Method for Determining Hydrologic Soil Group by Site Specific Soil Mapping

FINAL DRAFT

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Abstract: The hydrologic soil group (HSG) classification system places soils into groups based on their runoff producing characteristics. Soils are specifically classified as based on depth to the average seasonal high water table (SHWT), depth to restrictive layer and saturated hydraulic conductivity of the least transmissible layer (Ksat) (NEH, 2009). Implementation of a standard method used to define hydrologic soil groups (HSGs) is difficult in practice due to constantly changing standards, outdated soil surveys, and variability in field measurements. There are several purposes for determination of a soils HSG. HSGs are important in relation to soil hydrology, specifically in calculation of the curve number; a method that has become standard to predict runoff (Nielsen et al., 1998). Additionally, the HSG of a site is determined in planning for site development. Specifically, low impact development (LID), best management practices (BMP's) and septic system requirements are all impacted by a soils HSG classification.

Soils are classified at varying scales based on the intended use of the resulting soil survey. Since land use decisions are made from soil evaluations at local scales, also referred to as site specific soil mapping (SSSM), it has become essential that a field method be developed which allows soils to be accurately classified into HSGs during SSSM. This document further explains the importance of identifying HSGs at a SSSM scale and outlines a protocol based on the 2009 NRCS National Engineering Handbook (NEH); the most current standard published to identify HSGs.

The NEH Hydrologic Soil Groups Classification System:

Within the 1985 NEH, soils are assigned to four hydrologic groups and three dual groups.

Group	Description
A	• Contains soils having a high infiltration rate when thoroughly wet and therefore have a low runoff potential.
B	• Has moderate infiltration a low runoff potential.
C	• Has slow infiltration and higher runoff potential.
D	• Lists soils having a very slow infiltration rate and thus the highest runoff potential.

The most recent update by the NRCS to determination of Hydrologic Soil Group (HSG) was published in the 2009 National Engineering Handbook. This document was originally printed in 1964 with minor revisions in 1972 and another update in 1985.

In the 1985 NEH HSGs were classified based on runoff-producing characteristics as well as surface and horizon traits of the soils. The classifications were determined by "the minimum rate of infiltration obtained for a bare soil after prolonged wetting (NEH 1985, Chapter 7)" which generates the run-off potential. Infiltration is defined as "the rate at which water enters the soil at the surface and which is controlled by surface conditions (NEH 1985, Chapter 7)." The 1985 NEH does not provide specific details on how to assign HSGs to a soil series as based on calculation of the Ksat (saturated hydraulic conductivity) or depth to the water table, and was therefore general in nature and description. Commonly, HSGs are assigned by comparing soil profiles to previously classified profiles so that soils with similar properties are assigned to the same HSG. The premise is that similar soil properties will result in similar soil hydrology and therefore be contained within the same HSG. Typically, the most prevalent HSG is described, though more than one may be present.

In 2009 classification system was published in the Part 630 of the USDA NRCS Hydrology National Engineering Handbook and defines HSGs based on runoff-producing characteristics, wetness characteristics, water transmission after prolonged wetting, permeability, depth to seasonal high water table, and depth to very slowly permeable layers (USDA NRCS Part 630 Hydrology National Engineering Handbook (NEH) (210-IV-NEH, January 2009). These parameters are based on soils which are thoroughly wet, not frozen, have bare soil surface and are at a maximum swelling of expansive clays. Specifically, a soil is classified into a HSG by the water transmitting soil layer with the lowest saturated hydraulic conductivity, depth to any layer that is more or less water slowly permeable and depth to a water table (Table 1). "The least transmissive layer can be any soil horizon that transmits water at a slower rate relative to those horizons above or below it."

These changes within the 2009 NEH has resulted in the HSG classification system becoming more transferrable from the method to practice in the field. Additionally, this update may result in changes to pre-classified soils resulting in a need to re-classify a state's soil series. The purpose of this document is to explain identification of HSG in the field at scales of site specific soil mapping, and therefore it is highly recommended that the HSG defined by a soil series not be used in place of field testing.

