Sieve Analysis, Interpretation and it’s application to Title 5

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GRADY CONSULTING, L.L.C.

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- Grady Consulting LLC is a family owned & operated civil engineering, land surveying and landscape architecture company providing services throughout Massachusetts since 1998.

- 4 MA Professional Civil Engineers
- 6 MA Soil Evaluators
- 3 MA Title 5 System Inspectors (not a business priority)

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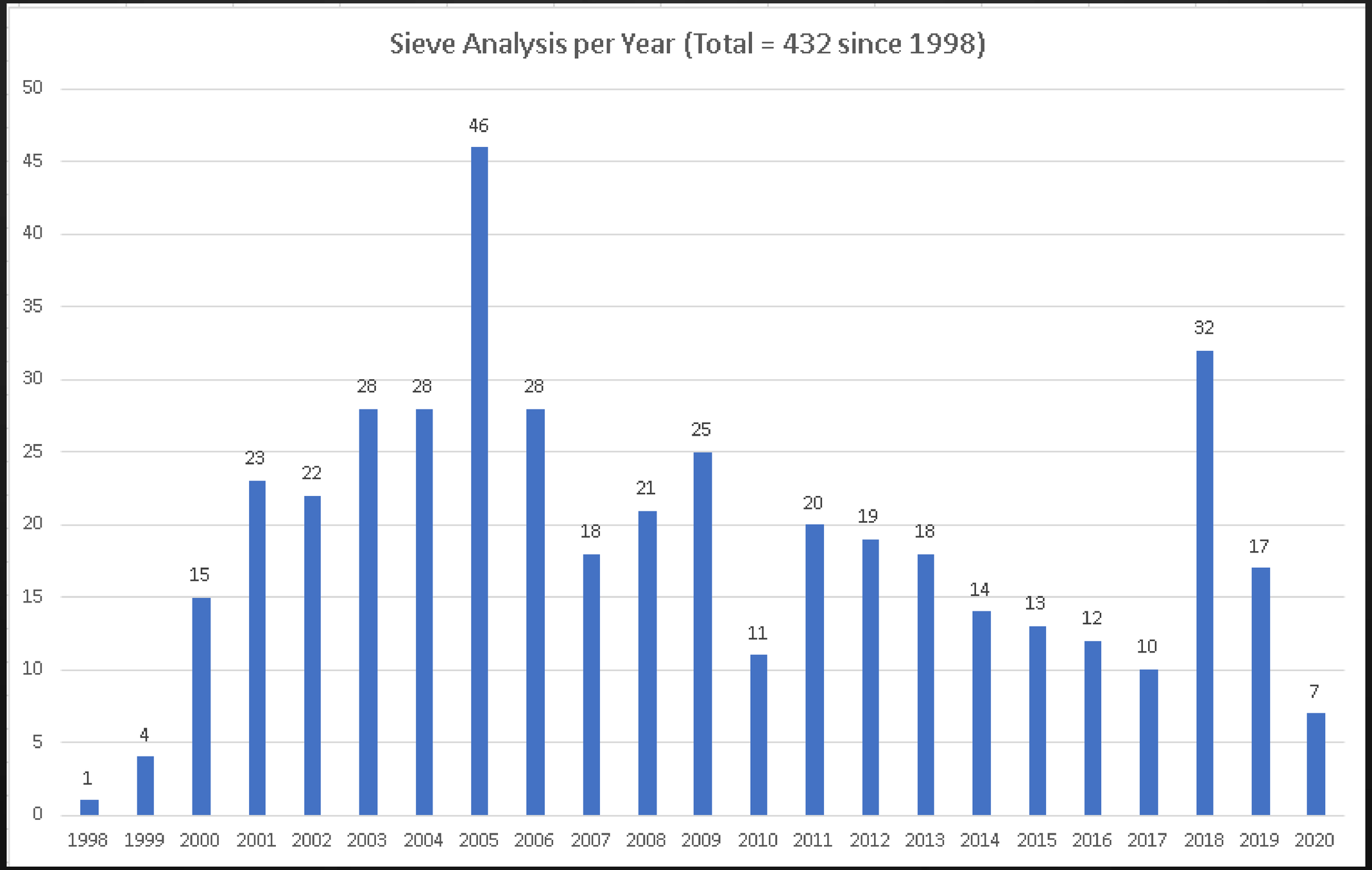
- Bachelor of Science in Civil Engineering
  Northeastern University, 1988
- Professional Civil Engineer, 1994
  - MA, ME, NJ, RI
- MA Soil Evaluator SE 926, 1995
- MA System Inspector SI 1218, 1995
- Certified Bottomless Sand Filter Designer, 2019

