date Shipped:	
Mode of Shipment:		Requested Turnaround:	
Send Results To:	☒ CLIENT OFFICE	☐ PROJECT OFFICE	
Send Results Via:	☒ E-MAIL ☐ FAX	☐ VERBAL	☐ HARD COPY

	SOIL *please include boring # and depth if known — Sample ID	Atterberg Limits (ASTM D 4318)	California Bearing Ratio (ASTM D 1883) *specify conditions below	USCS – Classification (ASTM D 2487)	Density (ASTM D 2937)	Direct Shear (ASTM D 3080) *specify conditions below	Direct Simple Shear (ASTM D 6528) *specify conditions below	Electrical Resistivity (ASTM G 57)	Grain Size (ASTM D 422) Sieve Only / Sieve & Hydrometer please circle one	Incremental Consolidation (ASTM D 2435)	Moisture Content (ASTM D 2216)	Organic Content (ASTM D 2974)	Permeability/ Hydraulic Conductivity (Fixed Wall - ASTM D 2434) (Flexible Wall – ASTM D 5084) please circle one	Ph (ASTM D 4972)	Proctor Compaction (Standard – ASTM D 698) (Modified – ASTM D 1557) please circle one	Specific Gravity (ASTM D 854)	Triaxial Shear (UU – ASTM D 2850) (CU – ASTM D 4767) (CD – US COE EM1110) *specify conditions below please circle one	Unconfined Compression (ASTM D 2166)	Other:	Other:
1	S8																			
2	S9												X							
3	S10												X							
4	S11			X					X											
5	S12												X							
6	S13												X(fw)							
7	S14																			

*Specify Test Conditions (Undisturbed or Remolded, Density and moisture, Test Normal Loads, Test Confining Stresses, etc.):
Desired Tests: 1) Permeability, moderate compaction (Priority); Sieve (no hydrometer)
Call to discuss need for Atterberg Limits, Hydrometer for classification, and compositing.

AUTHORIZE BY SIGNING AND DATING:

SIGNATURE: _____ **PRINT NAME:** _____ **DATE:** _____

P2/3

Relinquished By: Matthew W. Kropf	**DATE:** 12/13/17 **TIME:** 241 pm	**Received By:**	**DATE:** 12/14/17 **TIME:** 8:40
Relinquished By:	**DATE:** **TIME:**	**Received By:**	**DATE:** **TIME:**

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SOIL CHAIN OF CUSTODY & TEST REQUEST

CLIENT	
Company: GEOSPHERE	
Address: 51 PORTSMOUTH AVE	
City, State, Zip: EXETER, NH 03833	
Contact: DAVID NIEMEYER	E-mail: dniemeyer@geosphere nh.com
Phone: 603-773-0075 x12	Fax:

PROJECT	
Project Name: WAYLAND	
Address:	Client Project #: 17205
City, State, Zip:	
On-site Contact:	E-mail:
Phone:	Fax:

GeoTesting Express, Inc.
1145 Massachusetts Avenue
Boxborough, MA 01719
800 434 1062 Toll Free
978 635 0266 Fax

2662 Holcomb Bridge Road, Suite 310
Alpharetta, GA 30022
770 645 6575 Tel
770 645 6570 Fax

www.geotesting.com

INVOICE (complete if different from client)	
Company:	
Address:	
City, State, Zip:	
Contact:	E-mail:
Phone:	Fax:

GENERAL		
Purchase Order #: 17205		GTX Sales Order #:
Shipped By:		Date Shipped:
Mode of Shipment:		Requested Turnaround:
Send Results To:	☒ CLIENT OFFICE	☐ PROJECT OFFICE
Send Results Via:	☒ E-MAIL ☐ FAX	☐ VERBAL ☐ HARD COPY

