PRESTO!

Plan for Regional Sustainability Tomorrow

Scientific Advisory Committee Meeting #2

September 16, 2014

College Park, MD
The multi-year goal for this project is to develop, disseminate, and promote the implementation of a sustainable development strategy for the Baltimore-Washington region.

Well known examples of similar efforts include:
- Burnham plan for Chicago,
- Wallace-McHarg plan for the Valleys; and the series of
- Regional Plan of New York and its Environs

These plans or strategies were not prepared for, or adopted by, any public agency but were highly influential for decades after they were released.
1st Year Goals

• Stimulate a science-based conversation about sustainability in this region.
• Characterize existing sustainability conditions and trends.
• Identify key driving forces that will shape the future of the region.
• Deploy a highly developed set of data and analytic tools to develop the baseline and alternative scenarios.
• Begin a discussion of policy options and directions.
Review of Models
Model Overview

Components of the Sustainability Scenarios

Scenario Assumptions
- Economic & Political Assumptions
- Demographic and Societal Assumptions
- Technological and Behavioral Assumptions
- Technological & Environmental Assumptions

Model Elements
- Economic Projections from various sources
- Transportation – MSTM Travel Demand Model
- Growth – SILO Land Use Model
- Moving Emissions – MEM Model
- Building Emissions – BEM Model
- Water Quality – CBay Land Cover Change Model
Geography

<table>
<thead>
<tr>
<th>State</th>
<th>SMZ</th>
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<tbody>
<tr>
<td>MD</td>
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<td>VA</td>
<td>171</td>
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<td>PA</td>
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<td>WV</td>
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<td>DE</td>
<td>97</td>
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<td>DC</td>
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<tr>
<td>Total</td>
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</table>
Using ‘Adjusted’ CLRP

Total Population by Metro Area: Baltimore-Washington Region

- DC
- W & P
- MWCOG
- Hammer
- Baltimore
- BMC
- Hammer

Models: Woods and Poole, MWCOG, BMC, Hammer
The Baltimore-Washington Region
Population and Employment Assumptions: Adjusted CLRP
Agenda for Adjusted CLRP Inputs

- Notes on Model Inputs
- Employment Projection
  - Totals
  - By Sub-Region
- Population Projection
- Household Projection
  - Totals
  - By Sub-Region
• CLRP locations for jobs and households adjusted to totals from Thomas Hammer projections.
• All charts for Baltimore-Washington Region unless otherwise stated.
• Charles County added to Washington Outer Suburbs.
• Figures for entire region do not reflect differences between Baltimore and Washington metro areas.
Jobs Increase Over 1.8 Million in CLRP


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Pop. and Emp.

Bureau of Labor Statistic
Employment Increases Throughout Region

Actual and Projected Jobs by Sub-Region: CLRP (2007-2030)

Pop. and Emp. Bureau of Labor Statistic
## Significant Job Growth in Inner Suburbs and Washington Core

### Jobs by Sub-Region

<table>
<thead>
<tr>
<th></th>
<th>Employment 2007</th>
<th>Employment 2030</th>
<th>Total Change</th>
<th>Percent Change</th>
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</thead>
<tbody>
<tr>
<td><strong>Baltimore Core</strong></td>
<td>367,568</td>
<td>481,243</td>
<td>113,675</td>
<td>31%</td>
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<tr>
<td><strong>Baltimore Inner</strong></td>
<td>999,403</td>
<td>1,411,874</td>
<td>412,471</td>
<td>41%</td>
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<tr>
<td><strong>Baltimore Outer</strong></td>
<td>155,515</td>
<td>253,309</td>
<td>97,794</td>
<td>63%</td>
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<tr>
<td><strong>Washington Core</strong></td>
<td>1,029,312</td>
<td>1,446,503</td>
<td>417,191</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Washington Inner</strong></td>
<td>1,559,733</td>
<td>2,009,211</td>
<td>449,478</td>
<td>29%</td>
</tr>
<tr>
<td><strong>Washington Outer</strong></td>
<td>500,563</td>
<td>813,262</td>
<td>312,699</td>
<td>62%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,612,094</td>
<td>6,415,402</td>
<td>1,803,308</td>
<td>39%</td>
</tr>
</tbody>
</table>
Notable Job Growth in Some Suburban Centers
Population Increases Over 2 Million