Although the new standard has been published, it has been evident that this national document has been difficult to apply In general, soil scientists continue to use soil properties and their best judgments to assign HSGs. The purpose of this document is describe an applicable field method to use by scientists which will mitigate discrepancies when identifying the HSG for a soil during SSSM in the state of Rhode Island.

It is important to reiterate that use of the Rhode Island Soil Survey to identify the HSG of a soil at SSSM scales is inadvisable. The scale of the current RI Soil Survey is at a scale of 1:15,840 (though it was mapped at 1:12000). These maps are primarily used for solving hydrologic issues with community planning, watershed assessments, and flood prevention. While these applications are feasible at this scale, other applications are not. Site specific maps provide a more detailed, accurate, and comprehensive view of an area for land applications and are at a scale of 1:2400, 1:600 or larger, depending on the intended use of the map. Additionally, the RI Soil Survey was last updated in 1981 and therefore, is out of date with the new 2009 NEH specifications.

From Site Specific Soil Mapping to HSG Determination to Land Development:

SSSM aids municipal officials in decision making by surveying soil properties at a scale which allows for assessing the suitability of land for development. (Standards and Procedures for Site Specific Soil Mapping in Rhode Island, 2007). Results of site specific mapping can be applied to onsite waste water systems, stormwater planning and design, and planning of building sites and roads. SSSM is the best approach in assessing for hydrologic issues related to construction because the process provides visual confirmation of site constraints which lead to better decision making. SSSM also guides in selecting the most suitable field test sites for water table monitoring, well placement, permeability testing and test pit evaluations for wastewater treatment. This method is less expensive and less invasive as only hand held tools are required.

The accurate determination of a soils HSG is important specifically at local scales when assessing for soil hydrology and in determining site suitability. HSG identification is necessary when calculating the curve number (CN) which is used to implement protocol for hydrologic modeling as outlined in the Technical Release 55 (TR-55) (Rhode Island Stormwater Design and Instillation Standards Manual- Final Draft, RIDEM and CRMC April 2010). The CN is a number that references rainfall (inches) vs direct runoff (inches). This helps determine how much runoff per inch of rainfall will be received for a specific type of land use cover type. From this, calculations of storm runoff volume, peak discharge rates and other numerical estimates essential when preparing for land development can be determined. Specifically, results of these models assist in determining necessary site development and management related to Low Impact Developments (LIDs; i.e. rain gardens) and Best Management Practices (BMPs; i.e. infiltration basins and sediment retention ponds).

Stormwater treatment has come a long way in recent years as scientific advancement has increased understanding of water quality and the impacts of development to stormwater runoff. Management practices are now concentrating on water quality and quantity, including volume and peak runoff. New techniques in site planning and design have reduced the amount of runoff produced through LID methods and small-scale management practices. In Rhode Island, the use of natural systems (i.e. LIDs), rather than end-of-pipe treatment for stormwater is required by the Smart Development for a Cleaner Bay Act (RIGL 45-61.2). Benefits of LID include a reduction to the burden on municipal infrastructure, a decrease of surface runoff from impervious surface, stream lining the development application processes (saving money and time), and increasing overall environmental health for the public (Standards and Procedures for Site Specific Soil Mapping in Rhode Island, University of Rhode Island Cooperative Extension, 2007).

Methods for Identification of HSGs with use of Rhode Island SSSM:

In order to make the manual on Standards and Procedures for Site Specific Soil Mapping in Rhode Island more valuable in its applications, identification of HSGs were added. The criteria to identify HSGs utilizes the 2009 NEH as well as integrates the RI DEM storm water standards (May 2010) and LID practices. Additionally, DEM standards are used in the key to assist soil evaluators. The soil properties used to determine a soils HSG during SSSM are depth to seasonal high water table, depth to restrictive layer and subsurface texture of the least transmissible layer. The latter of the three characteristics is used in place of testing for Ksat.