SOIL *please include boring # and depth if known	Sample ID	Atterberg Limits (ASTM D 4318)	California Bearing Ratio (ASTM D 1883) *specify conditions below	USCS – Classification (ASTM D 2487)	Density (ASTM D 2937)	Direct Shear (ASTM D 3080) *specify conditions below	Direct Simple Shear (ASTM D 6528) *specify conditions below	Electrical Resistivity (ASTM G 57)	Grain Size (ASTM D 422) (Sieve Only) Sieve & Hydrometer please circle one	Incremental Consolidation (ASTM D 2435)	Moisture Content (ASTM D 2216)	Organic Content (ASTM D 2974)	Permeability/ Hydraulic Conductivity (Fixed Wall - ASTM D 2434) (Flexible Wall – ASTM D 5084) please circle one	Ph (ASTM D 4972)	Proctor Compaction (Standard – ASTM D 698) (Modified – ASTM D 1557) please circle one	Specific Gravity (ASTM D 854)	Triaxial Shear (UU – ASTM D 2850) (CU – ASTM D 4767) (CD – US COE EM1110) *specify conditions below please circle one	Unconfined Compression (ASTM D 2166)	Other:	Other:
1	S15			X					X											
2	S16												X							
3	S17			X					X											
4	S19												X							
5	S20			X					X				X							
6																				
7																				

*Specify Test Conditions (Undisturbed or Remolded, Density and moisture, Test Normal Loads, Test Confining Stresses, etc.):
Desired Tests: 1) Permeability, moderate compaction (PRIORITY); Sieve (no hydrometer)
Call to discuss need for Atterberg Limits, Hydrometer for classification, and compositing.

AUTHORIZE BY SIGNING AND DATING:

SIGNATURE: _____ PRINT NAME: _____ DATE: _____

P3/3

Relinquished By: Matthew W. Kugh	DATE: 12/13/17	Received By:	DATE: 12/13/17
	TIME: 2:40 pm		TIME: 2:40
Relinquished By:	DATE:	Received By:	DATE:
	TIME:		TIME:

Appendix D

Groundwater Model Summary Report
J. Matthew Davis & Associates, LLC

ADDENDUM TO:

HYDROGEOLOGICAL REPORT:
113-119 Boston Post Road in Wayland Massachusetts
Wayland, MA.

J. Matthew Davis & Associates, LLC
2 Maple St
Durham, NH

Submitted to:

Geosphere Environmental Management, Inc.
Exeter, NH

June 2018

INTRODUCTION

This report summarizes the groundwater model development, calibration, and simulation results for proposed leachfields at 113-119 Boston Post Road in Wayland Massachusetts (the "Site"). The primary purposes of the groundwater model are to:

- Synthesize hydrogeologic data available for the Site. These data were provided by Geosphere Environmental Management, Inc (GEOSPHERE) and obtained from Mass GIS.
- Using the data and standard groundwater model techniques, provide the following:
  - Estimated Seasonal High Ground Water (ESHGW)
  - Simulated 90-day mound height due to infiltration in leachfields superimposed on ESHGW.
  - Assessment of 90-day mound height relative to current ground surface elevations, and
  - Assessment of potential impact of leachfield operation on the nearby surface water stream.

DATA SYNTHESIS

The following data sets were utilized in the development of the groundwater model:

- Surface elevations from the 2010 FEMA LiDAR survey (tile 19_03064692) were obtained from the Mass GIS "Oliver" tool, imported into GIS and converted to feet. The ground surface elevations obtained are consistent with surface elevations provided by GEOSPHERE.
- Lithologic observations from 9 boreholes, including bottom of sand and gravel unit (top of Silt Layer) and permeability tests from a subset of 6 boreholes.

- ESHGW estimates from Test Pits (soil mottling) and April 2018 groundwater elevations from 6 Monitoring Wells.
- Surface water location and elevations provided as both GIS shapefiles (locations) and tabulated survey elevations (water surface elevations).
- Contours of observed groundwater elevations.

MODEL DEVELOPMENT

To meet the stated objectives, a MODFLOW model was developed using Groundwater Vistas (version 5.51). The overall model set up is illustrated in Figure 1. The finite difference grid has an overall 6 foot spacing of rows and columns. In the vicinity of the leachfields, the row and column spacings are reduced to approximately 3 feet by 3 feet. The overall model grid size is 155 rows by 217 columns. Two model layers were initially set up – one representing the overlying sand and gravel and the lower representing a low conductivity silt layer.

Based on groundwater observations, the flow is generally east to west and the surface water feature running through the site is expected to be hydraulically connected to the groundwater. For the purposes of this analysis the stream is expected to serve primary as a sink and is modeled using the Drain Package. Heads in the drain cells were set by piecewise linear interpolation based on surveyed water surface elevations. The drain boundary cells are assumed to be in good hydraulic connection with the aquifer and have conductances on the order of a few hundred feet-squared per day.

