



## Advanced Permeable Pavement for Storm Water Management

### Hydrologic & Hydraulic Design

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## Permeable Pavement Design

- Benefits
- Hydrologic and Hydraulic Design
- Engineering Design
- Construction Considerations

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## Types of Permeable Pavement

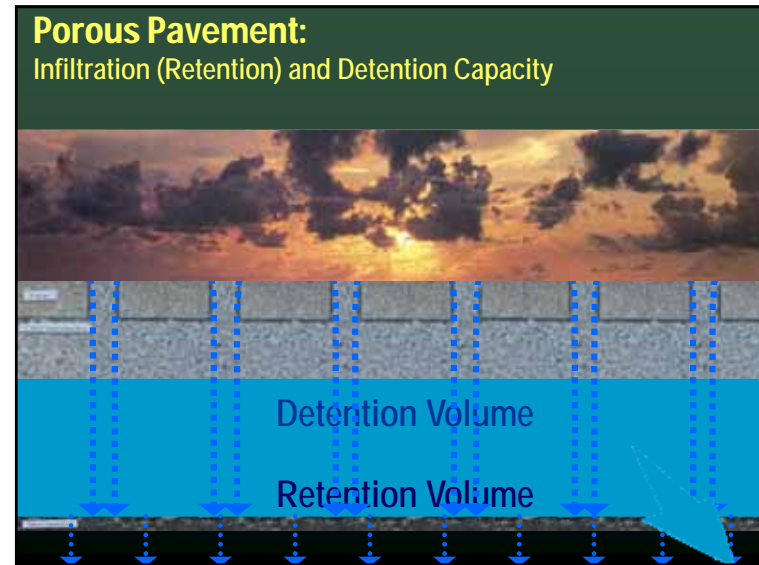
- Interlocking concrete pavers
- Pervious asphalt
- Pervious concrete
- Grid systems
- Gravel grass

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## Types of Permeable Pavement

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## Permeable Pavement Benefits

- Space efficient – detention and parking occupy same space
- Safety – reduced surface icing (Lund Institute of Technology, University of New Hampshire)
- Reduced frost heave (Lulea Univ of Technology)
- Can eliminate need for storm sewers & inlets
- Reduces surface runoff volumes and increases groundwater recharge
- Water quality benefits (See Tech Standard)
- Longevity (paver systems)
- Aesthetics (paver systems)