- Total Population
- Adjusted CLRP

Pop. and Emp.  US Census
Households Increase at Historic Rate

Actual and Projected Households: CLRP (2007-2030)

- **Households**
- **Adjusted CLRP**

Pop. and Emp. | US Census
---|---
Majority of CLRP Growth in Inner Suburbs

Actual and Projected Households by Sub-Region: CLRP (2007-2030)

- Core
- Adjusted CLRP
- Inner
- Adjusted CLRP
- Outer

Pop. and Emp. US Census
CLRP Household Growth in Core and Developed Corridors
## Greatest Growth in Washington Metro

### Households by Sub-Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Households 2007</th>
<th>Households 2030</th>
<th>Total Change</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
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<td>255,347</td>
<td>284,683</td>
<td>29,336</td>
<td>11%</td>
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<tr>
<td>Baltimore Inner</td>
<td>701,664</td>
<td>804,856</td>
<td>103,192</td>
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<tr>
<td>Baltimore Outer</td>
<td>149,126</td>
<td>197,330</td>
<td>48,204</td>
<td>32%</td>
</tr>
<tr>
<td>Washington Core</td>
<td>399,654</td>
<td>546,244</td>
<td>146,590</td>
<td>37%</td>
</tr>
<tr>
<td>Washington Inner</td>
<td>1,018,251</td>
<td>1,287,533</td>
<td>269,282</td>
<td>26%</td>
</tr>
<tr>
<td>Washington Outer</td>
<td>354,867</td>
<td>613,459</td>
<td>258,592</td>
<td>73%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,878,909</td>
<td>3,734,105</td>
<td>855,196</td>
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</tr>
</tbody>
</table>
Conclusion for Jobs and Employment

• In the projection, the region will add over 2 million people and 1.8 million jobs.
• Population growth predominantly in core and developed corridors.
• Job growth strong throughout region, particularly existing Washington employment centers.
Provisional Results: SILO
SILO Presentation

- Model overview
- Modeling location choice
- Selected results as indicators for sustainable development
SILO Overview

- Microscopic land-use model
- Fully integrated with travel demand model
- Open source: www.silo.zone
Location Factors

2-step Relocation Decision:

(1) Select Region
(2) Select Dwelling

Location Factors Step 1

<table>
<thead>
<tr>
<th>Regional price</th>
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</thead>
<tbody>
<tr>
<td>Regional accessibility</td>
</tr>
<tr>
<td>Regional school quality</td>
</tr>
</tbody>
</table>
Regional Location Factors

Price by region

Accessibility by region

School quality by region
Evaluation of location factors

Income Quartiles

School Quality

Accessibility

Price

SILO
### 2-step Relocation Decision:

1. **Select Region**
2. **Select Dwelling**

<table>
<thead>
<tr>
<th>Location Factors Step 2</th>
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<tbody>
<tr>
<td>Dwelling size</td>
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<td>Dwelling quality</td>
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<tr>
<td>School quality</td>
<td>Replaceable location factors</td>
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<tr>
<td>Auto accessibility</td>
<td></td>
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<tr>
<td>Transit accessibility</td>
<td></td>
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<tr>
<td>Price of dwelling</td>
<td></td>
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<tr>
<td>Travel time to work locations</td>
<td>Essential location factors</td>
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<td>Travel costs</td>
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Local Location Factors

School quality

Auto accessibility

Transit accessibility
# Replaceable Location Factors

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<th>Income Quartile</th>
<th>Dwelling Size</th>
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# Non-Replaceable Location Factors