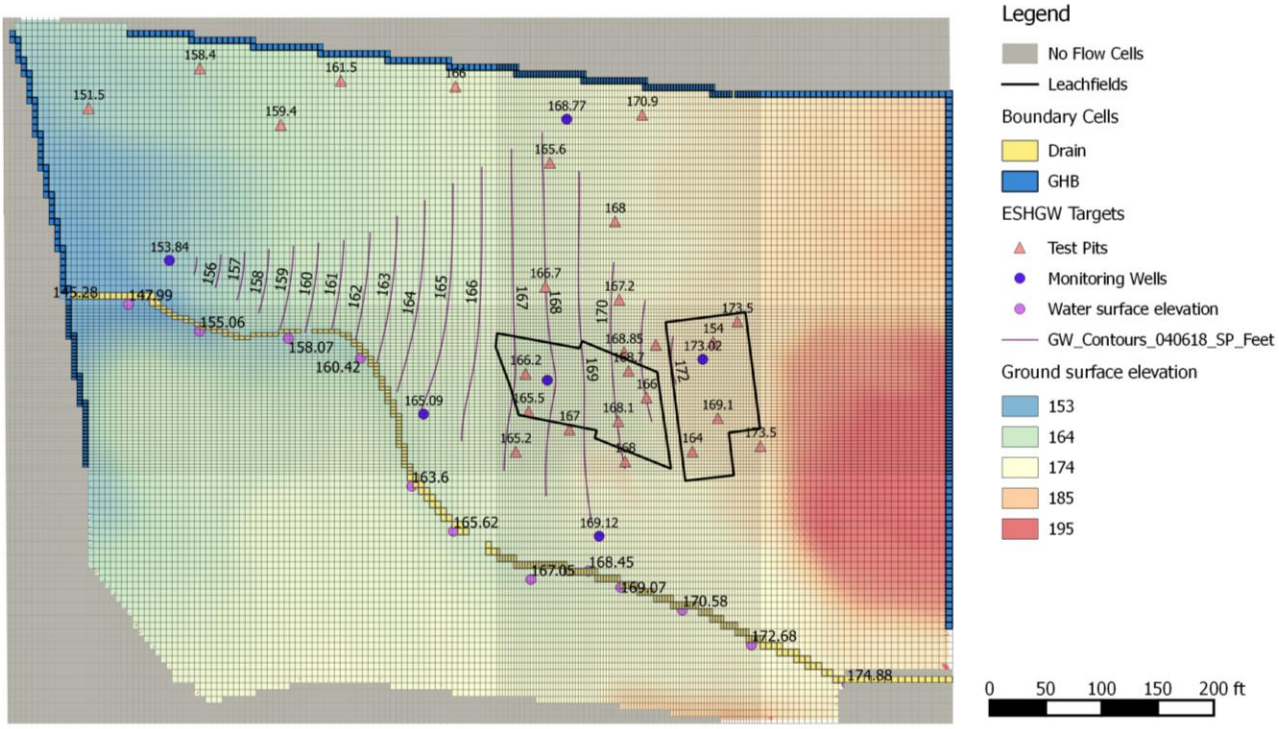

Figure 1. Overview of groundwater model setup.

Because of the limited amount of information available, the relatively limited model objectives, and the appearance of significant east-to-west groundwater flow through the site, the ambient gradient was established using the General Head Boundary (GHB) package along the eastern, northern, and western boundaries of the site. Heads along the boundaries were assigned to mimic

the observed natural gradient. While use of such a boundary condition has the potential to bias the model results, as shown below, the boundary appears to have a negligible impact on the mounding calculations.

The top of Layer 1 is set to the ground surface elevation, as determined by LIDAR, and the bottom is interpolated from 9 borehole observations of the bottom of the sand and gravel deposit (Figure 2). In the western portion of the model, the bottom of Layer 1 was manually reduced to facilitate model convergence in the vicinity of the downstream boundaries. The lower elevation of the bottom of Layer 1 in the vicinity of B7 is not expected to impact the simulation results in vicinity of the proposed leachfields.