## Water Quality Benefits

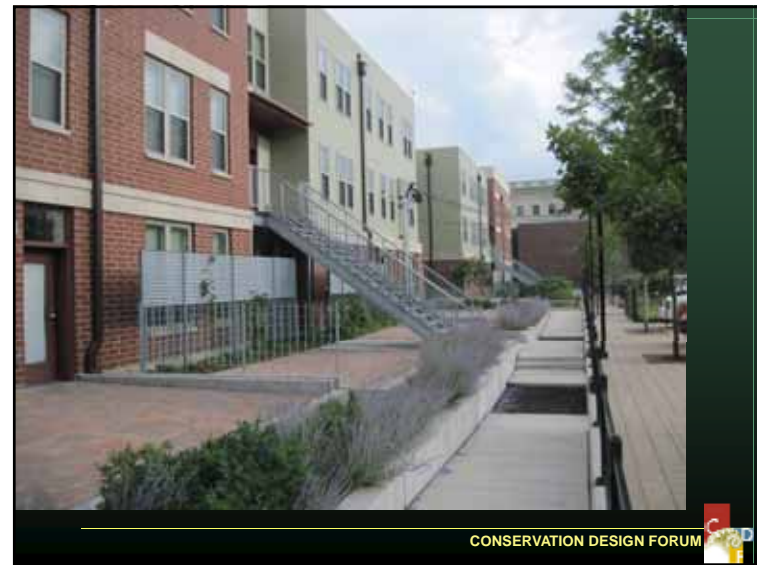
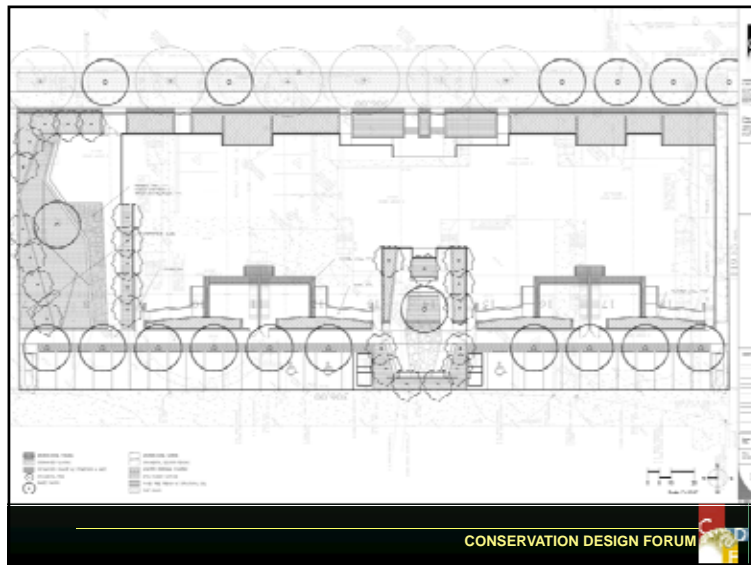
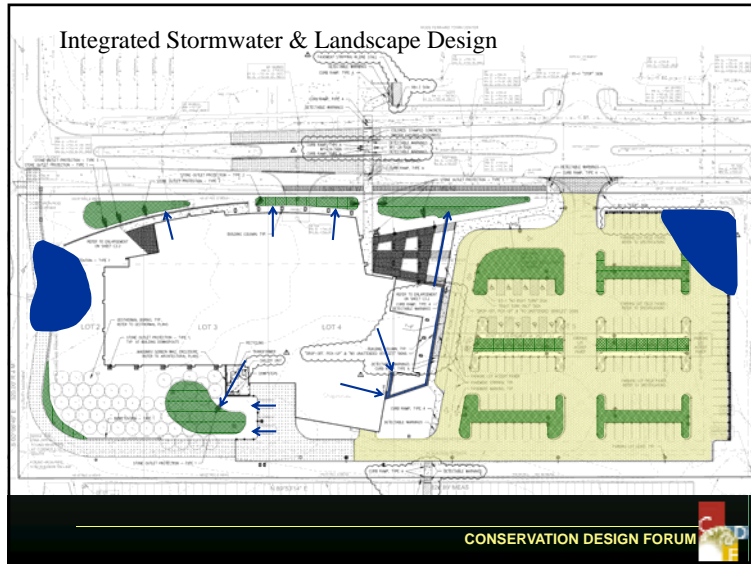
- Event runoff coefficient ~ 0.8 and annual C~0.5 for lined permeable pavement system (Nottingham Trent University)
- Reduced runoff temperature (subsurface) 5 to 7° C (9 to 13° F) relative to asphalt (University of Guelph)
- Microbial digestion of petroleum based hydrocarbons (Coventry University)
- > 95% removal of metals within gravel base (HydroCon GmbH, Hameln, Germany)
- Elimination of sealants (pavers and concrete)
- University of New Hampshire found 70% reduction in deicing salt usage.

## Fox River Water Reclamation District



## Fox River Water Reclamation District







## Site Analysis

- Soils
  - Depth to groundwater at least three feet (varies by state)
  - Avoid highly expansive clay soils
  - Avoid contaminated soils unless lined
  - California Bearing Ratio
  - Soil permeability
- Location
  - Avoid high sediment yielding areas
  - Avoid locations of contaminated runoff or risk of spills
  - Avoid significant run-on that could clog paving
  - Provide proper setback or waterproofing for building foundations
  - Provide proper setback from wells (varies by state)
- Traffic Loading
  - Pavers most suitable for parking lots
  - Limit paver use to streets with speeds < 30 mph
  - May need to provide weight restrictions for porous asphalt or concrete

