Land Use Planning for Integrated Water Management

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Project Objectives

1. Quantify relationship between land use and water supply benefits:
   - Water supply reliability
   - Flood management
   - Water quality
   - Habitat value
   - Climate Action Mitigation

2. Create an accessible tool which can be used to help guide land use decision making
Preliminary Findings

• There are few user-friendly tools which test and compare Low Impact Development scenarios

• Data is inconsistently available
  – Maintenance
  – Green infrastructure

• Less infrastructure is cheaper
  – Most cost effective residential development has least impervious surfaces
Approach

• Review existing tools
• Develop new tool
• Apply to case studies
• Quantify differences in case studies
• Identify lessons learned
Tool Review

**2. Water management and flood alleviation**

### 2.1 Energy and carbon emissions savings from reduced stormwater volume entering combined sewers

- **Current land cover**
  - Broadleaves
  - Grass

- **Proposed land cover**
  - Select
  - Grass

- **Current GI area**
  - 0 Ha

- **Future GI cover**
  - 0 Ha

- **Annual rainfall**
  - 800 mm/yr *Modify as appropriate*

- **Type of location**
  - Inner city

- **Current**
  - Water currently diverted from sewers: 0 l/yr
  - Equivalent current energy saving: 0 kWh/yr
  - Equivalent current carbon saving: 0 kg CO2/yr
  - Value of current carbon saving: 0 £/yr
  - Value of current energy saving: 0 £/yr

- **Proposed**
  - Water currently diverted from sewers: 0 l/yr
  - Equivalent current energy saving: 0 kWh/yr
  - Equivalent current carbon saving: 0 kg CO2/yr
  - Value of current carbon saving: 0 £/yr
  - Value of current energy saving: 0 £/yr

- **Calculation**
  - Auto-calculation cell. Uses cell E80 from calculation sheet below.
  - Auto-calculation cell. Uses cell E82.
  - Auto-calculation cell. Uses cell E83.
  - Auto-calculation cell. Uses cell E84.
Lessons from Existing Tools

- Comprehensive metrics
- Spatial scaling
- Local specificity
- Modifiable by anyone
- Clear user interface
Open and Accessible

- **Users**
  - Project developers
  - Elected and appointed decision-makers
    - Board of supervisors
    - Council members
    - Planning commissioners
  - Regional agencies
  - Researchers

- **Microsoft Excel**
  - All formulas can be accessed and changed
  - All data can be modified for local conditions
Scaling Up

• How do development choices scale?
  – Lot
  – Neighborhood
  – City
  – County
  – Watershed

• Focus of this tool: what is the impact of residential?
Study Area: Sonoma County
Lot
Neighborhood
Comprehensive Metrics

1. Percent Impervious Surfaces
2. Stormwater Runoff (from Impervious Surfaces)
3. Outdoor Water Requirements
Comprehensive Metrics

5. Cost of Implementation
6. Cost over 50 years
7. Cost over 100 years
Percent Imperviousness
Stormwater Runoff

<table>
<thead>
<tr>
<th>Month</th>
<th>Rain (in)</th>
</tr>
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<tbody>
<tr>
<td>January</td>
<td>4.05</td>
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<tr>
<td>February</td>
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<td>March</td>
<td>3.83</td>
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<td>April</td>
<td>2.18</td>
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<tr>
<td>May</td>
<td>1.62</td>
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<tr>
<td>June</td>
<td>0.43</td>
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<td>July</td>
<td>0</td>
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<tr>
<td>August</td>
<td>0</td>
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<tr>
<td>September</td>
<td>0</td>
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<tr>
<td>October</td>
<td>1.79</td>
</tr>
<tr>
<td>November</td>
<td>2.19</td>
</tr>
<tr>
<td>December</td>
<td>7.47</td>
</tr>
</tbody>
</table>
Outdoor Water Requirement

WUCOLS

– Evapotranspiration zone (ET)
– Species-specific plant water use coefficient
– Planting density
– Environmental exposure
– Irrigation efficiency
Greenhouse Gasses
# Cost of Implementation