Hydraulic conductivity of Layer 1 was set to 90 ft/day, as recommended by GEOSPHERE based on permeability test data.

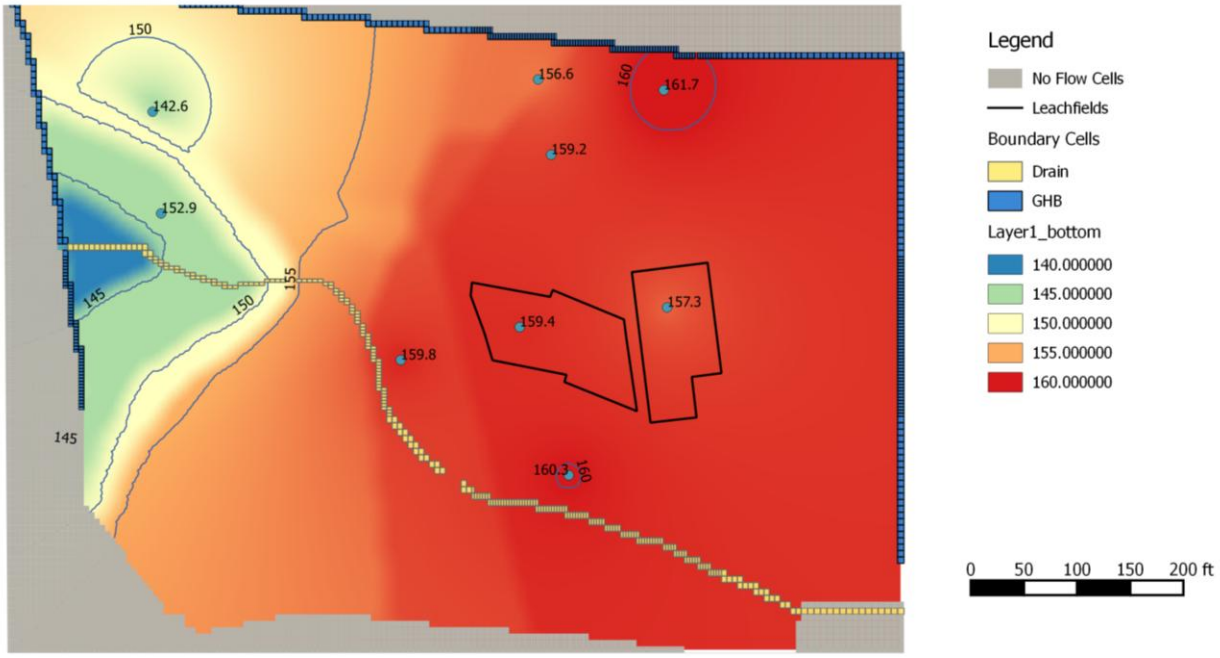

Figure 2. Bottom of Layer 1 interpolated from borehole observations. Adjusted in vicinity of B-7 to facilitate model convergence.

MODEL CALIBRATION

A steady state groundwater model was developed to simulate the estimated seasonal high ground water (ESHGW) elevations. Initially, the calibration targets were the ESHGW ("mottling") elevations observed in the test pits (coded as Group 1 targets). The test pit mottling observations were later augmented with actual seasonal high ground water elevations measured in April 2018 at 6 of the monitoring wells. The observed groundwater levels were added to the list of targets and coded as Group 2. Trial-and-error calibration was conducted until most (4 out of 6) of the simulated groundwater level observations were higher than the observed values.

Surface water elevation data used for Pine Brook was surveyed by Beals & Thomas as part of site plan development activities. In order to match heads with the April 2018 groundwater elevation at MW-6, it was necessary to raise the heads in the DRN cells (which model Pine Brook) by 0.5 feet to simulate surface water elevations that would correspond during periods of ESHGW.

The results of the calibration are shown in Figure 3. It should be noted that the objective of the calibration is to obtain a simulated ESHGW that exceeds most of the observed values, as opposed to most calibration efforts that look to obtain an unbiased (mean zero) set of residuals. As illustrated in Figure 3, the observed groundwater elevations tend to be higher than the ESHGW inferred from the Test Pits.

