Engineered Soils and Performance Design

By Charles Duprey, President
Of Naturcycle, LLC
April 11, 2019
Randolph Center, VT
VORS Conference
Naturcycle, LLC

► is working with people like you in “Restoring Earth.”
► Broker compost for a number of municipal and private compost producers around New York State.
► Provide expertise in compost use and sourcing.
► Manufactures a variety of quality engineered soils like Green Roof Media, Bio-Retention Mixes and many other blends from multiple NYS Sites.
► Offers value engineering on a variety of soil or compost designs

www.naturcycle.com
Overview

- Green Infrastructure
- Compost Defined and the USCC STA Program
- Engineered Soils
- Performance Designs
- Review
What is Green Infrastructure?

Green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle.

America’s Rivers Assoc “Rivers Connect Us”

....green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.

US EPA www.epa.gov/green-infrastructure/what-green-infrastructure

Trying to Mimic Nature by “Restoring Earth”
This is the “Natural” Cycle of Water
Our current environments...
Storm Water Hydrology Comparison

Source: Sego Jackson - 2001
These keys allow us to mimic the Natural Cycle with Green Infrastructure

**Key Elements of Green Infrastructure**

- **Conservation**
  - Preserve native habitats, vegetation, soils & natural drainage patterns

- **Directing Runoff**
  - Encourage infiltration and recharge of streams, wetlands, and aquifers

- **Custom Site Design**
  - Ensures each site protects the entire water shed

- **Small Scale Controls**
  - Mimics the natural process and hydrology

- **Maintenance, Pollution & Education**
  - Reduce pollutant loads
  - Educate and involve the public
  - Meeting Federal, State and Local Standards
All these Key Elements use and need COMPOST...

- **Conservation** -
  - Restore habits with engineered soils or compost
  - Amend soils in place with compost to reduce impact

- **Directing Runoff**
  - Compost Blankets
  - Compost Berms

- **Small Scale Controls**
  - Green Roofing
  - Rain Gardens

- **Custom Site Design**
  - Infiltration vs Retention Basins
  - Planting selection

This is just a small sampling of how compost is crucial to Green Infrastructure
What is Compost? - Compost Defined

- A humus-rich soil amendment made by the controlled biological decomposition of organic materials.
- Made from organic wastes like yard trimmings, organic by-products, industrial residuals, food scraps, animal manures, biosolids.
- Must go through an aerobic heating process to be biologically stable and mature.
- Can improve biological, physical and chemical characteristics of soils.
What is good compost? Look for STA

- Stable – low biological activity level (Respirometry vs Solvita)
- Mature – aged for optimum plant growth (Bioassay)
- Nutrient content – N, P, K (high percentage in slow release form)
- Organic matter content – 30-70%
- Moisture content
- pH – 6.0-8.0
- Soluble Salts - < 5 mmhos/cm

Good Parameters and USCC Seal of Testing Assurance Participation
### Compost Technical Data Sheet