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<th>Income Quartile</th>
<th>Replaceable Location Factors</th>
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<th>Distance to work</th>
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<td>0.60000</td>
<td>0.05000</td>
<td>0.25000</td>
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</tbody>
</table>
Age Pyramid

2000

NCSG

SILO

PRESTO!
Growth in Number of Households

- Population Growth
- Housing costs
- Average commute distance
- Population Growth
- Average monthly costs by dwelling type in 2000$
CLRP Household Growth in Core and Developed Corridors

Dwellings Per Square Mile - 2040

Dwellings Per Square Mile Change - 2000-2040

Population and Employment
Region is expected to grow substantially due to inmigration

Assumptions on net migration has major impact on
  – Construction
  – Housing prices
  – Population distribution

Zoning could have large impact on future population distribution
Transportation Model Results: MSTM
Agenda for Transportation

- Model Structure
- VMT/VHT
- Network Conditions
- Location of VMT/VHT
- Transit
  - Ridership
  - ridership location
The Model Projects VMT Will Continue to Increase

VMT and VMT/Capita in Maryland Relative to 2007 Levels

- Actual VMT
- Actual VMT/Capita
- Model VMT
- Model VMT/Capita

Transportation MD State Stat
## Model Projections for VMT and VHT Change

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2030</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily VMT (Millions)</td>
<td>153.33</td>
<td>200.64</td>
<td>31%</td>
</tr>
<tr>
<td>Daily VMT/Capita</td>
<td>27.29</td>
<td>30.38</td>
<td>11%</td>
</tr>
<tr>
<td>Daily VHT (millions)</td>
<td>4.63</td>
<td>6.87</td>
<td>48%</td>
</tr>
<tr>
<td>Daily VHT/Capita</td>
<td>0.82</td>
<td>1.04</td>
<td>26%</td>
</tr>
</tbody>
</table>
Volume Increases Throughout System, Particularly Fast Growing Suburbs
VMT per Mile Increases Dramatically on All Major Highways, Some Minor Ones.
Increased VMT With Little Network Change Increases Congestion
## VMT Increase Similar to Household Growth

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>VMT 2007 (Millions)</th>
<th>VMT 2030 (Millions)</th>
<th>VMT % Change</th>
<th>Households Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore Core</td>
<td>9.75</td>
<td>11.61</td>
<td>19%</td>
<td>11%</td>
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<tr>
<td>Baltimore Inner</td>
<td>51.85</td>
<td>66.82</td>
<td>29%</td>
<td>15%</td>
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<tr>
<td>Baltimore Outer</td>
<td>13.15</td>
<td>18.89</td>
<td>44%</td>
<td>32%</td>
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<tr>
<td>Washington Core</td>
<td>18.91</td>
<td>23.72</td>
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<td>37%</td>
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<tr>
<td>Washington Inner</td>
<td>78.60</td>
<td>101.74</td>
<td>29%</td>
<td>26%</td>
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<tr>
<td>Washington Outer</td>
<td>38.77</td>
<td>67.06</td>
<td>73%</td>
<td>73%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>211.04</strong></td>
<td><strong>289.84</strong></td>
<td><strong>37%</strong></td>
<td><strong>30%</strong></td>
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</table>
## VHT Increases Fastest in Outlying Counties

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>VHT 2007 (Millions)</th>
<th>VHT 2030 (Millions)</th>
<th>VHT % Change</th>
<th>Households Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore Core</td>
<td>0.38</td>
<td>0.46</td>
<td>19%</td>
<td>11%</td>
</tr>
<tr>
<td>Baltimore Inner</td>
<td>1.62</td>
<td>2.11</td>
<td>30%</td>
<td>15%</td>
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<tr>
<td>Baltimore Outer</td>
<td>0.41</td>
<td>0.62</td>
<td>49%</td>
<td>32%</td>
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<td>Washington Core</td>
<td>1.34</td>
<td>1.84</td>
<td>37%</td>
<td>37%</td>
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<tr>
<td>Washington Inner</td>
<td>3.19</td>
<td>4.66</td>
<td>46%</td>
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<tr>
<td>Washington Outer</td>
<td>1.37</td>
<td>3.69</td>
<td>170%</td>
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<td><strong>Total</strong></td>
<td><strong>8.31</strong></td>
<td><strong>13.38</strong></td>
<td><strong>61%</strong></td>
<td><strong>30%</strong></td>
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VHT Increases Faster than VMT