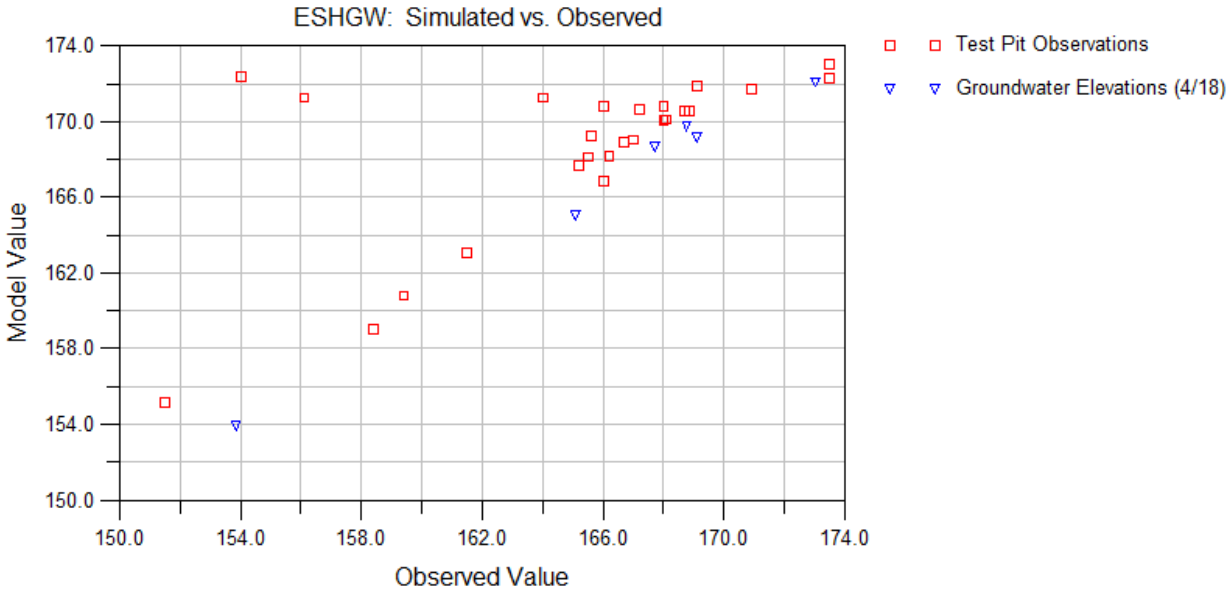

Figure 3. Comparison of simulated ESHGW surface with observations.

It was found that the general head boundary along the perimeter of the model was sufficient to match the heads and ambient recharge is not necessary to simulate the ESHGW surface. As shown in the east-west cross section in Figure 4, the geometry of the boundaries imparts a concave water table surface, as expected in an unconfined aquifer subjected to recharge. This concavity results in an overestimation of the head at B-4/MW (Infiltration Area 1), with a simulated head 0.99 higher than the observed head. Because of the already shallow water table condition, this model error results in the calibrated ESHGW having some heads slightly higher than the ground surface in Infiltration Area 1 under seasonal high conditions (see Figure 5 to the northeast of B-4/MW), which were not observed in the field. While these are artifacts of the model, the seasonal high water table in this area is very shallow. Another artifact of the GHB boundary is illustrated in Figure 5 along with western edge of the model where the GHB boundary allows for groundwater to exit the model out of the western boundary. Detailed field measured groundwater levels were not available along that boundary and the GHB boundary head values were set to be higher in the immediate vicinity of the stream than field observations have borne out. This resulted in the model generating an erroneous over-prediction of groundwater levels where the stream exits the western boundary. This local error in the model does not impact the behavior near the infiltration basins or the simulated interaction between the mound and the stream.