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## Site Analysis

### Select Paver Type by Use

Street Permeable Paver:  
*Eco-Optlock*

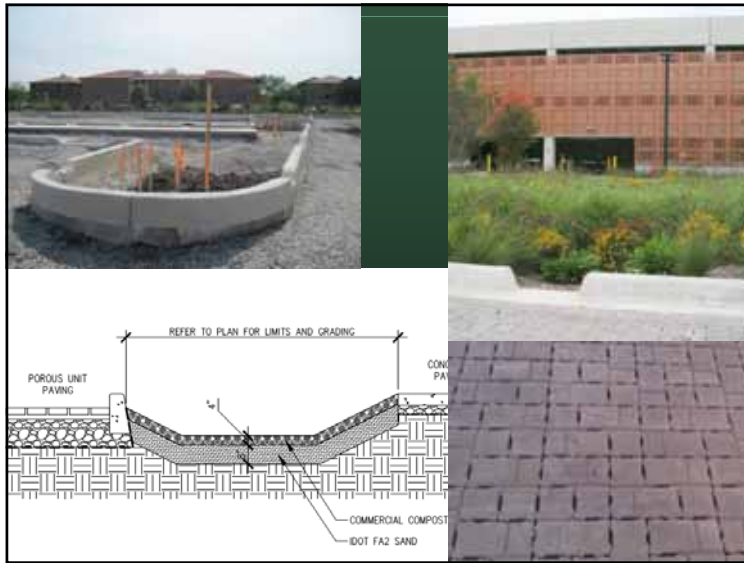
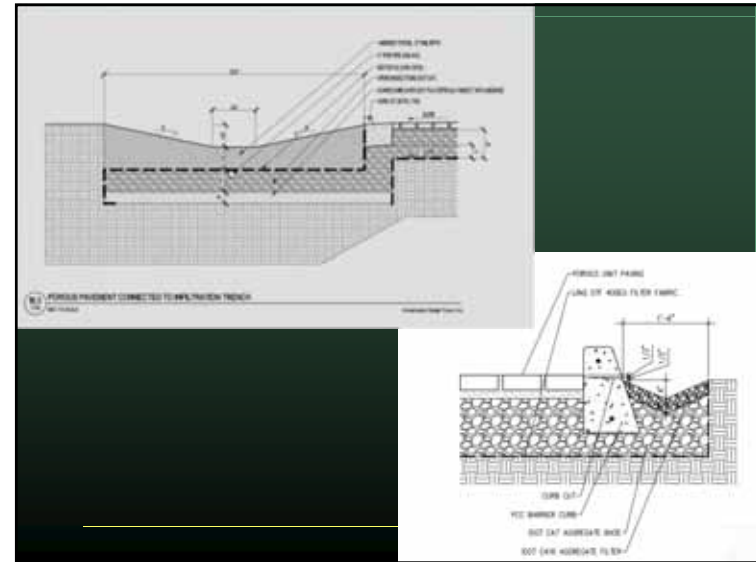
Sidewalk Permeable Paver:  
*Eco-Prioria*

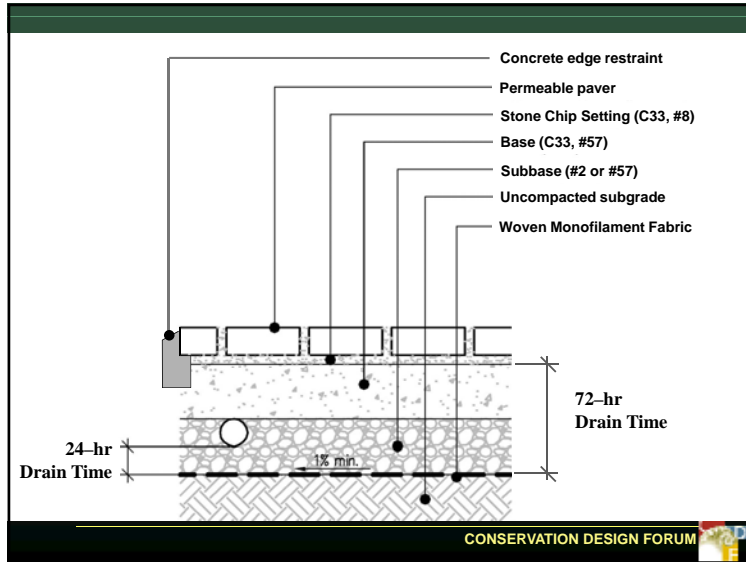
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## Hydrologic Design

- Surface drainage capacity
  - Up to 100 in/hr for new permeable paver systems
  - 10 in/hr minimum for WDNR Tech Standard
  - Use 2-3 in/hr\* for mature permeable paver installations
- Maximum subsurface drain time to prevent loss of subgrade strength based on CBR
- Provide perforated pipe drains if necessary to achieve drain time
  - Locate drain at bottom of base for low permeability soils
  - Locate drain above bottom to provide retention on moderate permeability soils

