

A Proposal for Statewide Knee-of-the-Curve BMP Sizing Criteria

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Overview

- Background
- Existing Methods
- Differences between and within Methods
- Comparisons of Sizing Results
- Proposal for New Knee-of-the-Curve Approach



Background: Different Sizing Methods

- **Volume Based Sizing**
 - Design storm (85th percentile, 24-hour)
 - Percent capture (80%)
 - SCS curve number
 - 4% of catchment area
- **Flow Based Sizing**
 - 0.2 in/hr rain intensity
 - 2 x (85th percentile hourly rainfall intensity)



Background: Different Method Applications

- **Post-Construction BMPs Permit Methods**
 - **Phase II**
 - Use volume or flow methods
 - **Caltrans**
 - Use 85th percentile design storm
 - **CGP**
 - Use SCS curve number



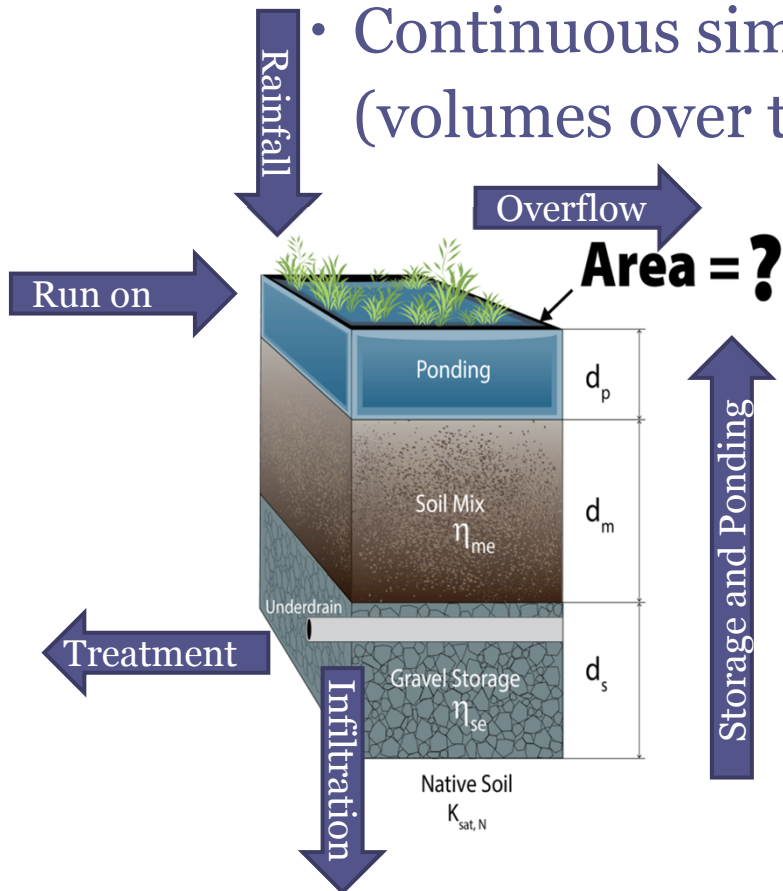
Background: Different Questions

- Why so many methods?
- Why different statewide methods?
- How do the sizing results compare?
 - Hang around to find out!
 - Example: Percent Capture vs Design Storm

Existing Methods: Percent Capture vs Design Storm

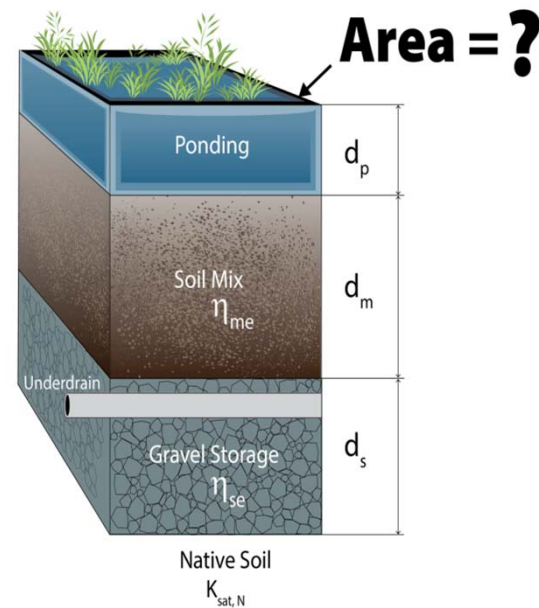
- Percent Capture

- Continuous simulation (volumes over time)



