Evaluation of Green Infrastructure Designs Using the Automated Geospatial Watershed Assessment Tool

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Outline

• Integrated Watershed Management in Arid Built Environments
• Urban Toolkit in the Automated Geospatial Watershed Assessment Tool
• Case Study in Sierra Vista, AZ
• Conclusions and Future Directions
Fixed spelling of integrated on Slide
"Outline"

Yoga Korgaonkar, 7/28/2015
Integrated Watershed Management

Integrated Watershed Management (IWM) is a comprehensive multi-resource management process, involving all stakeholders within the watershed, who together as a group, cooperatively work toward identifying the watershed’s resource issues and concerns.

IWM addresses the interrelationships between:
Water Supply – The Primary Driver in Built Arid Environments
  Flood Control
  Water Quality
  Biological Resources (Natural and Landscaping)
  Sustainable Communities (Greenness)
  Social/Economic Issues
Changed formatting
Yoga Korgaonkar, 7/28/2015
‘Harvestable’ Water (Rainwater/Stormwater) - Potential to Augment Water Supply
(From: Dr. Evan Canfield – Pima County Flood Control)
Low Impact Development (LID) Practices

• The effectiveness of a practice depends on your objective.
• If your objective is to capture stormwater to mitigate flood and water quality
  • Pervious Surfaces – driveways, roads, parking lots are very effective
• But if your primary goal is to augment water supplies then
  • Water Harvesting
  • Rain Gardens
  • Bio-retention Cells – with vegetation, are more effective

• Need tools that can assess the effects of different combinations of LID practices and evaluate between different development designs.
Automated Geospatial Watershed Assessment Tool
AGWA

- Endpoints: volume & peak runoff, sediment, plus N and P
- Simple, direct method for model parameterization
- Provide repeatable results for relative change assessments
- Five hydrologic models to address multiple scales
  - SWAT (2000, 2005) for large basins, daily time steps
  - KINEROS2 and KINEROS-OPUS for small basins, sub-hour time steps
  - Hillslope Runoff and Erosion Models (RHEM)
- Basic GIS functionality
  - watershed delineation
  - watershed discretization
  - model parameterization
  - execute the models
  - visualize results spatially and difference results across multiple simulations
Urban Toolkit

- Within the KINEROS2 Model
- Flow Route Delineation – routing water down streets or swales
- Lot Representation – potential to uniquely represent each lot
  - Impervious Area
  - Contributing Area
  - Flow Off → Flow On Processes
- LIDs on Lots
  - Basins
  - Water Harvesting
  - Pervious Surfaces
- Gray Infrastructure
  - Detention/Retention Ponds
- Visualization of Results
Formatting and slide layout
Yoga Korgaonkar, 7/28/2015
Lot Representation

- Each Home or Commercial Lot can have its own design.
- Based on the Lot Characteristics (setback, etc.) and LID practices, a lot is broken up into planes with difference input parameters.
- Flow Off $\rightarrow$ Flow On processes can be modeled.
- Water can be captured and non-contributing areas can be identified.
fixed typos

Yoga Korgaonkar, 7/28/2015
Case Study

- La Terraza Subdivision in Sierra Vista, AZ (13 ha)
- Two Events (SCS Type II Design Storm)
  - 10 year Return Period (34.29 mm; 1 hour)
  - 100 year Return Period (51.82 mm; 1 hour)
- Three LID Practices – Lot Only
  - Small Retention Basin (1.7 m$^3$; Ks = 201 mm/hr)
  - Pervious Driveway (Ks = 210 mm/hr)
  - Water Harvesting (1.9 m$^3$; Empty)
- Ten Scenarios
  - No LID Practices
  - Single LID Practice
  - Two LID Practices
  - All Three LID Practices
Results

• Post-Development Validation (Kennedy et al. 2013)

\[ y = 1.02x \quad R^2 = 0.91 \]

\[ y = 1.04x \quad R^2 = 0.92 \]
## Results

### 10 Year Return Period

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Peak Runoff (m3/s)</th>
<th>% Change in Peak Runoff wrt Pre-development</th>
<th>% Change in Peak Runoff wrt Post-Development</th>
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<tr>
<td>Pre-development</td>
<td>1.49</td>
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<td>NA</td>
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<tr>
<td>Post-development without LID</td>
<td>2.28</td>
<td>53.37</td>
<td>NA</td>
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<tr>
<td>Retention Basin</td>
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<td>Permeable Pavements</td>
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## Results

### 100 Year Return Period

<table>
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<th>Scenario</th>
<th>Peak Runoff (m3/s)</th>
<th>% Change in Peak Runoff wrt Pre-development</th>
<th>% Change in Peak Runoff wrt Post-Development</th>
</tr>
</thead>
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<td>Permeable Pavements + Rainwater Harvesting</td>
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<tr>
<td>All LID practices</td>
<td>3.67</td>
<td>25.59</td>
<td>-4.67</td>
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</table>
Results

Lot and Street Visualization

[Map images showing flow routes, streets, infiltration (% change), runoff (% change), and post-development with all GI compared to pre-development. Another map shows post-development without GI compared to pre-development.]
Conclusions

• Modeling framework works well on developed watersheds
• Supports the evaluation of different designs.
• Supports the assessment of the accumulative impacts of LID practices.
• Supports detailed representation and modeling of lot and drainage features on a small catchment.
• Future research includes:
  • Adding more LID practices and gray infrastructure practices.
  • Improve the hydrological representation of LID practices.
  • Improve the parameterization for LID practices.
  • Validation of LID Simulation. Data Sets?
  • Provide linkages to other software (e.g. SWMM).
  • Add water quality (N & P) modeling capability.
Acknowledgements

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