**A & L Great Lakes Laboratories, Inc. 3505 Conestoga Drive Fort Wayne IN 46808**

<table>
<thead>
<tr>
<th>Compost Parameters</th>
<th>Method</th>
<th>Reported as (unit of measure)</th>
<th>Test Results</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant Nutrients:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>TMECC 04.02-D</td>
<td>Total N</td>
<td>1.03 %</td>
<td>1.46 %</td>
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<tr>
<td>Phosphorus</td>
<td>TMECC 04.03-A</td>
<td>P2O5</td>
<td>0.45 %</td>
<td>0.64 %</td>
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<tr>
<td>Potassium</td>
<td>TMECC 04.04-A</td>
<td>K2O</td>
<td>0.17 %</td>
<td>0.53 %</td>
</tr>
<tr>
<td>Calcium</td>
<td>TMECC 04.05-CA</td>
<td>Ca</td>
<td>2.24 %</td>
<td>3.23 %</td>
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<tr>
<td>Magnesium</td>
<td>TMECC 04.05-MG</td>
<td>Mg</td>
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<td>0.90 %</td>
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<tr>
<td>Moisture Content</td>
<td>TMECC 03.09-A</td>
<td>%, wet weight basis</td>
<td>20.64 %</td>
<td></td>
</tr>
<tr>
<td>Organic Matter Content</td>
<td>TMECC 05.07-A</td>
<td>%, dry weight basis</td>
<td>0.16 %</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>TMECC 04.11-A</td>
<td>pH units</td>
<td>7.4</td>
<td></td>
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<tr>
<td>Soluble Salts (electrical conductivity EC,)</td>
<td>TMECC 04.16-A</td>
<td>dSm (mhos/cm)</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Particle Size</td>
<td>TMECC 02.02-B</td>
<td>% &lt; 9.5 mm (3/32 in), dw basis</td>
<td>100.00 %</td>
<td></td>
</tr>
<tr>
<td><strong>Stability Indicator (respiratory)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Evolution</td>
<td>TMECC-05.05-B</td>
<td>mg CO₂-Cg OM/dry</td>
<td>2</td>
<td>Stable</td>
</tr>
<tr>
<td></td>
<td>mg CO₂-Cg TV/d</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Maturity Indicator (bioassay):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Emergence</td>
<td>TMECC 05.03-A</td>
<td>average % of control</td>
<td>100</td>
<td></td>
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<tr>
<td>Relative Seedling Vigor</td>
<td>TMECC 05.04-A</td>
<td>average % of control</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td><strong>Select Pathogens:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMECC 07.01-B</td>
<td>PASS/FAIL: per US EPA Class A standard, 40 CFR, § 503.32(a)</td>
<td>PASS</td>
<td>Al, Cd, Pb, Hg</td>
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<tr>
<td>Trace Metals</td>
<td>TMECC 04.06</td>
<td>PASS/FAIL: per US EPA Class A standard, 40 CFR, § 503.32(a), Tables 1 and 2</td>
<td>PASS</td>
<td>Al, Ni, Se, Zn</td>
</tr>
</tbody>
</table>

Participants in the US Composting Council's Seal of Testing Assurance Program have shown the commitment to test their compost products on a prescribed basis and provide this data, along with compound and use instructions, as a means to better serve the needs of their compost customers.

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### Compost Technical Data Sheet

**Village of Eadicott WWTP**

<table>
<thead>
<tr>
<th>Product Name:</th>
<th>Naturcycle Compost “E”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Date</td>
<td>09/7/16 4:30 FM</td>
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<tr>
<td>Receive Date</td>
<td>9/9/16</td>
</tr>
<tr>
<td>A &amp; L Lab Number</td>
<td>67796</td>
</tr>
<tr>
<td>A &amp; L Report Number</td>
<td>F10253-0019</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Compost Parameters</th>
<th>Method</th>
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<td>Total N</td>
<td>1.07 %</td>
<td>2.70 %</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>TMECC 04.03-A</td>
<td>P2O5</td>
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<td>5.02 %</td>
</tr>
<tr>
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<td>K2O</td>
<td>0.16 %</td>
<td>0.40 %</td>
</tr>
<tr>
<td>Calcium</td>
<td>TMECC 04.05-CA</td>
<td>Ca</td>
<td>1.21 %</td>
<td>3.04 %</td>
</tr>
<tr>
<td>Magnesium</td>
<td>TMECC 04.05-MG</td>
<td>Mg</td>
<td>0.10 %</td>
<td>0.25 %</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>TMECC 03.09-A</td>
<td>%, wet weight basis</td>
<td>00.23 %</td>
<td></td>
</tr>
<tr>
<td>Organic Matter Content</td>
<td>TMECC 05.07-A</td>
<td>%, dry weight basis</td>
<td>72.14 %</td>
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<tr>
<td>pH</td>
<td>TMECC 04.11-A</td>
<td>pH units</td>
<td>5.6</td>
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<tr>
<td>Soluble Salts (electrical conductivity EC,)</td>
<td>TMECC 04.10-A</td>
<td>dSm (mhos/cm)</td>
<td>2.79</td>
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<tr>
<td>Particle Size</td>
<td>TMECC 02.02-B</td>
<td>% &lt; 9.5 mm (3/32 in), dw basis</td>
<td>98.58 %</td>
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<tr>
<td><strong>Stability Indicator (respiratory)</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Evolution</td>
<td>TMECC-05.08-B</td>
<td>mg CO₂-Cg OM/dry</td>
<td>1</td>
<td>Very Stable</td>
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<tr>
<td></td>
<td>mg CO₂-Cg TV/d</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Maturity Indicator (bioassay):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Emergence</td>
<td>TMECC 05.05-A</td>
<td>average % of control</td>
<td>100</td>
<td></td>
</tr>
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<td>Relative Seedling Vigor</td>
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<td></td>
</tr>
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<td><strong>Select Pathogens:</strong></td>
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<td></td>
<td></td>
<td></td>
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<td>PASS</td>
<td>Al, Ni, Se, Zn</td>
</tr>
</tbody>
</table>
Composting Council & Seal of Testing Assurance Program  