<table>
<thead>
<tr>
<th></th>
<th>Construction Cost ($)</th>
<th>Maintenance Cost</th>
<th>Lifespan (Years)</th>
<th>Source</th>
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<tbody>
<tr>
<td>Green Roof (Sq Ft)</td>
<td>22</td>
<td>28.5</td>
<td>35</td>
<td>20</td>
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<tr>
<td>Permeable Pavement - Pavers (Sq Ft)</td>
<td>17</td>
<td>19.5</td>
<td>22</td>
<td>25</td>
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<tr>
<td>Permeable Pavement - Porous Asphalt (Sq Ft)</td>
<td>1.98</td>
<td>2.25</td>
<td>2.6</td>
<td>Empire A</td>
</tr>
<tr>
<td>Permeable Pavement - Porous Concrete (Sq Ft)</td>
<td>4.5</td>
<td>6</td>
<td>7.5</td>
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<tr>
<td>Permeable Pavement - Gravel (Sq Ft)</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>25</td>
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<tr>
<td>Turf (Artificial) (Sq Ft)</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>25</td>
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<tr>
<td>Turf (Lawn) (Sq Ft)</td>
<td>0.75</td>
<td>1.25</td>
<td>10</td>
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<tr>
<td>Native Plants (1 gallon/1 sq.ft.)</td>
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<td>8.45</td>
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<tr>
<td><strong>Rain Garden</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees (15 gallon/per tree)</td>
<td>115</td>
<td>132.5</td>
<td>150</td>
<td>15</td>
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<td>Tree Box Filters</td>
<td>7100</td>
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<td></td>
<td>DetailsLa</td>
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<td>Bioswales (18&quot;x18&quot;/sq.ft.)</td>
<td>37.25</td>
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<tr>
<td>Downspout Disconnection</td>
<td>225</td>
<td></td>
<td></td>
<td>Letitia H</td>
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<tr>
<td>Planter Boxes (avg. size 4 x 8)</td>
<td>354</td>
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<td></td>
<td>DetailsLa</td>
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<tr>
<td>Rain Barrels (per 100 gallon reservoir)</td>
<td>580</td>
<td></td>
<td></td>
<td>DetailsLa</td>
</tr>
<tr>
<td>Rain Harvesting System - Welded Steel Tank</td>
<td>6900</td>
<td></td>
<td>35</td>
<td>Nicole O</td>
</tr>
<tr>
<td>Rain Harvesting System - Poly Tank</td>
<td>3810.4</td>
<td></td>
<td>20</td>
<td>Nicole O</td>
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<tr>
<td><strong>Vegetated Filter Strips</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amended Soil (Cubic Yard)</td>
<td>35</td>
<td>42.5</td>
<td>50</td>
<td>Bertotti</td>
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<tr>
<td>French Drain (Cubic ft avg)</td>
<td>14</td>
<td></td>
<td></td>
<td>DetailsLa</td>
</tr>
<tr>
<td>Greyscale system (sq ft)</td>
<td>0.50</td>
<td></td>
<td></td>
<td>DetailsLa</td>
</tr>
<tr>
<td>Irrigation Controller (includes wiring)</td>
<td>394</td>
<td></td>
<td></td>
<td>DetailsLa</td>
</tr>
</tbody>
</table>
Maintenance and Lifecycles

- Influenced by:
  - weather
  - maintenance
  - quality of component, installation
  - intensity of use

- Cost of replacement
Selecting Case Studies

Single Family Residential:
- Traditional
- SUSMP
- GreenPoint

Mixed Use (including SFR):
- One Planet
Stormwater Regulation Differences

**TRADITIONAL:**
Pre-stormwater runoff regulations (initiated in 1987)

**SUSMP:**
Adhered to local regulations

**GREENPOINT:**
Adhered to local regulations and Cal Green Codes

**ONE PLANET:**
Adhered to local regulations, Cal Green, LEED, One Planet standards
Tool Inputs

• Land cover
• Water infrastructure
Translating from Site to Tool
Traditional Neighborhood
SUSMP
SUSMP Neighborhood
GreenPoint
GreenPoint Neighborhood
Estimating One Planet Lots