Calculating the Ksat of a soil is time consuming and cumbersome as equipment and water would have to be brought to field sites for testing. Typically testing of hydraulic conductivity in the field includes use of an Aardvark, Amoozemeter, or a double ring infiltrometer. Each of these tests has advantages and disadvantages including cost, weight of equipment, ease of use, time, and required calculations. It is well known that measuring Ksat in the field results in variation in results as based on current site conditions and use of a device to measure this parameter.

<u>Depth to Seasonal High Water Table:</u>

Site Specific Mapping has the Depth to Seasonal High Water Table in six categories: 0”-12”, >12”-18”, >18”- 24”, >24-30”, >30-40” and > 40”. The 2009 NEH has the Depth to High Water Table divided at <24, <24-40”, and >40”.

<u>Depth to Restrictive Layer:</u>

Depth to Restrictive layer is placed into three categories in both the NEH and the Site Specific Mapping guide. Categories are <20”, 20”-40”, >40”.

<u>Subsurface Texture of Least Transmissible Layer:</u>

Textures described within the soil description note card include surface, subsurface and parent material. The map unit legend includes texture by describing general particle size class based on the substratum soil textures. For determination of HSG, it is important to select for the texture of the least transmissible layer over 10” thick.

<u>Removal of Dual HSGs:</u>

Dual HSGs, found within the NEH guide, were removed as options within the RI HSG method. These groups were removed from the Rhode Island Soil Survey and the RI DEM storm water manual and therefore, it was not applicable to add them into this method.

1. Depth to impermeable layer	2. Depth to high water table	1. Subsurface Texture of least transmissible layer	**HSG**
<20 in	__	N/A	D
20 to 40 in	<24 in	N/A	D
	≥24 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands and Sandy Loams	B
		Fine Sandy Loams and Silt Loams	C
		Clay Loams and Clay	D
>40 in	<24 in	N/A	D
	24 to 40 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		Silt Loams	C
		Clay Loams and Clay	D
	>40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		Fine Sandy Loams and Silt Loams	B
		Clay Loams	C
		Clay	D

This key is meant to be used in conjunction with the Site Specific Soil Mapping Guide so that the determination of HSG can become an addition to the derived map unit symbols determined in the field by soil scientists.

Compacted Soils:

It is important to consider the possibility of previous soil disturbance as a factor which can alter the HSG classification for a soil. Disturbance can result in compaction and the general guidelines for HSG determination no longer apply (NEH, 2009). Compaction could be due to many factors including foot and vehicle traffic, construction, tillage and erosion (UDEL, 2009). Signs of soil compaction can be noticed specifically when testing for soil consistence and excavation difficulty. Refer to the DEM Soil Evaluation Guidance Document and Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of OWTS for methods placement into a soil category. If a soil is classified as a soil category 8-10 as based on consistence and evacuation difficulty as opposed to morphology, it is likely the soil has been compacted. While up to the discretion of the soil scientist preforming the site survey, it is recommended that a soil be classified into a stricter HSG if the soil is severely compacted.

Conclusion:

Accurate identification of HSGs are necessary when determining applicable land use and development for an area. The HSG classification relates to soil hydrology specifically concerning, runoff, flooding and soil permeability. These parameters are integrated by use of the TR-55 method, a standard in Rhode Island, directly based on a locations HSG classification. Results go on to determine applicable LID and BMP's which will be put in place to mitigate environmental problems of flooding and water quality degradation.

It is essential that the scales at which site mapping is done match the geographical extent of the area to be altered by the mapping. In the case of land development, it is best to work at a local scale and therefore, preforming SSSM to identify the HSG for an area is a logical standard to work with so the optimum results are achieved.

Appendix A. Derivation of the Rhode Island Hydrologic Soil Group Classification Method

Table 1. 2009 NEH Criteria for HSG Determination.

Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

Depth to water impermeable layer 1/	Depth to high water table 2/	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG 3/
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 μm/s (>5.67 in/h)	0 to 60 cm [0 to 24 in]	A/D
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D
		≤1.0 μm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D
	≥60 cm [≥24 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D
		>4.0 to ≤10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D
	60 to 100 cm [24 to 40 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
	>100 cm [>40 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A
		>4.0 to ≤ 10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D

1/ An impermeable layer has a K_{sat} less than 0.01 μm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

7–4 (210–VI–NEH, January 2009)

Table 2. Simplified version of table 1 with added consistency with soils in RI.
Dual groups have been removed.