- Nationwide Trade group
  - 700 plus Members
  - 300 Products in STA
- Sets independent standards and created the TMECC to standardize compost analysis Nationwide in 1999
- NYS DOT Specs call for STA
Engineered Soils

- A manufactured soil product made from a variety of inert materials and an organic amendments
  - Examples
    - Washed, Sized Natural Sand
    - Crushed, or Natural Stone products
    - Expanded Aggregates
    - Compost, Peat, other OM sources
    - Washed fine products, like silt or clay
  - Based around detailed, replicable testing methodology (IE Some labs test things their own way)
  - Can be tailored to meet plant or stormwater needs
Creating Engineered soils with Compost

- Soil type drives the level of required amendment. For Simplification we can break soils into two categories

- Loam Soils (Average Density of 2600 lbs/ cu yd)
  - To raise the soil organic matter 1% in the overall final soil you need to add 1.5 Cubic yards of Compost (a ½” layer) and till to a depth of 6 inches per 1000 square feet.

- Sand/High Clay Soils (Average Density 3000 lbs / cu yd)
  - To raise the soil organic matter 1% in the overall final soil you need to add 1.75 Cubic yards of Compost (a 2/3” layer) and till to a depth of 6 inches per 1000 square feet.

Assumptions
- A Compost with at least 60% Organic Matter by LOI
- A compost with a density of 900 lbs / cu yd
Engineered Soils from a Specifier standpoint

- allow for manufactured soils in specs (sometimes prohibited)
- Remind contractors and installers of lead times (months not weeks)
- Train Landscape Architects and other professionals what to ask and look for
- Have standardized component programs and focus on final blended materials
Performance Designs

- Focusing on final soil characteristics
- Specify capable laboratories and testing agencies to speed process
- Should include a check on the inputs like existing ASTM or TMECC standards
- Quality Control Testing as part of specification (usually based on volume to assure compliance)
- Based around ranges achievable and comparable to USDA Soil Types
- Physical Samples can be a helpful tool before actual delivery
- Designed to achieve a goal, infiltration, retention, plant growth, low Nutrient,

**Naturcycle**
**Example for Battery Park Authority**

E. Clay – Soil particles sized below 0.002 millimeters

**As Designed Parameters for Engineered Soil A:**

A. \( \leq 10\% \) Gravel - Less than 10\% retained of the total sample on the No. 10 Sieve by ASTM F1632 Method B

B. 60 to 70\% Sand
   20 to 30\% Silt
   5 to 10\% Clay
   As tested by ASTM F1632 Method B

C. Sand Fraction shall contain less than 10\% Very Fine Sand defined as smaller than No. 270 Sieve as part of ASTM F1632

D. \( > 2.0 \) K/Sat in Inches Per Hour – at least 2 inches per hour with compaction energy modified to 5.75 foot pound per square inch by ASMT E2399

E. pH range 7.2 to 6.5 by ASTM D4972

F. 4 to 5.0 \% Organic Matter by Loss on Ignition by ASTM F1647
New York State Department of Transportation  
September 1, 2018 Specification

2. Topsoil - Lawn
- The pH of the material shall be between 5.5 and 7.6.
- The organic content shall be not less than 6% or more than 12%

<table>
<thead>
<tr>
<th>Gradation:</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
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</tr>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 10</td>
<td>90 to 100</td>
</tr>
<tr>
<td>No. 40</td>
<td>45 to 80</td>
</tr>
<tr>
<td>No. 200</td>
<td>25 to 70</td>
</tr>
<tr>
<td>2 Micron</td>
<td>5 to 35</td>
</tr>
</tbody>
</table>
NYS DOT allows for a soil amendment plan to achieve performance goal

- Add % of compost by volume to achieve final soil organic matter target without re-testing

- Requires STA Compost participation and or tested to TMECC Standards. That’s how you can do this state wide with many different soils and composts

- An expert in the field like a soil laboratory, compost producer or soil scientist can calculate a recommended rate

- It does not address infiltration, nutrients or other important Bio-retention factors