VMT and VHT % Change 2007 - 2030

- Baltimore Core
- Baltimore Inner
- Baltimore Outer
- Washington Core
- Washington Inner
- Washington Outer
- Total

VHT Increases Faster than VMT

Transportation
Rail Ridership Increases, Bus Ridership Decreases

Daily Ridership by Transit Mode

APTA ridership data adapted to Daily Rider Survey
VHT Increases Faster than VMT

Transportation
Red and Purple Lines Have Observable, Local Impact on Transit Use
## Core and Inner Washington Add Nearly 1,000,000 Daily Transit Trips

### Transit Production Change by Sub-Region

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>Transit Productions 2007</th>
<th>Transit Productions 2030</th>
<th>Total Change</th>
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<td>Baltimore Inner</td>
<td>369,406</td>
<td>476,740</td>
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<td>Baltimore Outer</td>
<td>8,354</td>
<td>12,594</td>
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<tr>
<td>Washington Core</td>
<td>651,992</td>
<td>1,050,484</td>
<td>398,491</td>
<td>61%</td>
<td>37%</td>
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<tr>
<td>Washington Inner</td>
<td>961,807</td>
<td>1,487,247</td>
<td>525,440</td>
<td>55%</td>
<td>26%</td>
</tr>
<tr>
<td>Washington Outer</td>
<td>106,089</td>
<td>226,879</td>
<td>120,790</td>
<td>114%</td>
<td>73%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,317,316</strong></td>
<td><strong>3,593,138</strong></td>
<td><strong>1,275,822</strong></td>
<td><strong>55%</strong></td>
<td><strong>30%</strong></td>
</tr>
</tbody>
</table>
Transit, However, Remains Small Portion of All Trips

Transit Rate: Productions

- Washington Core
- Washington Inner
- Washington Outer
- Baltimore Core
- Baltimore Inner
- Baltimore Outer

- Transit Rate 2007
- Transit Rate 2030

Transportation
Conclusion for Transportation

- VMT will grow
- Congestion will increase
- Transit critical but not a panacea
- Transit and highway capacity a concern
Emissions: MEM & BEM
• Model Structure

• CO$_2$ emissions:
  • Projected Total Emissions
  • By Source
  • Location

• Energy Use:
  • Projected Total BTUs
  • By Location

• Mobile Nitrous Oxide and Volatile Organic Compounds
  • Projected Total Emissions
  • By Location
MEM Model Structure

**MOVES**
- Calculate county level emissions rates
- Format them to MSTM Format

**MTSM**
- Calculate VMT and speeds (link level)
- Calculate intrazonal VMT (trips that begin and end within each zone)
- Add MOVES Road Types to MSTM loaded network

**MEM**
- Calculate Running Emissions
- Calculate Non-Running Emissions

Summarize Running and Non-Running Emissions
BEM Model Structure

- Probability of Local Combustion
  - <50%
  - >50%

- Measure CO₂ from combustion

- Measure Energy Consumption
  - Assign Future Growth to Zones
  - Assign Growth based on scenarios

- Estimate Emissions and Energy Consumption
  - Feed to Energy Sector Inventory
  - Land use inputs to Travel Model

- Base Inventory
  - Aggregate to zones
CO₂ Emissions Will Decline with State Programs; State Goal Unrealized

Actual and Projected Emissions 2006 - 2030

- Actual Emissions
- 2020 Goal
- State Projection Under Current Progress
- Projected Emissions - Business as Usual
- Projected Emissions w/ Maryland Climate Action Plan
CO\textsubscript{2} Emissions Decrease in All Sectors with Climate Action Plan