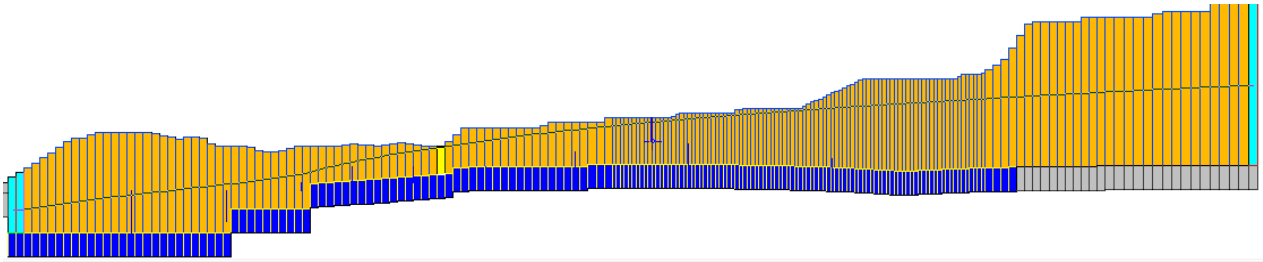

Figure 4. East-west cross section through MW4. Orange cells are Layer 1; dark blue = Layer 2; cyan = GHB; yellow = DRN; gray = No flow. Line of cross section shown in Figure 5.

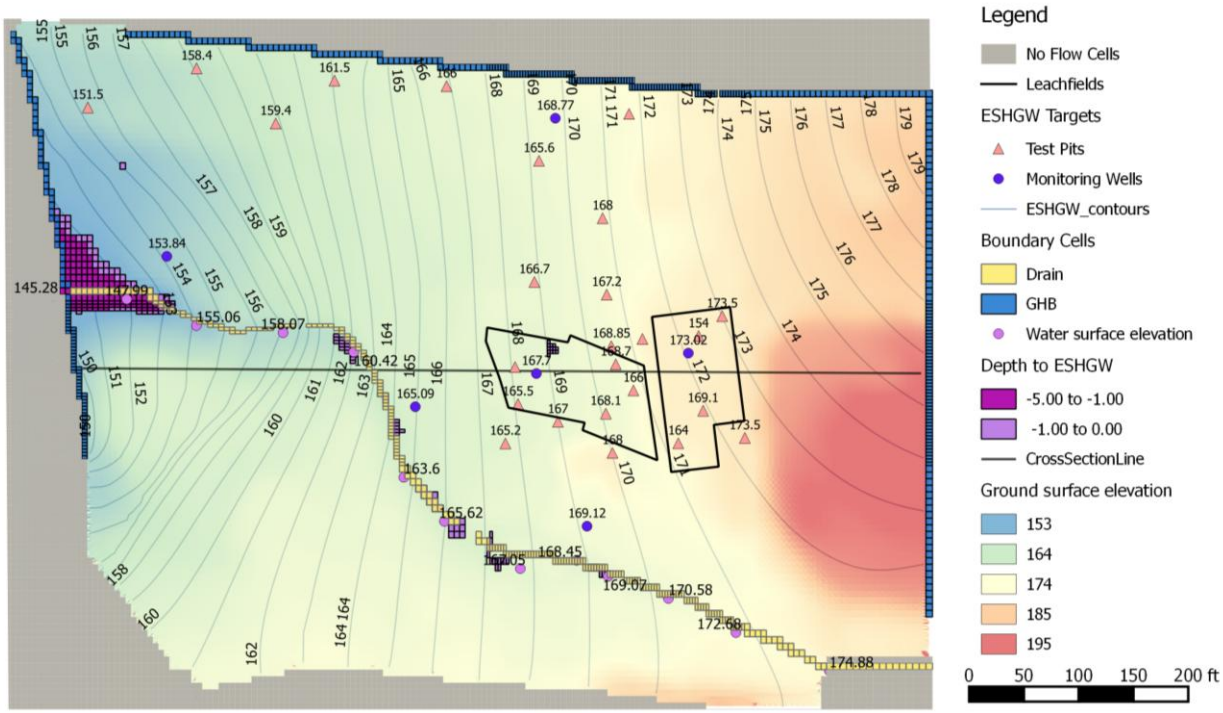

Figure 5. Calibrated ESHGW conditions.

Transient Simulations

To simulate the effects of infiltration in Septic Areas 1 and 2, the steady-state model calibrated to ESHGW was converted into a transient simulation with infiltration applied using the MODFLOW Recharge Package (Table 1). Based on the Title 5 guidance, the model was executed using a maximum monthly flow volume of 7,850, gpd, which is 80% of the design flow 9,813 gpd. The transient simulation has one stress period of 90-day duration, 20 time steps, and a time-step multiplier of 1.2. The initial heads were set to the calibrated ESHGW heads and mound height was computed as the change in head over the 90-day simulation.

Table 1. Infiltration basins, areas, and rates.