1. Depth to impermeable layer	2. Depth to high water table	3. Ksat of least transmissive layer	Ksat depth range	HSG
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<24 in	—	—	D
	≥24 in	>5.67 in/h	0-20 in	A
		>1.42 to ≤5.67 in/h		B
		>0.14 to ≤1.42 in/h		C
		≤1.14 in/h		D
>100 cm [>40 in]	<24 in	—	—	D
	≥24 to 40 in	>5.67 in/h	0-20 in	A
		>1.42 to ≤5.67 in/h		B
		>0.14 to ≤1.42 in/h		C
		≤0.14 in/h		D
	>40 in	>1.42 in/h	0-40 in	A
		>0.57 to ≤1.42 in/h		B
		>0.06 to ≤0.57 in/h		C
		≤0.06 in/h		D

Table 3. Amended General Guide to Saturated Hydraulic Conductivity in Relation to Soil Texture

St. Paul, MN (SSR 10), NRCS-USDA
This is a general guide. Bulk density of the soil may alter the defined rates.

Since the goal is to have HSG be determined in the field from texture instead of measuring Ksat, the NRCS table is used which correlates textures with Ksat ranges.

Texture	**General Textural Class**	**Permeability Class**	**Ksat Rate** in/hr	µm/sec
Gravel Coarse Sand	N/A	Very Rapid	>20.0	>141.14
Loamy Sand Loamy Fine Sand Loamy Coarse Sand Sand Fine Sand Coarse Sand	Coarse	Rapid	6.0-20.0	42.34-141.14
Coarse Sandy Loam Sandy Loam Find Sandy Loam	Mixed	Moderately Rapid	2.0-6.0	14.11-42.34
Very fine sandy loam Loam Silt Loam Silt	Mixed	Moderate	0.6-2.0	4.23-14.11
Clay Loam Sandy Clay Loam Silty Clay Loam	Mixed	Moderate Slow	0.2-0.6	1.41-4.23

Table 4. Ksat Range Criteria for the 2009 NEH and NRCS Cheat Sheet.
The NRCS Cheat Sheet was used to assist in determining textures comparable with Ksat ranges.
This table shows issues with using the NRCS table to replace Ksat with Texture.

- The ranges within the NEH overlap those in the NRCS table. Example: NEH Range is 1.42-5.67 and NRCS is 2-6.
- Based on the 2 other criteria of depth to impermeable layer and depth to water table, the ranges for HSG change meaning you cannot directly correlate texture with HSG (all 3 criteria must be included).
- Textures were allocated by expert opinions to create Table 5.

Hydraulic Conductivity Ranges (Ksat in in/hr)	2009 NEH (in/h)		NRCS (in/h)
	For: **1.** Depth to impermeable layer of 20-40” **2.** Depth to impermeable layer >40” and depth to high water table 24-40”	For: **1.** Depth to impermeable layer >40” and depth to high water table >40”	>20.0
			2.0-6.0
	>5.67	>1.42	0.6-2.0
	>1.42- ≤5.67	>0.57 to ≤1.42	0.2-0.6
	>0.14-≤1.42	>0.06 to ≤0.57	0.06-0.2
	≤0.14	≤0.06	<0.06

Table 5. Table 2 with addition of texture classes.

1. Depth to impermeable layer	2. Depth to high water table	3. Ksat of least transmissive layer	Ksat depth range	Textures	HSG
<50 cm [<20 in]	—	—	—	N/A	D
50 to 100 cm [20 to 40 in]	<24 in	—	—	N/A	D
	≥24 in	>5.67 in/h	0-20 in	Skeletal, Sands and Loamy Sands	A
		>1.42 to ≤5.67 in/h		Fine Sands and Sandy Loams	B
		>0.14 to ≤1.42 in/h		Fine Sandy Loams and Silt Loams	C
		≤1.14 in/h		Clay Loams and Clay	D
>100 cm [>40 in]	<24 in	—	—	N/A	D
	24 to 40 in	>5.67 in/h	0-20 in	Skeletal, Sands and Loamy Sands	A
		>1.42 to ≤5.67 in/h		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		>0.14 to ≤1.42 in/h		Silt Loams	C
		≤0.14 in/h		Clay Loams and Clay	D
	>40 in	>1.42 in/h	0-40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		>0.57 to ≤1.42 in/h		Fine Sandy Loams and Silt Loams	B
		>0.06 to ≤0.57 in/h		Clay Loams	C
		≤0.06 in/h		Clay	D