Total CO\textsubscript{2} Emissions by Source (Million Metric Tones CO\textsubscript{2} Equivalent)

- Mobile Emissions
- Building Emissions
- Energy Sector Emissions
CO$_2$ Emission per Square Mile Increases With Growth
Total Energy Use Increases, Energy Use per Capita Declines 20%

Building Based Energy Use and Energy Use Per Household Relative to 2006 Levels
Energy Use Increases in Growth Corridors

Energy Use (BTUs) Per Square Mile - 2030

Change in Energy Use (BTUs) Per Square Mile 2007-2030
NOx Increases, VOCs Decrease

Mobile Nitrogen Oxide and Volatile Organic Compounds Projected

- Daily NOx Emissions
- Daily VOC Emissions

Emissions

PRESTO!
NOx Increases in Areas of Increased Volume

Emissions
VOCs Increase in Some Locations, Fall in Others
• CO₂ emissions will decline with state strategies but not enough to achieve state goals.

• Population and jobs growth are the primary drivers of emissions and increased energy usage, offsetting efficiencies.

• Nitrous Oxide will increase as traffic increases while VOC will decline.
Land Cover and Water Quality
Agenda for Emissions Section

- Model Structure
- Notes on Outputs
- Existing Land Cover
- Land Cover Change
- Nutrient Loads
Water Quality Model Structure

- **MSTM**
  - Travel times

- **SILO**
  - Households per income class
  - Employment per sector

- **Accessibilities**
- **Land cover change patterns 1984 - 2010**
- **Zoning**
- **Land Area Suitable for Development**
- **Housing & Employment Densities**

**CBLCM** (30m-pixel level)
- Probability estimates of (Monte Carlo Simulation)
  - Residential development
  - Commercial development
    - Infill development

**Watershed Model**

Nutrient and sediment loads (#/acre/yr)

**Water Quality Model**

Water clarity, dissolved oxygen and chlorophyll-a

**Land use**
- Land cover
• Projects changes in land cover from greenfield development.
• Nutrient and sediment loading figures reflect additional loads from greenfield development.
• Lands that are unsuitable or unavailable for greenfield development include: existing development, steep slopes, public/protected areas, areas zoned for conservation or rural agriculture.
Forest and Farmland Sit Entwined Developed Land

Land Cover in the Study Area (2011)
Regulations in Maryland Limit Areas of Future Growth

Forest and Farmland Suitable for Development Remain Colored

Note that zoning data were not solicited from jurisdictions outside of Maryland.
Limited Land Supply Pushes Greenfield Development Outward

Forecasted Development in Study Area (2007-2030)
Forest Acres in Maryland Will Continue to Decline

Total Forest Acres: Maryland

- Forest Acres (Thousands)
- Projected Forest Acres (Thousands)

Water Quality
US Forest Service
Development of Forest Will Occur in Baltimore Washington Corridor

Forecasted Forest Conversion in Study Area (2007-2030)
Farmland Projected to Continue Declining at Slower Rate

Total Farmland Acres: Baltimore-Washington Region

- Farmland Acres (Thousands)
- Projected Farmland Acres (Thousands)

Water Quality US Farm Census

PRESTO!
Farmland Lost Greatest to the West

Forecasted Farmland Conversion in Study Area (2007-2030)
Nitrogen Loads Small Compared to Total Loads

Annual Nitrogen Loads (lbs) in Maryland - Actual and Projected From New Development

- **N State Target**
- **N Projected with New Development**

Water Quality MD State Stat

PRESTO!
Developed Forest Land Increases Nitrogen Loads

Additional Loads Small Compared to Current Annual Loads

Annual Phosphorous Loads (lbs) in Maryland - Actual and Projected From New Development

- P
- P State Target
- P Projected with New Development

Water Quality
Forest Decline Increase Phosphorous Loads

Forecasted Net Flux in Total Phosphorous (2007-2030)
New Development Increases Sediment Loads

