Designation: D8151 – 19$^{\varepsilon 1}$

Standard Practice for Obtaining Rainfall Runoff from Unvegetated Rolled and Hydraulic Erosion Control Products (RECPs and HECPs) for Acute Ecotoxicity Testing[1]

This standard is issued under the fixed designation D8151; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Eq 4 was editorially corrected in March 2020.

1. Scope

1.1 This practice establishes the guidelines, requirements, and procedures for obtaining rainfall runoff of unvegetated rolled and hydraulic erosion control products (RECPs and HECPs) during bench-scale conditions from simulated rainfall to be sent out for acute ecotoxicity testing.

1.2 This practice obtains unvegetated erosion control product (ECP) runoff from rainsplash-induced erosion under bench-scale conditions using bench-scale collection procedures.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this test method.

1.4.1 The procedures used to specify how data are collected/recorded and calculated in the standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of these test methods to consider significant digits used in analysis methods for engineering data.

1.5 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D4972 Test Methods for pH of Soils
D6026 Practice for Using Significant Digits in Geotechnical Data

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.25 on Erosion and Sediment Control Technology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D6475 Test Method for Measuring Mass per Unit Area of Erosion Control Blankets
D6566 Test Method for Measuring Mass Per Unit Area of Turf Reinforcement Mats
D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
D7101 Index Test Method for Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Soil from Rain Splash and Associated Runoff Under Bench-Scale Conditions

2.2 *EPA Standards:*[3]

Method 2002 Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
Method 2002.0 CERIODAPHNIA DUBIA Acute Toxicity Tests with Effluents and Receiving Waters
Method 2021.0 DAPHNIA PULEX AND D. MAGNA Acute Toxicity Tests with Effluents and Receiving Waters

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

4. Summary of Practice

4.1 This practice is used to obtain the rainfall runoff needed to determine the acute toxicity of rolled and hydraulic erosion control products (RECPs/HECPs) for a slope of 3:1 (H:V) and a rainfall intensity of 100 ± 5 mm/h.

4.2 Before testing, the rainfall simulator system is calibrated for the rainfall intensity and slope intended for use. The sand used in the soil containers is also tested prior to use.

4.3 The sand is compacted into six soil containers. Three of the soil containers are then protected with the unvegetated RECP or HECP; the other three remain unprotected. The 3 bare soil/unprotected containers are placed in the runoff ramps, covered, and the rainfall simulator is turned on and allowed to come to equilibrium. After equilibrium is reached, the cover is removed, the collection containers are moved into position and the test commences at a rainfall intensity rate of 100 ± 5 mm/h for 30 min. At the end of the test, the runoff collected from each ramp is filtered, measured, and poured into a container. The water from the 3 runoff ramps is combined into a single container. The single water sample is allowed to settle, then decanted to obtain the control sample to be shipped overnight for acute toxicity testing. This process is then repeated for the three soil containers that are unvegetated RECP or HECP protected.

5. Significance and Use

5.1 A large number of erosion control product manufacturers produce a variety of RECPs and HECPs that are designed to be applied to any land surface to stabilize soils and prevent erosion. Many of these products are engineered to absorb moisture and remain in place even under extreme rainfall events and are composed of substances that could go into solution with runoff. Based on the characteristics of these products and their intended and actual use in the environment, the most likely scenario through which aquatic organisms would be exposed to these products or their soluble components is through storm water runoff. Further, because such runoff events typically last for minutes to hours rather than days, use of acute (48 h) toxicity testing methodology is appropriate to model expected environment exposures.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Rainfall Simulator*—A laboratory device capable of simulating rainfall using sprinklers, nozzles or drop emitters to create uniform drops with a diameter, D_{50}, of 3.0 ± 0.25 mm from a drop height of 2000 ± 20 mm above the lowest point of the incline structure. It shall also be capable of producing a rainfall intensity of 100 ± 5 mm/h and must be centered over the incline structure to provide uniform rain application.

6.2 *Incline Structure*—A device comprised of 3 adjacent "runoff ramps" each having an opening at its lower end to accommodate a recessed soil container. The ramps shall be made of metal and 1000 ± 100 mm in length, 250 ± 25 mm wide, and have metal or plastic raised dividers of at least 25.0 mm tall between the ramps to prevent cross-ramp soil splash and run-on/runoff. The structure shall have and maintain a slope gradient of 3:1 (H:V). It is permissible for the structure to be adjustable providing it is able to achieve and maintain a gradient of 3:1 for use in this standard. Test Method D7101 provides a general figure of the incline structure.