**Infiltration**

- Lab verse Field analysis
  - Directly relates to compaction
  - ASTM F1815 is a common analysis for Saturated Hydraulic Conductivity should be paired with compaction rate ASTM D698 like 85% at proctor

- Sand particle shape effects results often (Rounded vs angular)
Further example - Green Roof Media as a performance media

- Green Roof media is a mix of inorganic lightweight materials and organic matter
- It is intended to be “Soil” Less
- Mainly researched from European designs
- Highly specialized blends of lightweight aggregates, sand and compost
- Only the highest quality compost is used
- Yes, I know it’s an engineered soil!
FLL Guidelines - Green Roof Media
Performance Based Characteristics

Summary of selected FLL* guidelines for green roof media.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Unit</th>
<th>Intensive</th>
<th>Single-Course Extensive</th>
<th>Multi-Course Extensive</th>
<th>Drainage Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size distribution</td>
<td>mass %</td>
<td>≤20</td>
<td>≤10</td>
<td>≤15</td>
<td>≤10</td>
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<tr>
<td>&lt; 0.063 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Water and air management</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Maximum water holding capacity</td>
<td>vol %</td>
<td>45 - 65</td>
<td>20 - 65</td>
<td>35 - 65</td>
<td>-</td>
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<tr>
<td>Air-filled porosity at max water</td>
<td>vol %</td>
<td>≥10</td>
<td>≥10</td>
<td>≥10</td>
<td>-</td>
</tr>
<tr>
<td>holding capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water permeability Kf</td>
<td>cm/s</td>
<td>0.0005 - 0.05</td>
<td>0.1 - 0.67</td>
<td>0.001 - 0.12</td>
<td>≥0.3</td>
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<tr>
<td></td>
<td>in/min</td>
<td>0.0118 - 1.18</td>
<td>2.36 - 15.8</td>
<td>0.024 - 2.83</td>
<td>≥7.08</td>
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<tr>
<td>pH value and salt</td>
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<td></td>
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<tr>
<td>pH CaCl2</td>
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<td>6.0 - 8.5</td>
<td>6.0 - 8.5</td>
<td>6.0 - 8.5</td>
<td>6.0 - 8.5</td>
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<tr>
<td>salt (water extract)</td>
<td>g(KCl)/L</td>
<td>≤2.5</td>
<td>≤3.5</td>
<td>≤3.5</td>
<td>≤2.5, ≤3.5</td>
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<tr>
<td>Organic Matter</td>
<td>g/L</td>
<td>≤90</td>
<td>≤40</td>
<td>≤65</td>
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<tr>
<td>Nutrients</td>
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<td></td>
</tr>
<tr>
<td>P₂O₅ (CAL)</td>
<td>mg/L</td>
<td>≤200</td>
<td>≤200</td>
<td>≤200</td>
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</tr>
<tr>
<td>K₂O (CAL)</td>
<td>mg/L</td>
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<td>≤700</td>
<td>≤700</td>
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<tr>
<td>Mg (CaCl₂)</td>
<td>mg/L</td>
<td>≤200</td>
<td>≤200</td>
<td>≤200</td>
<td>-</td>
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<tr>
<td>NO₃ + NH₄ (CaCl₂)</td>
<td>mg/L</td>
<td>≤80</td>
<td>≤80</td>
<td>≤80</td>
<td>-</td>
</tr>
</tbody>
</table>


Never just specify ASTM E2399 !!! Need more parameters like OM, Infiltration, pH ect..
Ignoring the list of performance guidelines and specifying only one ASTM E2399

Only specifying the dead weight of the material when saturated ignores the other keys to success (Mulch/Potting Media meets this)
Green Roof Media at Croton WTP Bronx
If Performance design goes right you can do almost anything

Croton Water Treatment Plant Bronx, NYC
14,000 Yards of Engineered Soil on Deck
10,000 Yards of LW Structural Soil around
What performance design allows for..

- Regional, Local Differences
  - Washed Sand vs Unwashed Sand Sources
  - Varying Compost addition levels
  - Addresses Varying Compost Types
  - Opens door to residuals
  - Allows for localized source solutions, like a crushed stone dust from a quarry in Southern VT verse a washed natural sand in Burlington VT
Review

- Green Infrastructure
- Compost Defined and the STA Program
- Engineered Soils
- Performance Designs
- Questions?
Questions?

Thank You for your time today.

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