Annual Sediment Loads (lbs) in Maryland - Actual and Projected From New Development

Water Quality

[S] Actual
[S Projected from New Development]
[S Linear Projection]
Sediment Loads Increase on Almost All Developed Lands

Forecasted Net Flux in Total Sediments (2007-2030)
Indicators
<table>
<thead>
<tr>
<th>Name</th>
<th>Input</th>
<th>Output</th>
<th>Neither</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Commuting Time (Traffic: Family)</td>
<td></td>
<td>✔</td>
<td></td>
<td>MSTM (VHT/VHD)</td>
</tr>
<tr>
<td>2. Free time</td>
<td></td>
<td></td>
<td>✔</td>
<td>Might Infer from #1 above</td>
</tr>
<tr>
<td>3. Local people interconnectivity</td>
<td></td>
<td></td>
<td>✔</td>
<td>Street connectivity index?</td>
</tr>
<tr>
<td>4. Life expectancy</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input</td>
</tr>
<tr>
<td>5. Public Health</td>
<td></td>
<td>✔</td>
<td></td>
<td>Only air and water quality</td>
</tr>
<tr>
<td>6. Mode choice</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input</td>
</tr>
<tr>
<td>7. Employment</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input; INFORUM output?</td>
</tr>
<tr>
<td>8. Quality of employ’t (living wage)</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input; INFORUM output?</td>
</tr>
<tr>
<td>9. GDP</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input; INFORUM output?</td>
</tr>
<tr>
<td>10. Genuine Progress Indicator</td>
<td></td>
<td>✔</td>
<td></td>
<td>Projection problem</td>
</tr>
<tr>
<td>11. Income</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input; INFORUM output</td>
</tr>
<tr>
<td>12. Income distribution</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO Input; projection problem</td>
</tr>
<tr>
<td>13. Local spending</td>
<td></td>
<td>✔</td>
<td>✔</td>
<td>Current/Projection challenge</td>
</tr>
<tr>
<td>14. Urban redevelopment</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>CBLCM;</td>
</tr>
<tr>
<td>15. Travel/housing costs tradeoffs</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>SILO input</td>
</tr>
<tr>
<td>Name</td>
<td>Input</td>
<td>Output</td>
<td>Neither</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------</td>
<td>--------</td>
<td>---------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>16. Access to Open Space</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>SILO input/ MSTM output?</td>
</tr>
<tr>
<td>17. GHG Emissions</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>MEM and BEM</td>
</tr>
<tr>
<td>18. NoX and Particulates</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>MEM and BEM</td>
</tr>
<tr>
<td>19. Net Primary Productivity (ecosyst)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td><img src="#" alt="Neither" /></td>
</tr>
<tr>
<td>20. Noise</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td><img src="#" alt="Neither" /></td>
</tr>
<tr>
<td>21. Rate of sprawl (ag/forest loss)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>CBCLM</td>
</tr>
<tr>
<td>22. Resource consumption (water, fossil fuels, calories)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td><img src="#" alt="Neither" /></td>
</tr>
<tr>
<td>23. Waste generation (air/water pollutants, solid waste)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>MEM and BEM</td>
</tr>
<tr>
<td>24. Water nutrient loading</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Neither" /></td>
<td>CBLCM Water model</td>
</tr>
</tbody>
</table>
SILO OVERVIEW
SILO Overview

• Microscopic land-use model
• Fully integrated with travel demand model
• Two implementations
  – Minneapolis/St. Paul
  – Maryland
• Open source: www.silo.zone
SILO Integration

Model | Data | Model | Data | Model
--- | --- | --- | --- | ---
MSTM | Travel times | SILO | Housing stock | CBLCM water quality
SILO | Migration projections | | | |
| | | Population distribution | | |
| | | | | |
| | | | | |
| | | | | |