Septic System Design Projects

- Approximately 6,800 projects since 1998
- Projecting approximately 480 projects for 2020
- Approximately 70% involve septic systems
- Approximately 432 sieve analysis since 1998


Sieve Analysis per Year (Total = 432 since 1998)
50
45
40
35
30
25
20
15
10
5
0
1
4
15
23
22
28
28
46
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1998
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2015
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2017
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2019
2020

Pertinent Title 5 Regulations 310 CMR:

15.101: Site Evaluation Criteria

(1) Every proposed disposal area shall be examined by a Soil Evaluator and the Approving Authority to determine if the disposal area is compatible with the proposed sewage disposal system in relation to the design flow set forth in 310 CMR 15.203 and system location criteria set forth in 310 CMR 15.106.

(2) Every proposed disposal area shall be assessed based on the following field test and analysis criteria:

(a) deep observation hole testing;
(b) soil profile determination;
(c) percolation testing;
(d) landscape position; and
(e) hydrogeologic properties

15.104: Percolation Testing

(1) The standard percolation test is intended to give an approximate measure of the soil's percolating capacity. Unsaturated hydraulic conductivities vary dramatically from the saturated hydraulic conductivity with changes in soil characteristics and moisture content. Percolation testing may be conducted at any time of the year and the data obtained in accordance with the procedures specified by 310 CMR 15.000 may be deemed valid for an indefinite period provided the soils within the site evaluated remain undisturbed and unaltered. All percolation testing shall be performed in the presence of the Approving Authority.

(2) A percolation test shall provide data necessary to assess the suitability of the soil to transmit water from the soil absorption system and to a depth of four feet below this elevation. Where the soil varies with depth as indicated by the results of the deep observation hole testing performed pursuant to 310 CMR 15.102, percolation tests shall be conducted in the soil which is identified to be the most restrictive by the Soil Evaluator with the concurrence of the Approving Authority.

(3) Percolation tests shall be performed by a Massachusetts Registered Professional Engineer, Massachusetts Registered Sanitarian, a Soil Evaluator, or a person who:

(a) in the opinion of the Approving Authority is qualified to perform such tests;
(b) has one year of documented experience in satisfactorily performing such tests; and
(c) has used or gained skills that demonstrate sufficient competence to perform such tests.

(4) At least one percolation test shall be performed at every proposed disposal area, one in the primary area in which the soil absorption system is to be located and one in the proposed reserve area. Additional tests shall be required where soil conditions vary or as determined by the Approving Authority or where system design exceeds 2,000 gpd. In such instances, a minimum of three percolation tests, spaced uniformly over the proposed soil absorption area, shall be performed in addition to the test in the proposed reserve area.

15.405: Contents of Local Upgrade Approval

(1) In granting local upgrade approvals pursuant to 310 CMR 15.404(2) where full compliance as defined in 310 CMR 15.404(1) is not feasible, the Approving Authority shall consider the impact of the proposed system and shall vary to the least degree necessary the requirements of 310 CMR 15.100 through 15.293 so as to allow for both the best feasible upgrade within the borders of the lot, and have the least effect on public health, safety, welfare and the environment. Under a local upgrade approval, the Approving Authority is allowed to diverge from the goal of full compliance only to the extent necessary to achieve a feasible upgrade and may allow divergence only from those provisions, and to the extent, as specified in 310 CMR 15.404(2) and 15.405(1). In determining whether full compliance is feasible, the Approving Authority should appropriately consider not only physical possibility as dictated by the conditions of the site, but also the economic feasibility of the upgrade costs. The Approving Authority should emphasize protection of water resources and treatment of the sanitary sewage. Absent conditions which would result in a different outcome based on best professional judgment, the options set forth below should be considered in the order in which they appear with 310 CMR 15.405(1)(a) being the first option to be considered and rejected or adopted and 310 CMR 15.405(1)(k) being the last option to be considered and rejected or adopted:

15.405: continued

(i) A sieve analysis may be performed in accordance with Department guidance if a percolation test in accordance with 310 CMR 15.104 and 15.105 can not be performed as determined by the Approving Authority;

(This is the only reference to the use of sieve analysis for system design directly within Title 5 Regulations 310 CMR:)

Prior to 2006 sieve analysis was not listed in 15.405 and it was administered as a Title 5 Variance (I almost forgot about those days)

- Obtain Board of Health approval first
- Send to DEP for approval second
- This added a month to every system installation

COMMONWEALTH OF MASSACHUSETTS
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Secretary

ROBERT W. GOLLEDGE, Jr.
Commissioner

TITLE 5 ALTERNATIVE TO PERCOLATION TESTING GUIDANCE FOR SYSTEM UPGRADES

Effective Date: May 3, 2006

Program Applicability: BRP/DWM/Watershed Permitting/Title 5 Program

Supersedes Policy #: BRP/DWM/PeP-P00-1, dated January 7, 2000

Regulation Reference: 310 CMR 15.104 / 310 CMR 15.405(1)(i)

Approved by:

Purpose: This document contains the Title 5 Program's guidance for reviewing applications for Local Upgrade Approvals which propose use of sieve analysis in substitution of the percolation testing requirements of Title 5 for the upgrade of on-site sewage treatment and disposal systems.

Applicability: This guidance applies to applications for Local Upgrade Approval for system upgrades where percolation testing in accordance with Title 5 cannot be performed. The alternative to percolation testing set forth in this guidance may be used, when percolation testing is not possible due to high groundwater and the applicant seeks to proceed with a system upgrade, rather than wait for groundwater to recede to perform percolation tests.

The alternative outlined in this guidance may be used only for the repair or upgrade of an existing system when no increase in design flow is proposed. This alternative is an option for Board of Health consideration under Local Upgrade Approvals at 310 CMR 15.405.

Title 5, 310 CMR 15.104, requires percolation testing as part of the site evaluation for a new system or a system upgrade. Since the standards for new construction are more stringent than those for system upgrades, the alternative described in this guidance does not apply to cases of new construction, or increases in existing design flow.

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Title 5 requires percolation testing to be performed in the most restrictive soil layer of the naturally occurring pervious material beneath a proposed soil absorption system (SAS). The Department recognizes that at certain times, however, high groundwater conditions preclude performance of standard percolation tests. During such times, the applicant may choose to perform dewatered percolation testing. Provided that an immediate upgrade is not being required by the local approving authority or DEP, or the upgrade timelines in 310 CMR 15.305, if applicable, would not be violated, the applicant also may wait until groundwater has receded and standard percolation testing can be performed. Alternatively, in accordance with this guidance, the applicant may proceed with a sieve analysis if the local Approving Authority determines a percolation test cannot be performed.

Dewatered percolation testing involves lowering the groundwater table to a point where testing can be performed in accordance with Title 5. Since dewatered percolation testing frequently is difficult and, in many cases, infeasible, attempting dewatered percolation testing is not a prerequisite prior to applying for use of a sieve analysis under this guidance.

Impervious & extremely low permeability soils

In cases of impervious soils or soils with extremely low permeability, the alternatives set forth in this guidance are **not** appropriate as such soils simply cannot support an on-site system. Where the Soil Evaluator, the local approving authority, or DEP determines that the soils are impervious or of extremely low permeability, for example, due to the presence of ledge, greater than 40% clay, or highly compacted till, and there is no feasible alternative (e.g. a shared system), then a tight tank to eliminate a failed system, approved under 310 CMR 15.260, would be the only option.

Requirements for obtaining local upgrade approval for sieve analysis use and relief from the percolation testing provisions

When an applicant proposes to upgrade a system, percolation testing cannot be performed due to high groundwater and the soils are neither impervious nor of extremely low permeability, the Approving Authority may approve/allow a sieve analysis in substitute of the Title 5 percolation testing requirements. In addition to complying with the other requirements of Title 5, the sieve analysis and local upgrade approval application to the local approving authority must contain the following:

1. documentation of a demonstration that percolation testing cannot be performed;
2. the Soil Evaluator's determination, along with the written concurrence of the local approving authority, of whether the soils are uncompacted or compacted;
3. results of performance of a Particle Size Analysis by a soils laboratory;
4. the Soil Evaluator's determination of the soil type, which must be based on the Particle Size Analysis and the USDA Soil Textural Triangle in Title 5; and
5. the Soil Evaluator's determination of the soil class under 310 CMR 15.243, which must be based on the soil type; and
6. plans for a system upgrade designed in accordance with the criteria in this policy for the soil type, class and determination of soil compaction.