Description	Area [Square Feet]	Infiltration [gpd]	Recharge [ft/day]
Septic Area 1	10,304	4,674	0.061
Septic Area 2	8,696	3,176	0.049

Results of the mounding simulation (Figure 6) show a maximum mound height contour of 0.25 feet enclosing the maximum mound height of 0.29 feet. As with the ESHGW simulation, the 90-day simulation of infiltration results in some heads exceeding the ground surface elevation (so-called flooded cells). As shown in Figure 6, when heads in the vicinity of the Septic Areas are higher than the ground surface, they are less than 1 foot. As noted above, the ESHGW simulation exhibits flooded cells in the vicinity of MW-4 and the calibrated ESHGW at B-4/MW is 0.99 feet higher than measured in the field. Therefore, these flooded cells are largely a reflection of the model misfit near B-4/MW.

To assess the changes in flows in the vicinity of the infiltration basins, a Zone Budget was calculated for the rectangular region shown in Figure 6. Analysis of the mass balance illustrates the effect of the boundary condition on the model (Table 2). Without infiltration, the groundwater flow in the steady-state ESHGW model is primarily from east to west with some inflow from the north and a net outflow of 1,079 cubic feet per day to the stream. Under stressed conditions, the flow rates after 90 days approach steady state conditions and show that stream discharge increases by about a third to 1,440 gpd, represents about 34% of the infiltrated water. The mounding from the infiltration results in decreased ambient flow from the east, reducing flow into the polygon from that direction by 2%. Flows from the north are small compared to the east-to-west flow and are decreased by 14%, as groundwater will be diverted around the mound. It is important to note that while the discharge to the stream within the Mass Balance Polygon increases by approximately 360 cubic feet per day (cfd), this increase flow is not necessarily originating from the Septic Areas. As the mounding raises the heads in the vicinity, the increase in heads to the south of the infiltration areas will result in an increase in the discharge to the stream, even though the water is not originating from the infiltration areas.

Table 2. Comparison of fluxes through rectangular region shown in Figure 6.

	ESHGW			90 day w/ infiltration			Difference
Description	Inflow	Outflow	Net (cfd]	Inflow	Outflow	Net (cfd)	Relative
West	-	11,691	(11,691)	-	11,823	(11,823)	1.13%
East	11,874	370	11,504	11,634	404	11,230	-2.38%
North	1,899	37	1,862	1,658	64	1,594	-14.39%
South	333	930	(597)	336	945	(609)	2.01%
Infiltration			-	1,049		1,049	n/a
Stream	-	1,079	(1,079)	-	1,440	(1,440)	33.46%

Particle tracking was performed with MODPATH on a steady state model with constant infiltration. Because the simulated flow is primarily in Layer 1 and that is the layer with the boundary conditions, it is not possible to determine the parcels of water leaving the model that originate as infiltration. To do so would require a multi-layer model with more detailed hydrogeologic information and the use of the solute transport equations using a model such as MT3D-MS. However, to illustrate the flow paths and potential interaction with the stream, it is possible to allow traced particles to exit the model using a 'weak sink' option in MODPATH. For the simulations presented here, the "weak sink strength" parameter was set to 0.25, meaning that particles will exit the cell when 25% or more of the flow into the cell discharges to the

boundary cell. As shown in Figure 6, many particles pass through cells in which less than 25% of the water discharges to the stream and these particles continue to the GHB cells along the western margin of the model.