- Design Storm

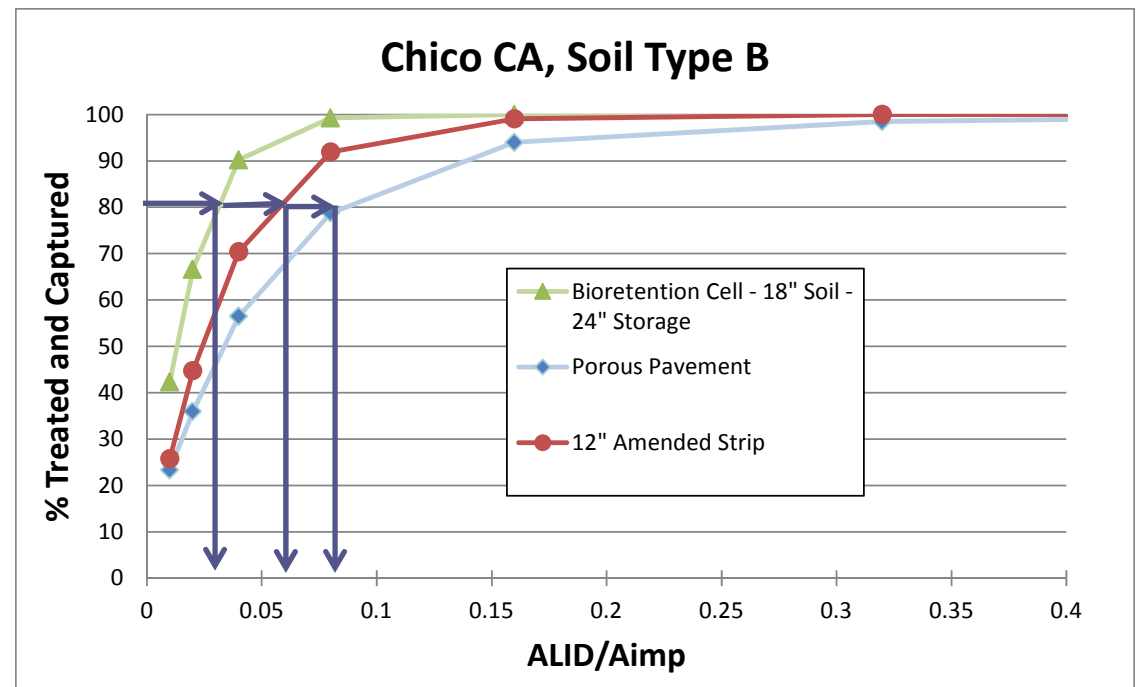
- Storage volume (one point in time)



Existing Methods: Percent Capture

- Integrated Water Balance

- Calculate % capture:
$$\frac{\sum Volume\ retained}{\sum volume\ entering\ BMP}$$
- Develop design curves for multiple scenarios
 - Historic rainfall
 - BMP characteristics
 - Underlying soils
- Lookup % capture
- Read off area