Table 6. Field Method of HSG Determination.

1. Depth to impermeable layer	**2.** Depth to high water table	**2.** Subsurface Texture of least transmissible layer	**HSG**
<20 in	__	N/A	D
20 to 40 in	<24 in	N/A	D
	≥24 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands and Sandy Loams	B
		Fine Sandy Loams and Silt Loams	C
		Clay Loams and Clay	D
>40 in	<24 in	N/A	D
	24 to 40 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		Silt Loams	C
		Clay Loams and Clay	D
	>40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		Fine Sandy Loams and Silt Loams	B
		Clay Loams	C
		Clay	D

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All soils with a depth to water impermeable layer <20" and/or a depth to the seasonal high water table of <24" will be in HSG D.

Steps:

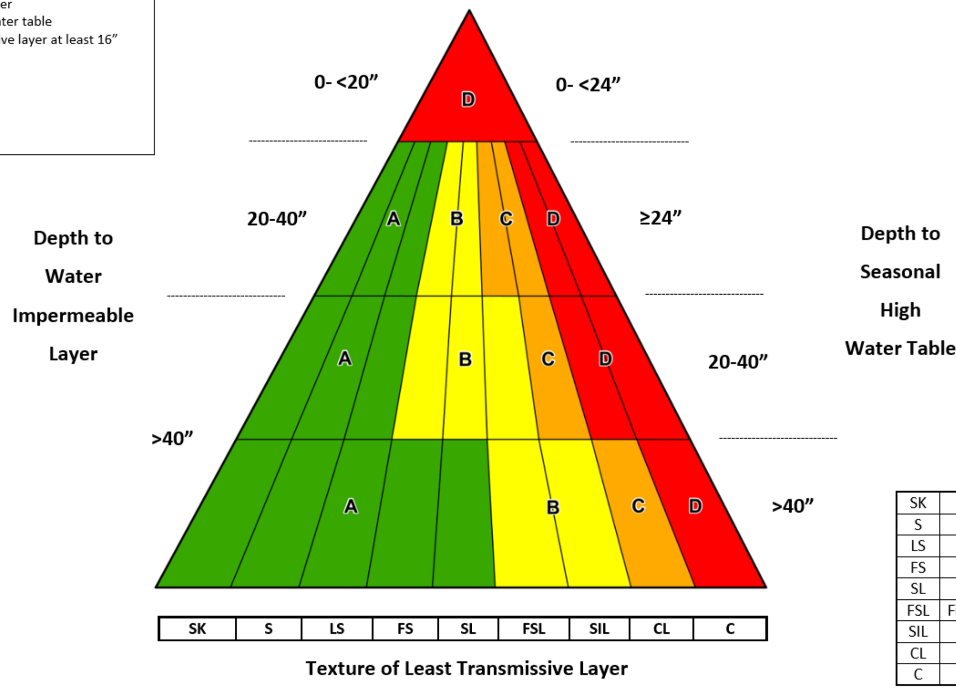
1. Depth to impermeable layer
2. Depth to seasonal high water table
3. Texture of least transmissive layer at least 16" thick

Example:

1. Depth to IL= 35"
2. Depth to SHWT=28"
3. Texture= Sandy Loam
4. HSG= B

Hydrologic Soil Group Triangle

Rhode Island



SK	Skeletal
S	Sand
LS	Loamy Sand
FS	Fine Sand
SL	Sandy Loam
FSL	Fine Sandy Loam
SIL	Silt Loam
CL	Clay Loam
C	Clay