Eco-Hydrology Modeling in Coastal Louisiana to Assess Project Effects on the Landscape

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Director of Natural Systems Modeling and Monitoring at the Water Institute of the Gulf (TWIG)
June 7, 2012
**Team Members**

<table>
<thead>
<tr>
<th>Member</th>
<th>Affiliation</th>
<th>Title</th>
<th>Sub-Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehab Meselhe</td>
<td>Water Institute, University of Louisiana Lafayette</td>
<td>Work Group Leader, Sub Group Leader</td>
<td>Chenier Plain</td>
</tr>
<tr>
<td>Alex McCorquodale</td>
<td>University of New Orleans</td>
<td>Water Quality Specialist, Sub Group Leader</td>
<td>Pontchartrain-Barataria</td>
</tr>
<tr>
<td>Jeff Shelden</td>
<td>Moffat &amp; Nichol</td>
<td>Sub-Group Leader</td>
<td>Atchafalaya Basin</td>
</tr>
<tr>
<td>Mark Dortch</td>
<td>Moffat &amp; Nichol</td>
<td>Water Quality Specialist</td>
<td>Atchafalaya Basin</td>
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<tr>
<td>Gerald Duszynski</td>
<td>Fenstermaker</td>
<td>Technical Advisor, QA/QC</td>
<td>–</td>
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<tr>
<td>Stokka Brown</td>
<td>Fenstermaker</td>
<td>Point of Contact, Modeler</td>
<td>Chenier Plain</td>
</tr>
<tr>
<td>Mallory Davis</td>
<td>Fenstermaker</td>
<td>Modeler</td>
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<td>Peter Elkan</td>
<td>Moffat &amp; Nichol</td>
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<tr>
<td>Jonathan Wang</td>
<td>Moffat &amp; Nichol</td>
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<tr>
<td>Jenni Schindler</td>
<td>University of New Orleans</td>
<td>Modeler</td>
<td>Pontchartrain-Barataria</td>
</tr>
</tbody>
</table>
Modeling in a Systems Context

Stage, Salinity, Water Quality

Stage, Salinity

Land Configuration, Elevation

Eco-hydrology

Stage, Salinity, Sediment

Land Configuration, Elevation

Wetland Morphology

Dominant Vegetation

Vegetation

Dominant Vegetation

Ecosystem Services

Stage

Island Configuration

Barrier Shoreline Morphology

Storm Surge/Waves

Surge, Waves

Risk Assessment
Outline

- Model Domain
- Model Setup
  - Input & Output
  - Assumptions
  - Mechanics
- Model Testing
  - System Quality
  - Calibration & Validation
- Model Simulation Process
- Master Plan Results
Outline of Model Domain
<table>
<thead>
<tr>
<th>Region</th>
<th>Channel</th>
<th>Open Water</th>
<th>Marsh</th>
<th>Upland</th>
<th>Offshore</th>
<th>Total</th>
<th>Surface Area Ranges in km² (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB</td>
<td>-</td>
<td>89</td>
<td>7 Nodes</td>
<td>89</td>
<td>2.2 – 5844 (716)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend**
- PB Offshore Nodes
- PB Model Domain
- PB Polygons

**Map:** Pontchartrain/Barataria Basin Model Domain
<table>
<thead>
<tr>
<th>Region</th>
<th>Channel</th>
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<th>Upland</th>
<th>Offshore</th>
<th>Total</th>
<th>Surface Area Ranges in km² (Average)</th>
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</thead>
<tbody>
<tr>
<td>AA</td>
<td>74</td>
<td>21</td>
<td>70</td>
<td>-</td>
<td>4</td>
<td>169</td>
<td>0.04 – 3361 (118)</td>
</tr>
</tbody>
</table>

**Atchafalaya Basin Model Domain**

**Legend**
- AA Model Domain
- AA Polygons

**Milage Scale**

0 12.5 25 50 75 100
<table>
<thead>
<tr>
<th>Region</th>
<th>Channel</th>
<th>Open Water</th>
<th>Marsh</th>
<th>Upland</th>
<th>Offshore</th>
<th>Total</th>
<th>Surface Area Ranges in km² (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>33</td>
<td>19</td>
<td>105</td>
<td>-</td>
<td>6 Nodes</td>
<td>157</td>
<td>0.6 – 1844 (86)</td>
</tr>
</tbody>
</table>