• City's Code of Ordinances
  – Lot Size
  – Space Between Structure and Lot Line
  – Location and Size of Driveway
  – Maximum Percent Turf

• Landscaping
  – Combine Zoning Code With Own Discretion
  – Turf
  – Trees
  – Remaining Landscaping
    • Rain Garden
    • Rain Barrels
One Planet Neighborhood

- Streets
  - City's Streets and Roadway Design Standard

- Sidewalks
  - City's Code of Ordinances

- Size, Housing Location, Green Space, Type of Streets, Parking Areas
  - Final Development Plan
## Preliminary Results: Land Cover

<table>
<thead>
<tr>
<th></th>
<th>Traditional</th>
<th>SUSMP</th>
<th>GreenPoint</th>
<th>One Planet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Lot Size</strong></td>
<td>5,318</td>
<td>5,562</td>
<td>5,023</td>
<td>5,509</td>
</tr>
<tr>
<td><strong>Composite Roof</strong></td>
<td>2,480</td>
<td>1,831</td>
<td>2,001</td>
<td>2,080</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td>777</td>
<td>2,069</td>
<td>435</td>
<td>0</td>
</tr>
<tr>
<td><strong>Permeable Pavers</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>828</td>
</tr>
<tr>
<td><strong>Turf Grass</strong></td>
<td>598</td>
<td>1,125</td>
<td>0</td>
<td>364</td>
</tr>
<tr>
<td><strong>Cultivated Garden</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>185</td>
</tr>
<tr>
<td><strong>Sparse Vegetation</strong></td>
<td>1,228</td>
<td>0</td>
<td>2,587</td>
<td>2,052</td>
</tr>
<tr>
<td><strong>Dense Vegetation</strong></td>
<td>235</td>
<td>537</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Trees (count)</strong></td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Preliminary Results: Land Cover

- Total Lot Size
- Composite Roof
- Concrete
- Turf Grass
- Sparse Vegetation
- Dense Vegetation
- Trees

Legend:
- Traditional
- SUSMP
- Greenpoint
- One Planet
## Preliminary Results: Land Cover

<table>
<thead>
<tr>
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<th>GreenPoint</th>
<th>One Planet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Impervious</td>
<td>61%</td>
<td>70%</td>
<td>48%</td>
<td>38%</td>
</tr>
<tr>
<td>Peak Monthly Runoff</td>
<td>15,157</td>
<td>18,150</td>
<td>11,337</td>
<td>9,680</td>
</tr>
<tr>
<td>Peak Monthly Outdoor Water</td>
<td>4,492</td>
<td>6,094</td>
<td>2,775</td>
<td>3,711</td>
</tr>
<tr>
<td>Peak Monthly GHG</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Cost, Implementation</td>
<td>$23,828</td>
<td>$26,835</td>
<td>$24,431</td>
<td>$40,013</td>
</tr>
<tr>
<td>Cost, 50 years</td>
<td>$32,816</td>
<td>$47,328</td>
<td>$24,053</td>
<td>$62,078</td>
</tr>
<tr>
<td>Cost, 100 years</td>
<td>$65,034</td>
<td>$93,531</td>
<td>$47,575</td>
<td>$107,116</td>
</tr>
</tbody>
</table>
Less Infrastructure is Less Expensive

• Impervious surfaces are costly
  – Replacement of surfaces over time
  – Storm water runoff requires even more infrastructure

• Better to adapt than mitigate
  – Less additional infrastructure is best
Not all Infrastructure is Equal

• Upfront costs

• Lifecycle costs
  – Maintenance
  – Replacement

• Spillovers
  – Green infrastructure as public amenities
Opportunities/Challenges

• Align cost incentives
  – Who builds?
  – Who maintains?
  – Who benefits?

• Link upstream LID and downstream grey infrastructure
  – Watershed planning
  – Cumulative impacts
Questions? Comments?