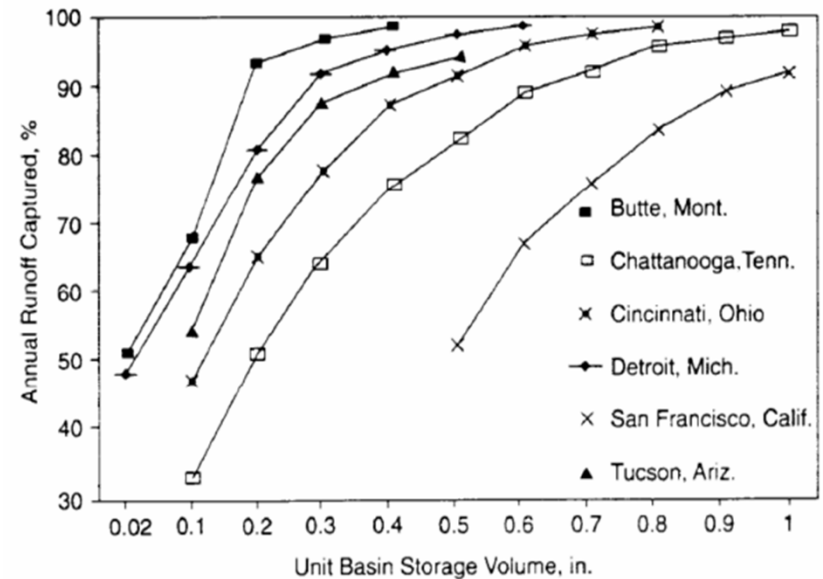
Existing Methods: Why 80% Capture?

- Roesner et al., 1991
 - 6 detention basins in US
 - Volume capture vs BMP size
 - Size indicates cost
 - Point of diminishing returns (knee-of-the-curve)
 - Optimized storage volume
 - Knee-of-the-curve capture ranged 80 - 90%

Source: Storm Water Best Management Practices Design Guide (EPA, 2004)

- Standard Urban Stormwater Mitigation Plans, 2000
 - Adopt 80% (the low end)

Source: Response to Comments on Draft PCRs (Central Coast Water Board, 2013)

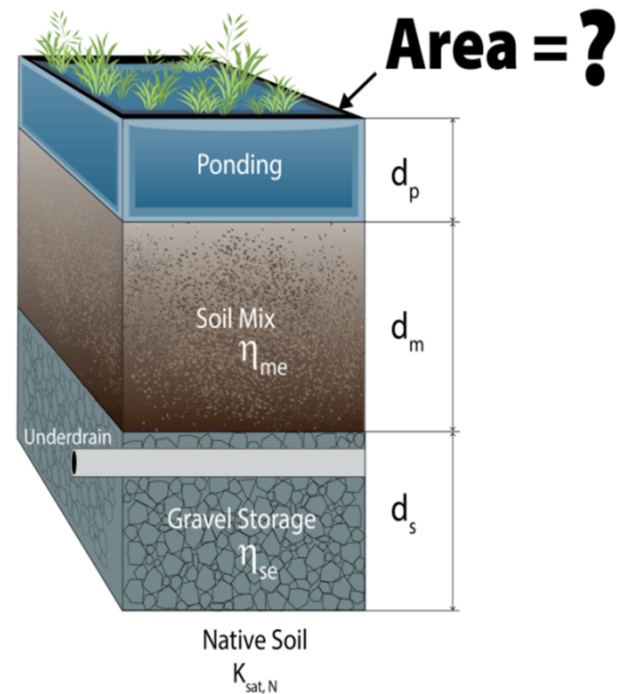


Existing Methods: Why 80% Capture?

- Guo and Urbanos 1996
 - 7 US locations
 - Volume and event captures ranged 82 - 88%
 - CASQA Handbook 2003
 - Use local requirement for % capture
 - If not specified, use knee-of-the-curve (typ. 75-85%)
- Source: CASQA New Development and Redevelopment BMP Handbook*
- Caltrans Basin Sizer
 - Dozens of California locations
 - Knee-of-curve ranged 70-95%

Existing Methods: Design Storm

- Algebraic Water Balance
 - BMP Storage = Run on + BMP Rainfall
 - $d_s * \eta_s * A_{BMP} = RF_{ds} * (C * A_{catchment} + A_{BMP})$
 - Solve for A_{BMP}



Existing Methods:

Why 85th Percentile Design Storm?