6.3 *Runoff Collection Containers*—Any type of bucket having sufficient diameter and capacity to collect and hold all the runoff from each of the ramps.

6.4 *Soil Containers*—Watertight, plastic pipe section cylinders that are nominally 200 ± 10 mm inside diameter with a height of 100 ± 10 mm.

6.5 *Filter Paper*—Grade 3 filter paper having the following characteristics: typical particle retention in liquid of 6 µm, nominal thickness of 390 µm, typical water flow rate of 28 mL/min, nominal ash content of 0.06 %, and made of cellulose.

6.6 *Measuring Device*—A surveyor's rod, tape measure, or similar with a minimum length of 2 m and divisions of 1 mm.

6.7 *Timing Device*—A clock, stopwatch, digital timer, or comparable device readable to 1 second or better.

6.8 *Rain Gauges*—Any type of container is allowed provided they meet the following specifications: Each container must have identical dimensions (same diameters and depths). Each container must be calibrated such that the marked graduation lines accurately measure the amount of rainfall

[3] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov.

within ±1 mm. Lines shall be marked every 1 mm. Clear plastic or glass containers are recommended.

6.9 *Graduated Cylinders*—The capacity of the graduated cylinders must be large enough to measure the volume of runoff water collected in the rain gauges during calibration of the rainfall simulator and the volume of water obtained in the collection buckets during testing. Typically, a 250 mL graduated cylinder has enough capacity. The graduated cylinders must be readable to the nearest 1 mL.

6.10 *Oven*—Vented, thermostatically controlled oven capable of maintaining a uniform temperature of 43 ± 5°C throughout the drying chamber. Typically, a forced-draft oven satisfies these requirements.

6.11 *Balance*—Balances shall conform to the requirements of Guide D4753. The balance shall have a readability without estimation of 0.0001 g. The capacity of this balance will need to exceed the mass of the container plus flour pellets.

6.12 *Sieves*—A 0.212 mm (No. 70) sieve, lid and pan, as well as the following sieves are needed: 6.3 mm (¼ in.), 4.75 mm (No. 4), 4.0 mm (No. 5), 3.35 mm (No. 6), 2.8 mm (No. 7), 2.36 mm (No. 8), 2.00 mm (No. 10), 1.7 mm (No. 12), 1.4 mm (No. 14), 1.0 mm (No.18), 0.500 mm (No. 35), and 0.250 mm (No. 60).

6.13 *Miscellaneous*—The following items are also needed: waterproof barrier (plastic sheeting, lids, canopy), 230 mm wide by 25.4 mm deep cake pans, flour sifter, Pillsbury Best all-purpose flour (Note 2), ruler, evaporating dishes, desiccator (optional), sieve shaker (optional), high-density polyethylene (HDPE) containers, bucket/container large enough to hold the filtered water from all three runoff ramps, coolers, and ice.

NOTE 2—The subcommittee is committed to identifying alternate flour as soon as the test described in this standard is performed outside the United States.

7. Materials and Sampling

7.1 *Soil Type*—The soil type to be used during testing is sand conforming to the properties listed in Table 1. Perform the following testing on the bulk sand according to the listed methods. Record the results of the testing in accordance with the requirements of each individual standard. These tests must be done before initial use of the bulk sand sample and anytime thereafter when the bulk sand sample has been replenished with new sand. Make sure the bulk sand sample has been blended well to provide a representative specimen for initial testing.

7.1.1 Particle-size distribution as determined by Test Methods D6913. The target gradation curve that should provide a material with grain size properties meeting Table 1 is 100 % passing the 2.00 mm (No. 10) sieve, 65 % passing the 0.850 mm (No. 20) sieve, 33 % passing the 0.300 mm (No. 50) sieve and 18 % passing the 0.106 mm (No. 140) sieve. See Test Method D7101 for an example graph.

7.1.2 Plasticity Index as determined by Test Methods D4318.

7.1.3 Optimum water content and maximum dry unit weight as determined by Test Methods D698. Determine and record the value corresponding to 90 % of the maximum dry unit weight.