**Legend**
- CP Locks
- CP Model Domain
- CP Offshore Nodes
- CP Polygons

**Chenier Plain Model Domain**
Model Input and Output

<table>
<thead>
<tr>
<th>Model Input</th>
<th>Model Output</th>
<th>Symbol</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>Stage</td>
<td>STG</td>
<td>Daily</td>
</tr>
<tr>
<td>Water and Air Temperature</td>
<td>Salinity</td>
<td>SAL</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>Gulf Stage, Salinity, and Nutrients</strong></td>
<td>Sediment Retention</td>
<td>TSS</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>River Discharge, Sediment, and Nutrients</strong></td>
<td>Accretion</td>
<td>ACC</td>
<td>Yearly</td>
</tr>
<tr>
<td>Diversion Discharge, Sediment, and Nutrients</td>
<td>Total Kjeldahl Nitrogen</td>
<td>TKN</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Tidal range</td>
<td>TRG</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Nitrate + Nitrite Nitrogen</td>
<td>NO3</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Water Temperature</td>
<td>TMP</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Ammonium Nitrogen</td>
<td>NH4</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Dissolved Organic Nitrogen</td>
<td>DON</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Total Phosphorus</td>
<td>TPH</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Soluble Phosphorus</td>
<td>SPH</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Phytoplankton as Chlorophyll-a</td>
<td>ALG</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Detritus</td>
<td>DET</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Water Age</td>
<td>AGE</td>
<td>Monthly</td>
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<tr>
<td></td>
<td>Nitrogen Removal Rate</td>
<td>NRM</td>
<td>Yearly</td>
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</tbody>
</table>

*Bolded, Red Inputs are varied based on scenario*
Model Assumptions

- Modeling approach based on conservation of mass
- Momentum/dynamic exchange not included
- Hydrology and constituents semi-coupled
- Flow variables spatially averaged over each compartment
- Water column fully mixed and aerobic at all locations and times
- Transfer of nutrients from bed to water column not included
- Compartments prevented from filling up due to deposition (AA model only)
- Sediment accretion in channels is not included
Model Mechanics

PB

Cell Type
- Upland
- Marsh
- Open water

Exchange Type
- Inter-cell exchange
- Intra-cell exchange
- Tributary input
- Mississippi River input
- Precipitation-Evaporation
- Precipitation-Evapotranspiration

a. Plan view of PB model dynamics

AA & CP

Cell Type
- Marsh
- Open water
- Channel

Exchange Type
- Inter-compartment exchange
- Tributary input
- Precipitation-Evapotranspiration

a. Plan view of AA and CP model dynamics

b. Cross-section view of PB model dynamics for a generalized interior cell

b. Cross-section view of AA and CP model dynamics for a generalized interior marsh compartment
Mass Transfer
System Quality
System Quality
System Quality
Calibration and Validation

<table>
<thead>
<tr>
<th>Model</th>
<th>Calibration Year(s)</th>
<th>Validation Year(s)</th>
</tr>
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<tbody>
<tr>
<td>PB</td>
<td>1990 - 2009</td>
<td></td>
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<tr>
<td>AA</td>
<td>2007</td>
<td>2008 - 2009</td>
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<tr>
<td>CP</td>
<td>2007</td>
<td>2010</td>
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</tbody>
</table>
Calibration and Validation
Calibration and Validation

- Stage (m NAVD88)

- Date

- Observed: USGS 8017118

- Modeled: CP011
Project Types

- Marsh Creation
- Hydrologic Restoration
- Diversion
- Channel Re-alignment
- Ridge Restoration
- Barrier Island Restoration
- Oyster Reef Development
- Hurricane Protection
Simulations

**First 25 Years**

- Eco-hydrology
- Stage, Salinity
- Vegetation
- Stage, Salinity
- Barrier Shoreline Morphology
- Stage
- Wetland Morphology
- Land Configuration, Elevation

**Second 25 Years**

- Stage, Salinity, Sediment
- Eco-hydrology
- Stage, Salinity
- HVAC Configuration
- Elevation
- Stage
- Stage, Salinity, Sediment
Output from Wetland Morphology
Output from Wetland Morphology
Output from Wetland Morphology
Master Plan

Primary Concerns

• PB region – Sediment Accretion
• AA region – Salinity and Sediment Accretion
• CP region – Salinity
PB Results - Cumulative Accretion over 50 years

Future Without Action
Less Optimistic Scenario

Master Plan
Less Optimistic Scenario

Compartment receiving diverted flow
AA Results - Average Annual Salinity for 2nd 25 years

Future Without Action
Less Optimistic Scenario

Master Plan
Less Optimistic Scenario
AA Results - Cumulative Accretion over 50 years

Future Without Action
Less Optimistic Scenario

Master Plan
Less Optimistic Scenario
CP Results - Monthly Averaged Salinity

October 2030
Less Optimistic Scenario

Future Without Action

Master Plan

January 2051
Less Optimistic Scenario

Future Without Action

Master Plan
• Eco-Hydrology group designed computationally efficient tools/models for the Louisiana Coast

• Models functioned as a component of integrated analysis approach

• A 50-year analysis was performed with a full landscape update at year-25

• Eco-Hydrology models provide assessment of relative project effects on the ecosystem hydrology

For more information on these models, please visit the Master Plan website: http://www.coastalmasterplan.louisiana.gov/2012-master-plan/draft-2012-master-plan/
Thank You!