- Not sure
- CA Rainfall Analysis?
 - 80% capture size = 85th percentile design storm size

Differences between Methods

- Different Mathematics
 - Static vs dynamic
 - Design storm: volume at one point in time
 - Percent capture: volume throughout time
- 80% Capture based on 1 BMP, 6 US Locations
 - Not representative of CA climate variations
 - Not representative of LID BMPs (treat and retain)
 - Single discharge mechanism vs. multiple mechanisms
 - Size not the only indicator of cost

Differences within Methods

- Different Models
 - Green Ampt vs Horton
 - Orifice sizing (stage-storage-discharge)
 - Rainfall to runoff conversion
 - Runoff coefficient
 - Initial abstraction
 - Curve number
- For Example
 - CA LID Sizing Tool vs EPA Stormwater Calculator
 - SWMM vs SWMM
 - Up to 4% differences
 - CA LID Sizing Tool vs SAHM
 - SWMM vs HSPF
 - Up to 24% differences
 - Difference due to stage-storage-discharge relationships

Comparison of Sizing Results: CA Phase II LID Sizing Tool

- Inputs
 - Location
 - K_{sat}
 - Catchment area
- Output: BMP Sizes
 - Multiple BMPs
 - Bioretention
 - Biostrips & bioswales
 - Porous pavement
 - Infiltration trenches, galleries, etc.
 - Multiple Sizing Methods
 - 85th percentile, 24-hr design storm
 - 80% capture
 - 4% equivalent
 - Central Coast simple method

California Phase II LID Sizing Tool

Welcome to the California Phase II Low Impact Development (LID) Sizing Tool. This is a web-based tool that assesses stormwater practices in selecting and sizing LID Best Management Practices (BMPs) that meet the sizing requirements set forth in California's National Pollutant Discharge Elimination System (NPDES) permit for stormwater discharges from small municipal separate storm sewer systems (MS4s). The tool allows users to input their location, soil type, and impervious area, and then queries a database containing pre-sized BMP tables and design curves for a variety of LID BMP types, performs permeable-paving calculations, and calculates equivalent areas for each LID BMP type. Sizing results are provided based on three different sizing methods allowed by the Phase II permit: a Design Storm Method, a Percent Capture Method, and a Saturated Bioretention or Equivalent Performance Method. Sizing results are also provided for the Central Coast NPDES Region 33 simple sizing method based on the reduction of runoff. Users are also provided references for considering LID BMP treatment factors beyond sizing, such as site topography and geometry and LID BMP maintenance requirements and costs. The tool includes training videos to visually instruct users on various aspects of the tool's interface, input, and output. Further information about the tool and its development is provided in the [README/FAQ page](#).

The tool contains a database that is linked to a database through a server. The database stores precipitation and evaporation data for multiple geographic locations throughout California, pre-defined parameters for multiple LID BMP types and project soil types, and pre-sized design curves based on SWMM 5 modeling. Over 13,000 SWMM simulations were run to develop these curves. After the user enters project information into the tool's website, the server queries the database, performs calculations, and returns the areas required for various LID BMP types.

Use these Layers to help you find the results for steps 1 to 3 below the map.

Step 1: Climate Stations

Step 2: Soil Types

Step 3: Find your impervious area

Distance (feet): 0

Area (acres): 0

To ensure the most accurate results zoom in close to your site.

Step 1: Select a climate station

Climate Station: CHICO VALLEY FAHRI

This tool currently provides results based on 16 climate stations throughout California. Use the drop down to choose the climate station that best represents your project site. You can view the location on the map by clicking the Climate Station you order Step 1 of the Layers sidebar. Then click on any station on the map to learn its name, year on record, 80% percentile design storm, and other information. You will be able to override the design storm on the following page.

Step 2: Input a saturated hydraulic conductivity

Saturated Hydraulic Conductivity: 5 inches per hour

Enter your project site's saturated hydraulic conductivity.

If you don't know it, check with your local regulator to see if it is acceptable to use estimates from the USDA NRCS. If it is, you can view the USDA NRCS hydrologic soil group on the map above by checking the "Soil Types" box in Step 2 of the Layers sidebar and clicking on the color covering your project location.

To see tables of saturated hydraulic conductivities for soil groups and textures click here.