7.1.4 pH as determined by Test Method D4972.

7.2 *RECP/HECP*—The representative sample shall be obtained from a package, roll or both. The package or roll must be checked for visible damage, such as tears, rips, and holes, prior to use. If the packaging is damaged, do not use it for testing. All RECPs/HECPs shall be free of extraneous foreign materials, such as, metals or non-standard plastics that could interfere with production application. The RECP or HECP shall be applied to the soil surface in accordance with the manufacturer's recommended application methods.

7.2.1 Determine and record the mass per unit area in accordance with Test Methods D6475 and D6566 for the RECP/HECP being evaluated in this standard.

7.2.2 Obtain a representative sample of 1 m^2 when evaluating RECPs and 500 g when evaluating HECPs. Select 3 test specimens from the representative sample for use in testing. Make the test specimens large enough to cover the entire soil container surfaces and in accordance with the manufacturer's installation instructions.

TABLE 1 Typical Soil Properties

Property	Sand	Sieve Size(s)
D_{100} (mm)	$D_{100} < 4.75$	No. 4
D_{85} (mm)	$4.75 > D_{85} > 0.850$	No. 4 and No. 20
D_{50} (mm)	$0.850 > D_{50} > 0.300$	No. 20 and No. 50
D_{15} (mm)	$0.300 > D_{15} > 0.075$	No. 50 and No. 200
Plasticity Index	Nonplastic	
pH	6.0-8.0	

8. Calibration of Rainfall Simulator

8.1 Calibration of the rainfall simulator is performed by measuring and determining the drop height, the rainfall intensity and uniform distribution, and raindrop size with the incline structure at the specified slope. At a minimum, this calibration shall be done before initial use, after equipment repair/maintenance, and annually thereafter.

8.2 *Drop Height*—Position the incline structure such that the slope is 3:1 (H:V). Determine and record the drop height of the raindrops to the lowest point of the incline structure to the nearest 1 mm using a measuring device. Make adjustments as needed.

8.3 *Rainfall Intensity and Distribution:*

8.3.1 Maintain the 3:1 (H:V) slope of the incline structure. Place a rain gauge in the middle of each ramp. Cover the rain gauges with a waterproof barrier, such as plastic sheeting, lids or canopy. Turn on the rainfall simulator and allow it to come to equilibrium, then quickly remove the waterproof barrier and start the timing device. Allow the simulator to run for a minimum of 15 mins (Note 3). After 15 min, turn off the rainfall simulator and stop the timing device. Record the duration of the rainfall to the nearest 1 second.

NOTE 3—If desired, the time interval for conducting the calibration can be longer than 15 minutes.

8.3.2 Determine and record the amount of water collected in each rain gauge to the nearest 1 mm. The rainfall intensity is calculated by multiplying the amount of water by the corresponding time factor of 4 to achieve mm/h. For example, if 25 mm of water was collected in 15 min, the rainfall intensity is (25 × 4) 100 mm/h.

8.3.3 Using the rainfall intensity determinations, determine the rainfall distribution is uniform by comparing the amount collected in each of the three rain gauges. If the three intensity determinations vary by more than 10 % adjust the simulator and repeat the calibration.

8.4 *Raindrop Size:*

8.4.1 Completely fill three 230 mm labeled cake pans with sifted Pillsbury Best all-purpose flour (Note 4). Record the identification number of the cake pans. Use a ruler to strike off the surface of the flour to produce a smooth, uncompacted surface. The flour should be a minimum of 25.4 mm deep. Place 1 filled cake pan in the middle of each ramp and cover with a waterproof barrier. The cake pan must be held horizontally 300 to 450 mm above the surface of the incline structure. Resift the flour if the pans will sit for more than 2 hours prior to calibration.

NOTE 4—Repeated use of the flour pan method has shown variability is introduced when different brands of flour are used. Pillsbury Best all-purpose flour has produced the most repeatable results. In addition, pie pans have historically been used, but cake pans produce more repeatable results because they do not contain the wide edges like pie pans.

8.4.2 Turn on the simulator and allow it to reach equilibrium. Then briefly remove the waterproof barrier to allow raindrops to impinge on the flour to form pellets having little to no overlap for approximately 2 to 4 seconds. Either turn off the simulator or quickly re-cover the pans being careful to not allow the cover to make contact with the flour. Record the exposure time for each pan.