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## Hydrologic Design

- Hydraulic conductivity of base
  - Darcy’s law ( $Q=kiA$ )
  - #57 stone  $k \sim 0.13$  ft/s
  - #2 stone  $k \sim 22$  ft/s (too high to use without restricted release)
  - $i$  = subgrade slope
- Restrict release to meet local standards
  - Perforated pipe control (Mannings formula)
  - Restrictor control (orifice equation)

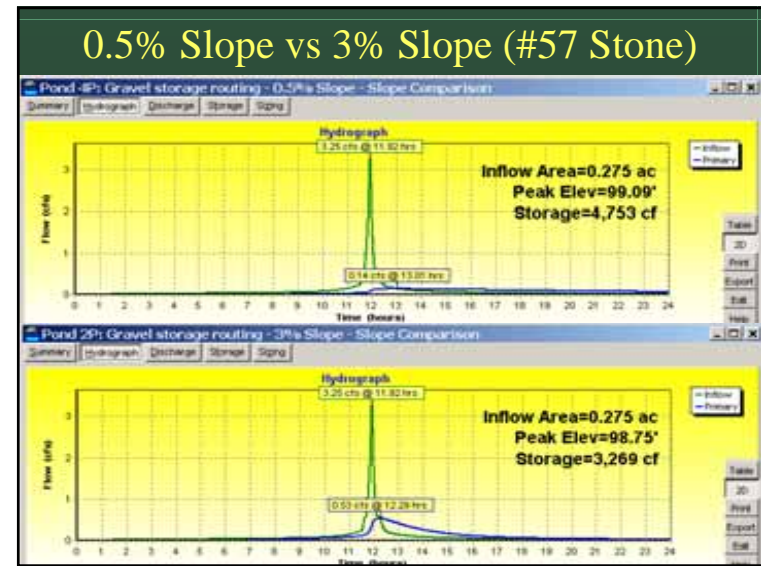
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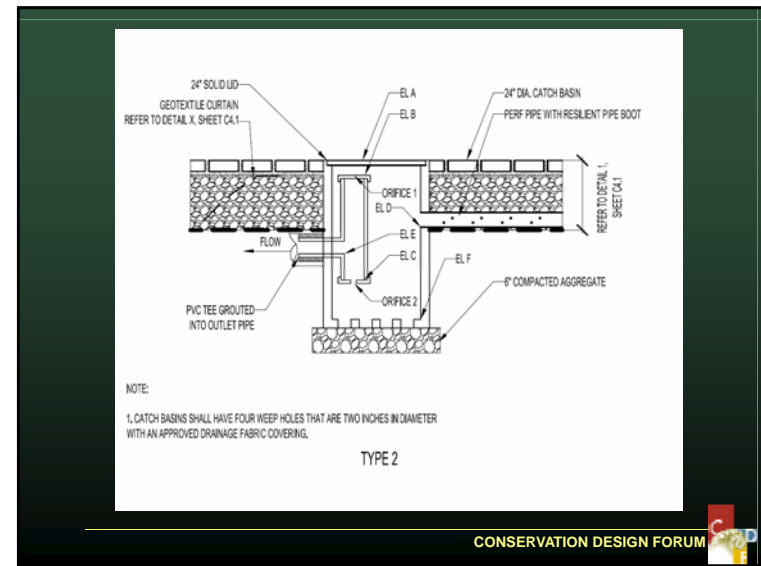
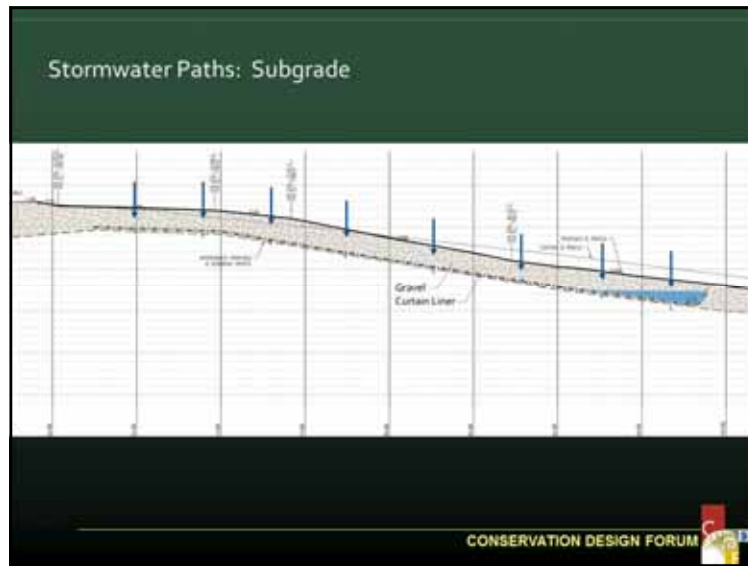
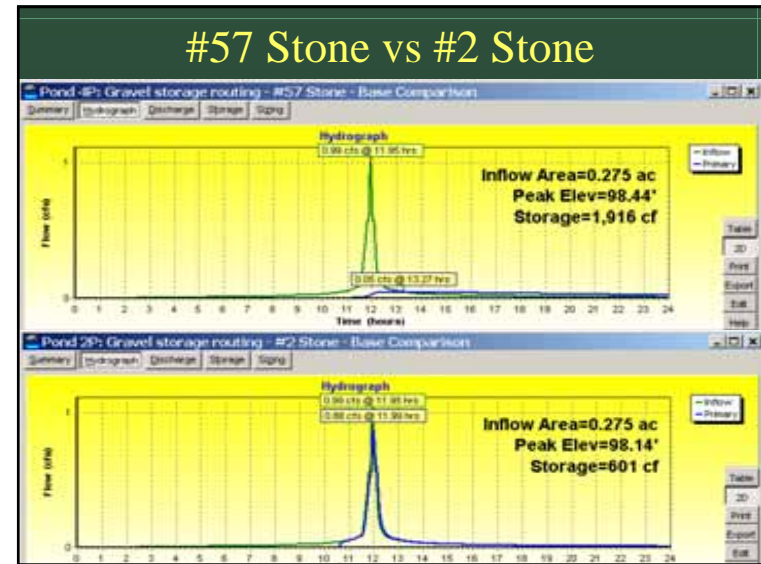
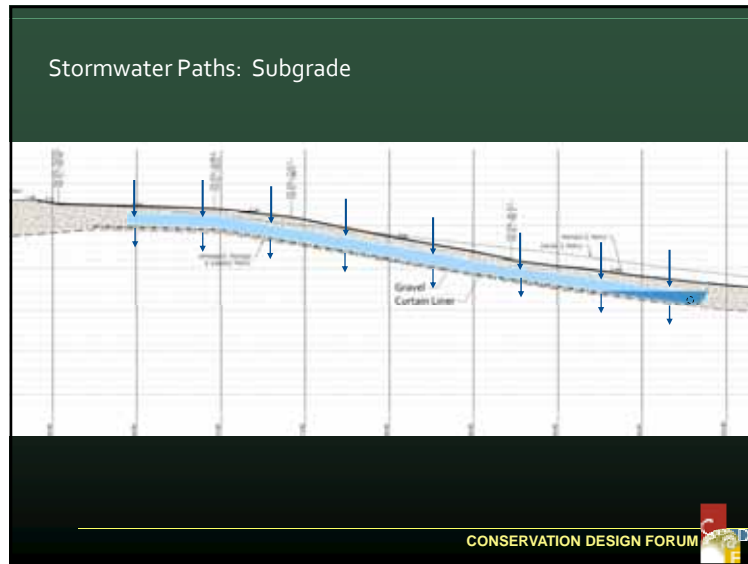
## Impact of gravel gradation & slope