1) Demonstration that percolation testing cannot be performed

Percolation testing must be attempted in the presence of the local approving authority, or its authorized representative, and determined not to be possible due to high groundwater.

2) Determination of compacted vs. uncompacted soils

Without the benefit of percolation testing, more reliance is placed on the determination of soil compaction. Since compacted soils can be extremely firm in place, but friable when removed for a sample, the Soil Evaluator must make an in-situ determination of the soil structure and consistence. The Soil Evaluator, **with the written concurrence of the local approving authority**, must determine whether the soils in the area of the proposed SAS are compacted or uncompacted. The Soil Evaluator must use the techniques described in Appendix 1.

For uncompacted soils, the Soil Evaluator can use the results of the particle size analysis to determine the soil type and class, and, subsequently, the effluent loading rate. In compacted soils, such as dense, compact till, the compacted nature of the material results in a significant decrease in the amount of pore space necessary for groundwater flow and particle size analysis results alone are inadequate for determining an effluent loading rate.

3) Particle Size Analysis

In the presence of the local approving authority or its authorized representative, the Soil Evaluator must obtain a soil sample from the most restrictive layer of the four feet of naturally occurring pervious material for the particle size analysis. Although for purposes of obtaining an effluent loading rate, the particle size analysis is considerably more useful in the case of uncompacted soils, the analysis still is useful to characterize compacted soils, particularly where the soils have a high percentage of clay.

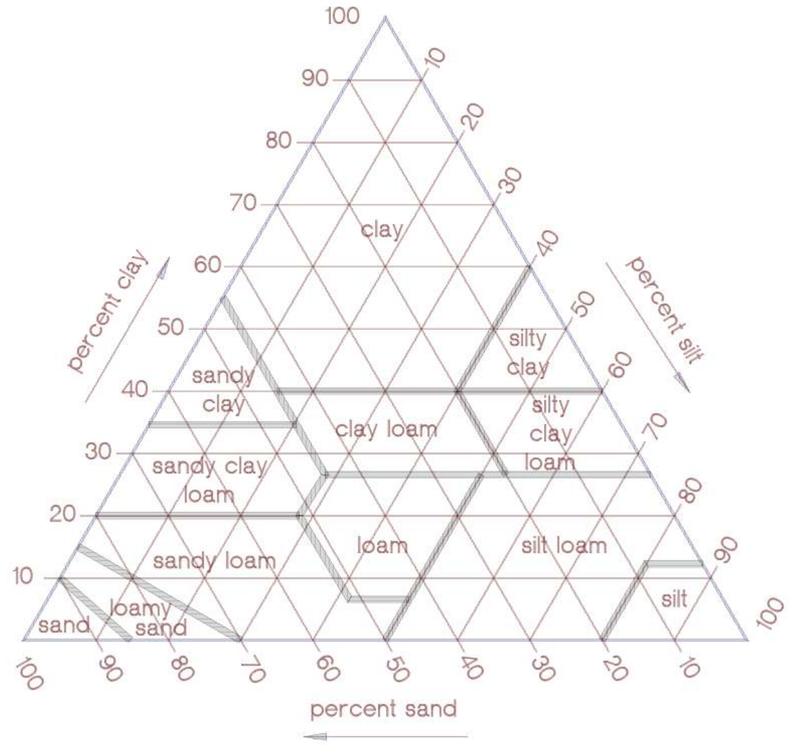
The particle size analysis, performed by a qualified soils laboratory, must be used to determine the percentages of sand, silt and clay in the soil sample. The analysis must be performed for both compacted and uncompacted soils. The particle size analysis must be performed in accordance with Appendix 2.

4) Determination of soil type

Once the relative percentages of sand, silt and clay have been determined through particle size analysis, the Soil Evaluator must use the USDA Soil Textural Triangle in 310 CMR 15.243(2) to determine the soil type.