8.4.3 Air dry the flour-filled cake pans for a minimum of 12 h. Then, one at a time, empty the cake pan's contents onto a 0.212 mm (No. 70) sieve to carefully remove as much of the loose flour from the pellets as possible. Record the identification and mass of each evaporating dish. Transfer the pellets to a labeled evaporating dish and heat in the 43 ± 5°C oven for 6 h. Repeat for the other two cake pans.

8.4.4 Remove the evaporating dishes from the oven and cool to room temperature in a desiccator or cover with lids. Determine and record the total mass, M_t, of the hard flour pellets to the nearest 0.0001 g.

8.4.5 Assemble the two sieve sets. The first set consists of the following: 6.3 mm (¼ in.), 4.75 mm (No. 4), 4.0 mm (No. 5), 3.35 mm (No. 6), 2.8 mm (No. 7), 2.36 mm (No. 8) and a pan. The second set consists of the following: 2.00 mm (No. 10), 1.7 mm (No. 12), 1.4 mm (No. 14), 1.0 mm (No.18), 0.500 mm (No. 35), 0.250 mm (No. 60) and a pan. Carefully place the hard pellets on the 6.3 mm (¼ in.) sieve and put the lid on the sieve set. Shake the sieves by hand or place in a verified sieve shaker for 2 min. Starting with the largest sieve, remove any foreign matter and any double pellets from the sieve and determine and record the mass of the pellets retained on the sieve to the nearest 0.0001 g and count the number of pellets (8.4.5.1). Repeat for each subsequent sieve. The pellets retained in the pan are then placed on the first sieve of the second sieve set. Shake the second set of sieves for 2 min. Repeat the culling, mass determination, and counting for the second set of sieves.

8.4.5.1 It is possible that the finer sieves can have so many pellets retained on them that counting each one is not economically feasible. In these instances it is common practice to count a smaller number of pellets, determine the mass of that amount, and then divide the total mass of all the pellets retained on the sieve by the mass of the smaller number of pellets multiplied by the smaller number of pellets to determine the estimated number of pellets retained (Note 5).

NOTE 5—Usually, if there are 200 or less pellets they are counted. When there are more than 200 pellets the average mass of 200 pellets is used to calculate and determine the amount of pellets retained. For example: total mass of all pellets retained on sieve is 1.8500 g. 200 pellets are counted and their mass is 0.8564 g. 1.8500/0.8564 = 2.16 × 200 = 432 pellets retained on the sieve.

8.4.6 Calculate the average mass of raindrop, W, for each sieve size. Divide the mass of the pellets, M_p, by the number of pellets, C_p, retained on each sieve.

$$W_i = \frac{M_{pi}}{C_{pi}} \tag{1}$$

where:

W_i = average mass of pellet, nearest 0.0001 g,
M_{pi} = mass of pellets, nearest 0.0001 g,
C_{pi} = number of pellets, and
i = subscript indicating the sieve size.

8.4.7 Calculate the mass of the raindrop, M_d, with correction (Laws and Parson, 1943)[4] using the following equation:

$$M_{di} = (-24.697 \times W_i^2 + 3.6167 \times W_i + 1.0287) \times W_i \tag{2}$$

where:

M_{di} = corrected mass of pellet, nearest 0.0001 g.

8.4.8 Calculate the diameter of average raindrop, D_r, using the following equation:

$$D_{ri} = 10 \times \sqrt[3]{\frac{6}{\pi} \times M_{di}} \tag{3}$$

where:

D_{ri} = diameter of average raindrop, nearest 0.001 mm.

8.4.9 Calculate the percent passing, PP, each sieve using the following equation:

$$PP_i = 100\left(1 - \frac{CMR_i}{M_t}\right) \tag{4}$$

where:

PP_i = percent passing each sieve, nearest 1 %,
CMR_i = cumulative mass of pellets retained, nearest 0.0001 g; where CMR_i is the mass of the pellets retained on an individual sieve plus the masses of pellets retained on all the coarser sieves in a given sieve set, and
M_t = total mass of pellets, nearest 0.0001 g.

[4] Laws, J.O., and Parsons, D.A., "The Relation of Raindrop-Size to Intensity." *Transactions*, American Geophysical Union., Vol. 24, Part 2, 1943, p. 452-460.