- 40 stall parking lot
- 0.5% vs 3% cross slope
- 18” depth base
- #57 vs #2 stone base
- Type II Storm Event

200 feet  
 60 feet

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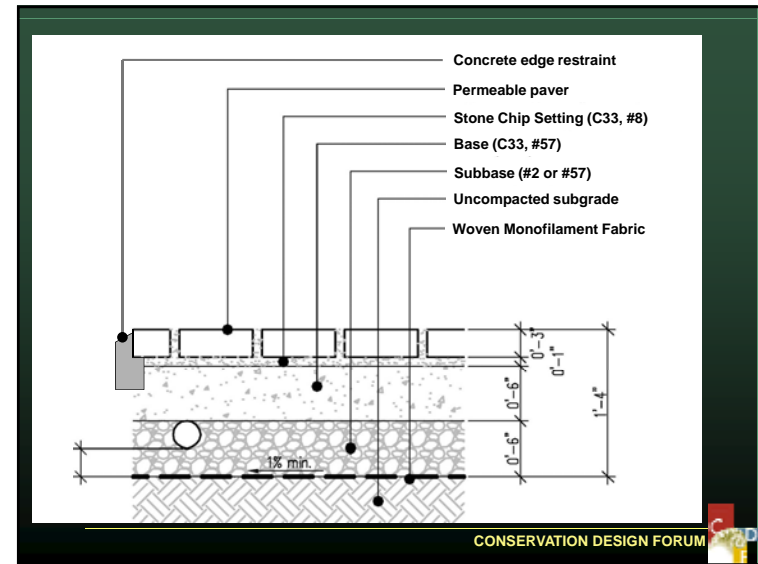




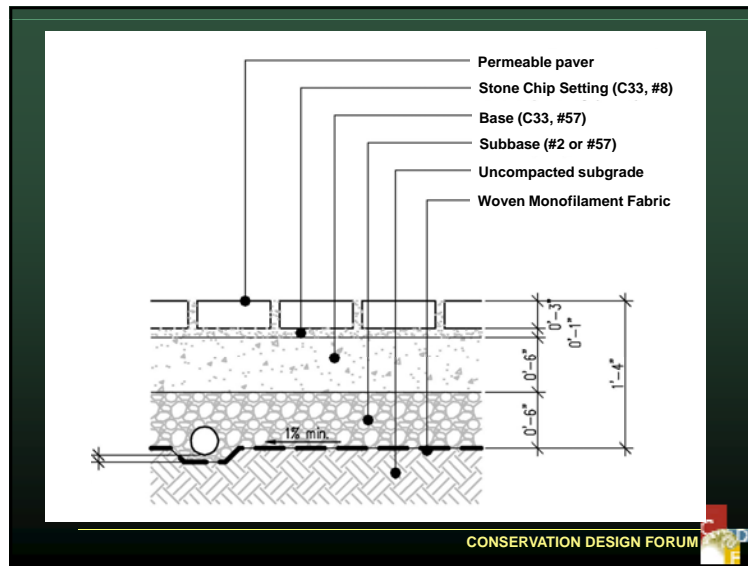
## Engineering Design

- Edge Restraint (permeable pavers)
  - Necessary to maintain interlock between pavers
  - Concrete curb or soldier course set in concrete
- Surface slope as low as 0.5% to 1%
- Open graded, crushed, clean stone for all courses
- Subgrade compaction – minimum necessary
- Woven monofilament geotextile between subgrade and subbase
  - Reduced blinding
  - Lower elongation
  - Select high permeability (permittivity > 1.2/s)

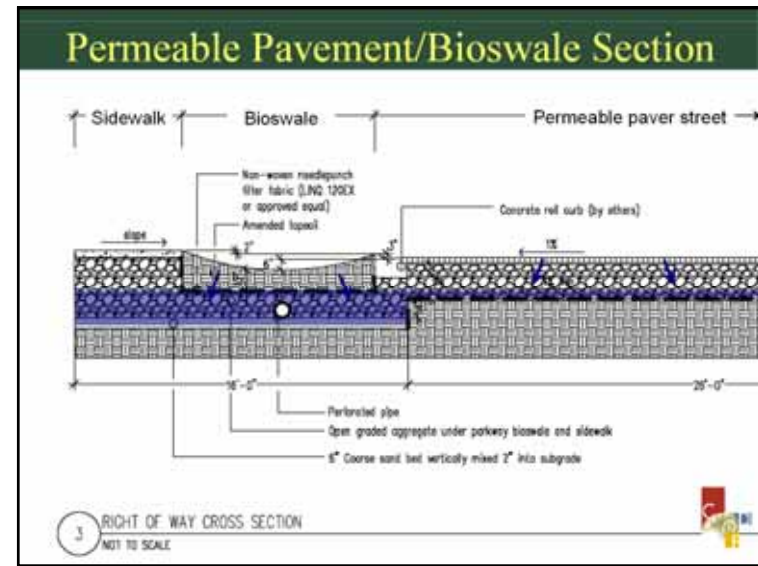
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3 RIGHT OF WAY CROSS SECTION  
NOT TO SCALE