(2) Textural Classifications are made based on the relative proportion of sand, silt and clay in the soils and in accordance with the following textural triangle:

SOIL TEXTURAL TRIANGLE



15.244: Types of Soils

Sands:	Soil is 85% or more sand and the percentage of silt plus 1.5 times the percentage of clay is 15 or less.
Loamy sands:	At the upper limit soil is 85 to 90% sand and the percentage of silt plus 1.5 times the percentage of clay is 15 or less; at the lower limit, soil is 70 to 85% sand and the percentage of silt plus twice the percentage of clay is 30 or less.
Sandy loams:	Soil is 20% or less clay and 52% or more sand and the percentage of silt plus twice the percentage of clay exceeds 30; or soil is less than 7% clay, less than 50% silt, and between 43 and 52% sand.
Loam:	Soil is 7 to 27% clay, 28 to 50% silt, and less than 52% sand.
Silt loam:	Soil is 50% or more silt and 12 to 27% clay; or 50 to 80% silt and less than 12% clay.
Silty clay loam:	Soil is 27 to 40% clay and less than 20% sand.
Clay:	40% or more clay, less than 45% sand, and less than 40% silt.
Silt:	80% or more silt and less than 12% clay.
Sandy clay loam:	20 to 35% clay, less than 28% silt, and more than 45% sand.
Clay loam:	27 to 40% clay and 20 to 46% sand.
Sandy clay:	35% or more clay and 45% or more sand.

5) Determination of soil class

Based on the soil type, the Soil Evaluator must classify the soil into one of the four soil textural classes described in 310 CMR 15.243 (1).

(This step is where we see most errors – there is a tendency to look at the sieve results and overlook the on-site evaluation such as when textural triangle indicates loamy sand but soil evaluation determined land loam – when they don't match we always take more conservative loading rate which is Class II Sand Loam in this example – we have seen opinions vary on this topic)

15.243: Types of Soil Textural Classes

(1) The following soil textural classes apply to soil types of which they are composed:

CLASS I	Sands, Loamy Sands
CLASS II	Sandy Loams, Loams
CLASS III	Silt Loams, Sandy Clay Loams with less than 27% clay, Silt
CLASS IV	Clays, Silty Clay Loams, Sandy Clay Loams with 27% or more Clay, Clay Loams and Silty Clays

6) Design Criteria – uncompacted vs. compacted soils

a) For **uncompacted Class I and uncompacted Class II soils**, the results of the particle size analysis, the soil type and the soil classification must be used to determine the effluent loading rate based on the effluent loading rate table, below. The system upgrade must be designed with that effluent loading rate and the requirements of Title 5.

b) For **compacted soils and all Class III and all Class IV soils** the design criteria, set forth below, must be used to design the system upgrade. Where the soils are compacted or Class III or Class IV soils, extremely low permeability could limit the soils' ability to adequately accept a subsurface discharge. These systems, therefore, must have a conservative design, intended both to allow an on-site discharge and prevent breakout. In addition to meeting Title 5 requirements, the design criteria for a system upgrade in compacted soils and in Class III and Class IV soils are as follows:

1. in accordance with the Effluent Loading Rate table, below, the effluent loading rate is limited to 0.15 gallons per day (gpd) per square foot (sf);
2. pressure distribution is required;
3. a four foot vertical separation to high groundwater elevation, or a five separation in soils greater than 85% sand. Where the required separation to the high groundwater elevation will not be met, an Innovative/Alternative (I/A) treatment technology approved by DEP for Remedial Use is required and the local approving authority and DEP may approve a reduction down to a minimum of a two foot separation to high groundwater elevation, or a three foot separation in soils that are greater than 85% sand;
4. where feasible, four feet of naturally occurring pervious material. Where there are not four feet of naturally occurring pervious material, the applicant must satisfy the requirements of 310 CMR 15.415 for the siting of a system upgrade with less than four feet of naturally occurring pervious material and an I/A treatment technology approved by DEP for Remedial Use is required. In such cases, the local approving authority and DEP may approve a reduction to a minimum of two feet of naturally occurring pervious material;
5. where feasible, a fully sized SAS. Where a fully sized SAS is not feasible, then an I/A treatment technology approved by DEP for Remedial Use is required and the local approving authority and DEP may approve a reduction of up to 50% in the required SAS size;
6. a modified septic tank is required where there will be a reduction in the required four or five foot separation to high groundwater elevation, or a reduction in the required four feet of naturally occurring pervious material, or a reduction in the required SAS size. The modified septic tank shall have a valve located in the septic tank discharge pipe so that in the event of breakout or other hydraulic failure, the discharge pipe valve could be closed and sealed and the discharge pipe beyond the valve removed, converting the septic tank to a tight tank. If converted to a tight tank, the volume of the septic tank, together with that of the pump chamber, may be used to meet the requirements for tight tank size in 310 CMR 15.260(2)(a);
7. a condition that prohibits any increase in design flow and requires a notice, recorded with the deed, that both prohibits any increase in design flow and references the Approving Authority's approval letter of the Local Upgrade Approval.