SILO

NCSG

PRESTO!
SILO ASSUMPTIONS
Initial Run: SILO vs. Hammer

SILO Assumptions
## Assumptions on Net Migration

### Elements of population Growth

<table>
<thead>
<tr>
<th>Natural Growth</th>
<th>Birth $b$</th>
<th>Source: National birth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Death $d$</td>
<td>Source: National death rate</td>
</tr>
<tr>
<td>Migration</td>
<td>Inmigration $i$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outmigration $o$</td>
<td></td>
</tr>
<tr>
<td>Population Growth</td>
<td>$b - d + i - o$</td>
<td></td>
</tr>
</tbody>
</table>

Tommy Hammer forecasted growth

\[
\text{Given} \quad \text{Calculated by SILO}
\]

<table>
<thead>
<tr>
<th>Tommy Hammer forecasted growth</th>
<th>=</th>
<th>Birth</th>
<th>-</th>
<th>Death</th>
<th>+</th>
<th>Inmigration</th>
<th>-</th>
<th>Outmigration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecaster estimation</td>
<td>=</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Inmigration to match Hammer targets

SILO Assumptions
1. Forecasts employment by sector
2. Forecasts birth and death by cohort-survival method
3. Fills in missing population to serve jobs with inmigrants

Forecast used here dates back to 2007 and does not reflect recent recession.
Net immigration per resident

Revised Tommy Hammer

SILO Assumptions
Reasonability Check

**Net Migration**

- **International**: 0.39%
- **Domestic**: 0.03%
- **Total**: 0.42%

Source: [http://clustermapping.us](http://clustermapping.us)
Assumptions on Vacancy Rates

- A small share of dwellings is empty, providing the opportunity to move
- Vacant housing drives in SILO
  - Housing price
  - Incentive for developers to build new dwellings
Observed vacancy rates

<table>
<thead>
<tr>
<th>Region</th>
<th>Vacancy Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>10.3%</td>
</tr>
<tr>
<td>Inner</td>
<td>3.7%</td>
</tr>
<tr>
<td>Outer</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

SILO Assumptions
<table>
<thead>
<tr>
<th>Dwelling Type</th>
<th>Description</th>
<th>Vacancy Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFD</td>
<td>Single-family, detached</td>
<td>1%</td>
</tr>
<tr>
<td>SFA</td>
<td>Single-family, attached</td>
<td>3%</td>
</tr>
<tr>
<td>MF234</td>
<td>Multi-family with 2, 3 or 4 units</td>
<td>5%</td>
</tr>
<tr>
<td>MF5plus</td>
<td>Multi-family with 5 or more units</td>
<td>4%</td>
</tr>
<tr>
<td>MH</td>
<td>Mobile home</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: MetCouncil Minneapolis/St. Paul
Development activity and vacancy

Assumed average vacancy

Vacancy rate

Share of dwellings added

SILO Assumptions
Development activity and vacancy

<table>
<thead>
<tr>
<th>Dwelling type</th>
<th>Base vacancy</th>
<th>Add at base vacancy</th>
<th>Add at 0% vacancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFD</td>
<td>1.0%</td>
<td>0.20%</td>
<td>5%</td>
</tr>
<tr>
<td>SFA</td>
<td>3.0%</td>
<td>0.35%</td>
<td>5%</td>
</tr>
<tr>
<td>MF234</td>
<td>5.0%</td>
<td>0.50%</td>
<td>5%</td>
</tr>
<tr>
<td>MF5plus</td>
<td>4.0%</td>
<td>0.43%</td>
<td>5%</td>
</tr>
<tr>
<td>MH</td>
<td>3.0%</td>
<td>0.35%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Assumptions on Development Potential

• SILO’s developer model requires information on where new housing can be developed
• New development shall include both Greenfield and infill development
Development Potential outside MD

1. Collect Zoning Data

2. Calculate Potential Density

3. Collect Housing Stock Data (Census)

4. Calculate Development Potential

Potential = Area - Roads - PublicSpace - ...

Existing housing stock in base year

Difference between potential and actual housing stock