Step 3: Input the impervious area

Impervious Area: 1000

The CA Phase II NPDES permit requires that the project area be divided into discrete Drainage Management Areas (DMAs). Runoff from each DMA must be managed using LID BMPs that meet specific sizing criteria specified in the permit. The tool uses a scenario where the DMA consists of a 100% impervious catchment draining to a LID BMP. Input the size of the impervious catchment of the DMA of interest for your project.

You can use your own measured area or calculate an area using the measure tool in Step 3 of the Layers sidebar.

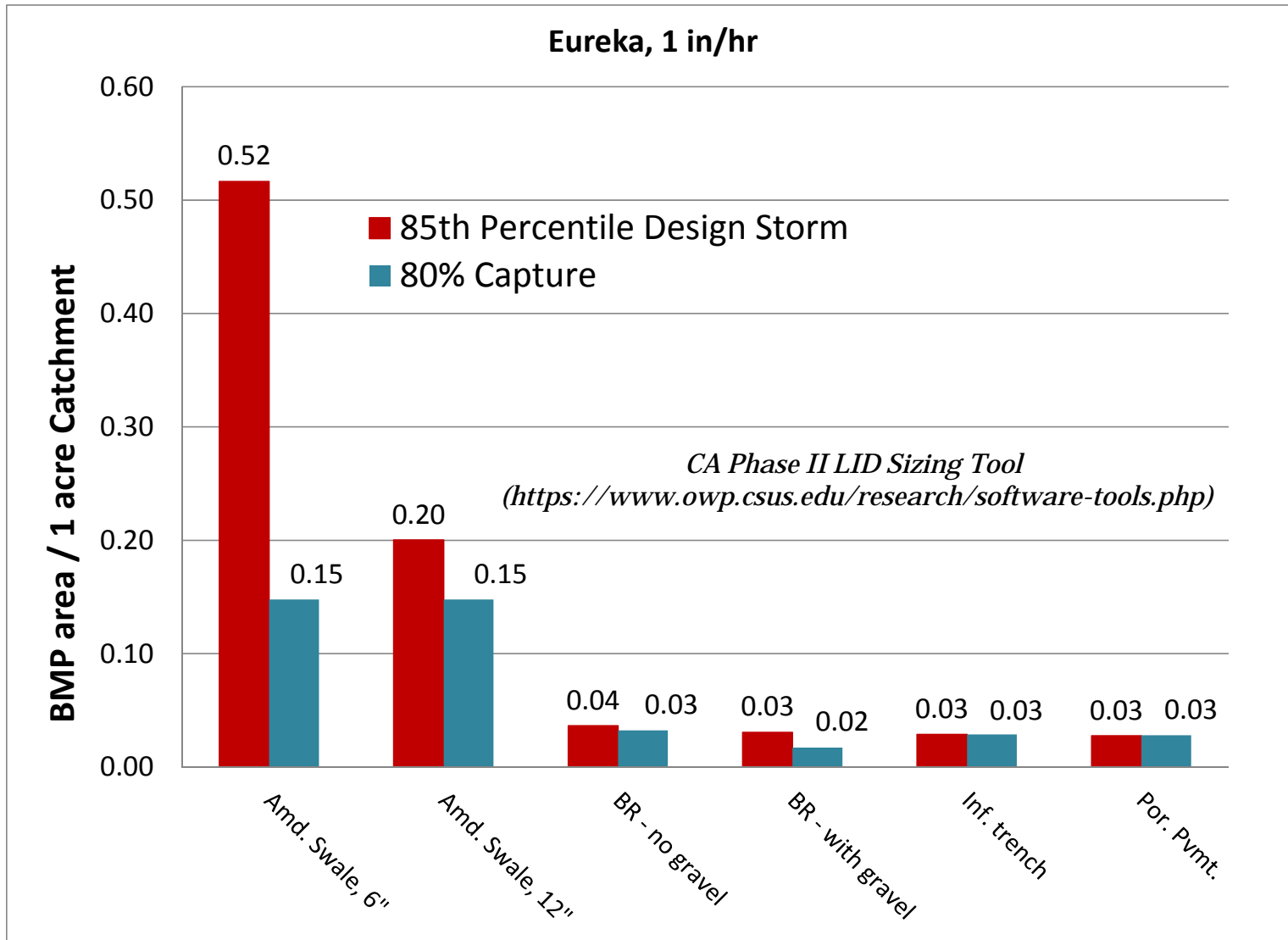
After clicking submit you will be given a table of LID BMP sizes designed to treat the impervious area.