Effluent Loading Rates for systems designed and approved under this guidance

Soil Type	Uncompacted Class I and Class II Soils[1]	All compacted soils and all Class III and all Class IV Soils[2]
Class I	> 85% sand 0.74 gpd/sf 70 – 85% sand 0.66 gpd/sf	0.15 gpd/sf
Class II	0.33 gpd/sf	

1 The system must be designed based on the applicable effluent loading rate in this table and the requirements of Title 5.

2 The system must be designed based on a 0.15 gpd/sf loading rate, the design criteria on page 4 of this guidance, and the requirements of Title 5.

On-site investigation techniques to determine if soils are compacted (compact till):

- Note the ease or difficulty of excavation by the backhoe (does the excavator experience difficulty digging, does the bucket chatter across the surface of the material making shallow cuts with each pass – these soils may be compacted).
- Pick at the side of a test hole with a knife or hand tool to feel for the ease or difficulty of penetration (difficulty would suggest compacted material).
- Note the presence of angular shaped rock fragments (suggests compacted till).
- Note the speed at which groundwater weeps into the pit (groundwater weeping slowly into the pit would suggest dense, compacted material).
- Note the consistency of undisturbed soil clod (squeeze the clod of soil between your thumb and index finger; initially compact till will resist crushing and then with increased pressure will rupture suddenly). The consistency of soil in compacted material will be firm, whereas in uncompacted material, the consistency will be loose or friable.
- Note the soil saturation (compacted soils will appear moist, not saturated, due to the lack of pore space).

Adapted from the DEP approved Title 5 Soil Evaluator Course Materials

APPENDIX 2

The standard method for Particle Size Analysis is the method of Gee and Bauder (1986) in **Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods, 2nd Edition ,** published by the American Society of Agronomy-Soil Science Society of America. This method, or another method acceptable to the Department, must be used by the soils laboratory. The soils laboratory must:

- determine the relative percentages of sand, silt and clay from the soil sample that passes through a #10 sieve, (which removes aggregate from the sample),
- use a #270 sieve to separate the sand fraction from the remaining combined silt and clay fraction,
- establish the relative percentages of silt and clay in the sample by either pipet or hydrometer method.

Title V Soil Analysis

Address: Bound Brook Court, Scituate
Briggs # 82829
Tested: 12/17/19

1.	Lab Ref. No.	Description	Source
	M-31104	-#10 Fraction	TH #1

2. Particle Size Analysis (ASTM D 422)

Sieve Size		Results
Standard	Alternate	(% Passing by Wt.)
2.0 mm	#10	100
0.850 mm	#20	83
0.425 mm	#40	65
0.180 mm	#80	41
0.150 mm	#100	36
0.053 mm	#270	19
0.0374 mm		19
0.0240 mm		16
0.0140 mm		13
0.0100 mm		12
0.0071 mm		10
0.0035 mm		9
0.0015 mm		7