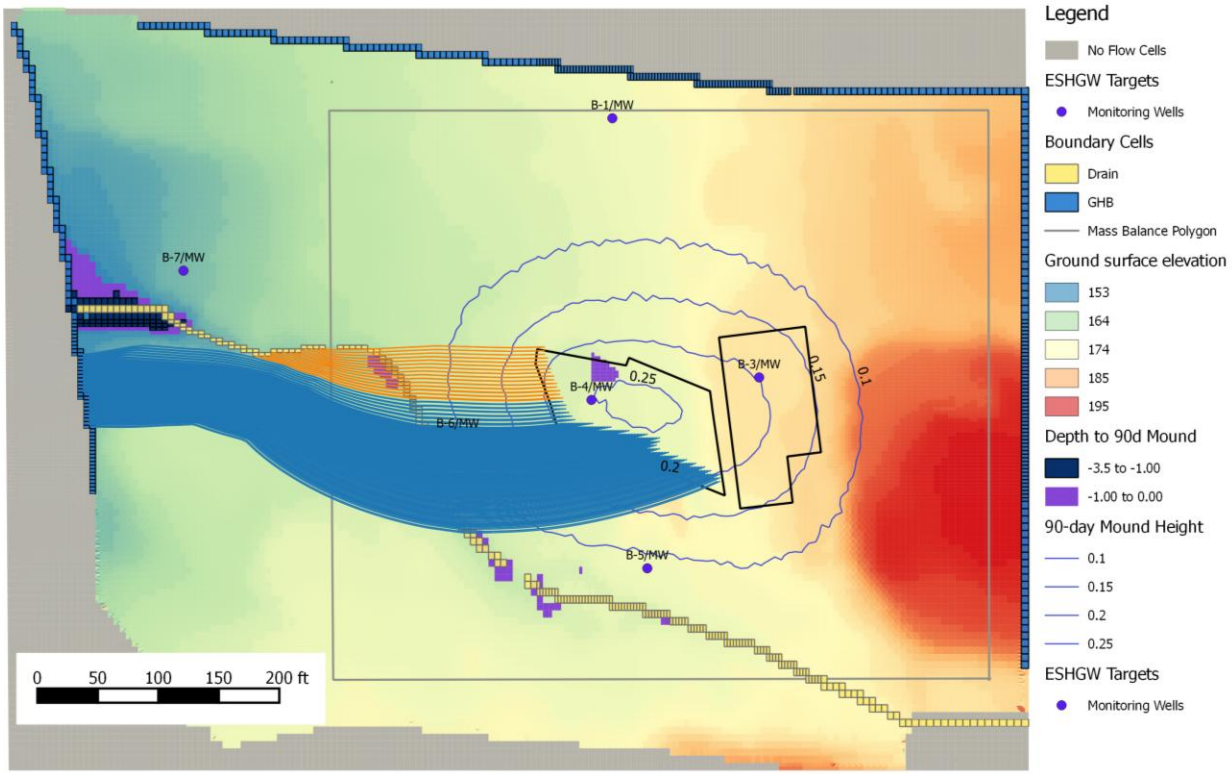

Figure 6. Results of 90-day transient simulation with infiltration and steady state particle tracking. Particle traces are colored based on the type of boundary cell to which they exit (orange = DRN; blue = GHB).

SUMMARY TABLE OF ESHGW VALUES.

Location Name	Observed [elevation, ft]	Computed [elevation, ft]	Residual [ft]
OSE-TP_2	166.00	166.88	-0.88
OSE-TP_3	159.40	160.80	-1.40
OSE-TP_4	158.40	159.04	-0.64
OSE-TP_5	151.50	155.16	-3.66
OSE-TP_6	170.90	171.70	-0.80
OSE-TP_7	165.50	168.14	-2.64
OSE-TP_8	166.20	168.15	-1.95
OSE-TP_9	168.10	170.11	-2.01
OSE-TP_10	168.85	170.56	-1.71
OSE-TP_11	168.70	170.57	-1.87
OSE-TP_12	167.20	170.68	-3.48
OSE-TP_13	168.00	170.83	-2.83
OSE-TP_14	166.70	168.89	-2.19
OSE-TP_15	165.60	169.25	-3.65
OSE-TP_16	169.10	171.91	-2.81
OSE-TP_17	173.50	172.32	1.18
OSE-TP_18	164.00	171.26	-7.26
OSE-TP_19	173.50	173.01	0.49
OSE-TP_20	165.20	167.71	-2.51
OSE-TP_21	168.00	170.04	-2.04
OSE-TP_22	166.00	170.80	-4.80
OSE-TP_23	167.00	169.04	-2.04
TP-A	154.00	172.40	-18.40
TP-B	156.10	171.27	-15.17
TP_4	161.50	163.06	-1.56
B-1/MW	168.77	169.77	-1.00
B-3/MW	173.02	172.08	0.94
B-4/MW	167.70	168.69	-0.99
B-5/MW	169.12	169.19	-0.07
B-6/MW	165.09	165.06	0.03
B-7/MW	153.84	153.89	-0.05