Submit

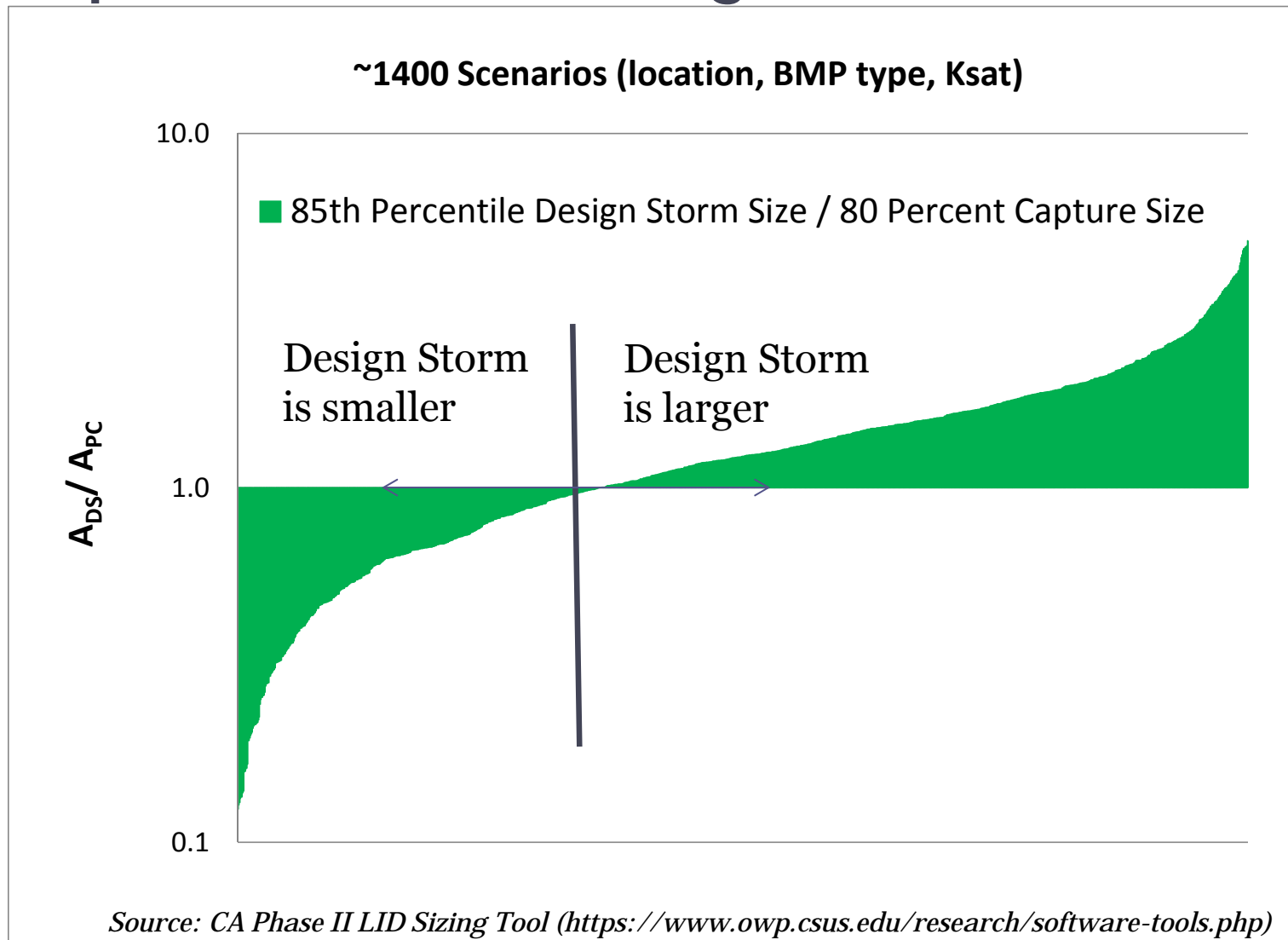
Comparison of Sizing Results:

Storm Water Treatment Measures				
LID BMP Types	Permit Compliant LID BMP Areas (acres)			
	Design Storm 0.8 inches ^{1, 8}	Percent Capture ²	Baseline Bioretention or Equivalent Performance ³	Central Coast Simple Method 0.8 inches ^{4, 8}
Bioretention Cell - 18" Soil - 12" Gravel Storage	<u>0.048</u>	<u>0.018</u>	<u>0.040</u>	<u>0.210</u>
Bioretention Cell - 18" Soil - 24" Gravel Storage	<u>0.038</u>	<u>0.018</u>	<u>0.040</u>	<u>0.094</u>
Bioretention Cell - 18" Soil - 36" Gravel Storage	<u>0.031</u>	<u>0.018</u>	<u>0.039</u>	<u>0.060</u>
Bioretention Cell - 24" Soil - 12" Gravel Storage	<u>0.043</u>	<u>0.018</u>	<u>0.039</u>	<u>0.210</u>
Bioretention Cell - 24" Soil - 24" Gravel Storage	<u>0.034</u>	<u>0.017</u>	<u>0.039</u>	<u>0.094</u>
Bioretention Cell - 24" Soil - 36" Gravel Storage	<u>0.029</u>	<u>0.017</u>	<u>0.039</u>	<u>0.060</u>
Bioretention Cell - Soil Depth Varies ⁵ - No Gravel Storage	<u>0.045</u>	<u>0.033</u>	<u>0.075</u>	<u>0.045</u>
Infiltration Basin - Vegetated	<u>0.015</u>	<u>0.016</u>	<u>0.037</u>	<u>0.015</u>
Infiltration Gallery	<u>0.012</u>	<u>0.016</u>	<u>0.037</u>	<u>0.012</u>
Infiltration Trench	<u>0.035</u>	<u>0.029</u>	<u>0.069</u>	<u>0.035</u>
Overland Flow no amendment	<u>N/A</u>	<u>0.100</u>	<u>0.300</u>	<u>N/A</u>
Porous Pavement	<u>0.034</u>	<u>0.028</u>	<u>0.068</u>	<u>0.034</u>
Strip, Amended 6"	<u>0.710</u>	<u>0.068</u>	<u>0.160</u>	<u>0.710</u>
Strip, Amended 12"	<u>0.250</u>	<u>0.057</u>	<u>0.140</u>	<u>0.250</u>
Strip, Amended 18"	<u>0.160</u>	<u>0.048</u>	<u>0.130</u>	<u>0.160</u>
Swale, Amended 6" ⁶	<u>0.710</u>	<u>0.150</u>	<u>0.480</u>	<u>0.710</u>
Swale, Amended 12" ⁶	<u>0.250</u>	<u>0.150</u>	<u>0.480</u>	<u>0.250</u>

Comparison of Sizing Results



Comparison of Sizing Results



Are We Making a Difference?

- Regarding Stormwater Management and BMP Implementation, Intent is there
 - Simplified, uniform procedures
 - Multiple benefits
 - Improve receiving water quality
 - Stormwater as a resource
- Perhaps design standards need to catch up
 - More systematic approaches
 - Better understanding of design standards
 - Updated design standards for LID BMPs being implemented in CA


Proposal for New Knee-of-the-Curve

- Calculate design curves for LID BMPs
 - Determine true knee-of-the curve capture
 - Determine corresponding design storm size
- Redefine cost/practicality indicator
 - Replace size with materials
 - Replace size with water quality benefit measurement
- Monitor performance
 - Compare actual performance to intended design
 - Compare performance among design approaches

What do you think/know?

- Is there a need for new design curves (and storms)?
 - CA specific locations
 - LID BMP characteristics
 - New “diminishing returns” indicator
- How can we gather design/performance information to get meaningful data?
- Are we making a difference?
- Where *DID* the 85th percentile design storm come from?!

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