100 - 19 = 81% Sand

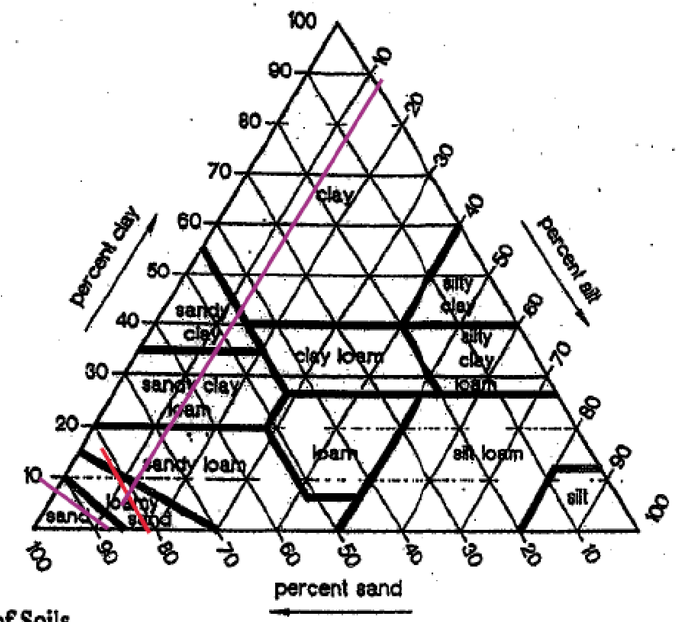
12% Silt

7% Clay

3. The above analysis was performed in accordance with D.E.P. policy# BRP/DWM/PeP-001-1, Appendix 2.

- determine the relative percentages of sand, silt and clay from the soil sample that passes through a #10 sieve, (which removes aggregate from the sample),
- use a #270 sieve to separate the sand fraction from the remaining combined silt and clay fraction,
- establish the relative percentages of silt and clay in the sample by either pipet or hydrometer method.

SOIL TEXTURAL TRIANGLE



15.244: Types of Soils

81% SAND
12% SILT
7% CLAY

SOIL IS 70-85% SAND AND THE PERCENTAGE OF SILT PLUS TWICE THE PERCENTAGE OF CLAY IS 30 OR LESS.

12 + 2(7) = 26 < 30 SOIL IS A LOAMY SAND

SOIL WAS CLASSIFIED IN THE FIELD AS SANDY LOAM
USE EFFLUENT LOADING RATE = 0.33

Soil Type		Uncompacted Class I and Class II Soils[1]
Class I	> 85% sand	0.74 gpd/sf
	70 – 85% sand	0.66 gpd/sf
Class II		0.33 gpd/sf

3. LEACHING CHAMBERS: P.R. =30 MIN/IN CLASS II (FROM SIEVE ANALYSIS) USE E.L.R = 0.33

SYSTEM #1

USE: 1–28' LONG X 17' WIDE X 16" DEEP LEACHING CHAMBER SYSTEM IN BED CONFIGURATION WITH 63 – 4' LONG INFILTRATOR QUICK4 HIGH CAPACITY LEACHING CHAMBERS IN 9 ROWS OF 7.

(PER MODIFIED CERTIFICATION FOR GENERAL USE DESIGN STANDARD ITEM 6.) EFFECTIVE LEACHING AREA = 4.73 SF/LF
PROPOSED AREA: 252 LF x 4.73 SF\LF = 1192 S.F.
CAPACITY: 1192 S.F. x 0.33 GPD/S.F. = 393 = 393 GPD(D.D.F.)

SYSTEM #2

USE: 1–48' LONG X 34' WIDE X 16" DEEP LEACHING CHAMBER SYSTEM IN BED CONFIGURATION WITH 144 – 4' LONG INFILTRATOR QUICK4 HIGH CAPACITY LEACHING CHAMBERS IN 12 ROWS OF 12.

(PER MODIFIED CERTIFICATION FOR GENERAL USE DESIGN STANDARD ITEM 6.) EFFECTIVE LEACHING AREA = 4.73 SF/LF
PROPOSED AREA: 576 LF x 4.73 SF\LF = 2,725 S.F.
CAPACITY: 2,725 S.F. x 0.33 GPD/S.F. = 899 > 891 GPD(D.D.F.)

Request in writing (excerpt from cover letter)

On behalf of the applicant we hereby request the Board of Health approve the following Local Upgrade Approval.

15.405(1)(h) – Reduction in separation between the bottom of the soil absorption system and the high groundwater elevation from the required 4 feet to 3 feet.

15.405(1)(i) – To allow the use of a sieve analysis where a perc test could not be performed.

Commonwealth of Massachusetts
City/Town of Scituate

Form 9A – Application for Local Upgrade Approval

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 your local Board of Health to determine the form they use.

B. Proposed Upgrade of System (continued)

- ☐ Relocation of water supply well (explain):

_____

_____

_____

- ☐ Reduction of 12-inch separation between inlet and outlet tees and high groundwater
- ☐ Use of only one deep hole in proposed disposal area
- ☒ Use of a sieve analysis as a substitute for a perc test
- ☐ Other requirements of 310 CMR 15.000 that cannot be met – describe and specify sections of the Code:

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