One Team: Relevant, Ready, Responsive, Reliable

Inner Harbor Navigation Canal
Lake Borgne
Hurricane Risk Reduction Project
Tulane University - April 3, 2009
Dale Miller, P.E., S.E., INCA Engineers
IHNC Map

Lake Pontchartrain
Seabrook
N.O. East
IHNC
Lower 9th Ward
Mississippi
Chalmette
Michoud Slip / Canal
Gulf Intercoastal Waterway
Bayou Bienvenue
Mississippi Gulf Outlet
Lake Borgne
Project Mission

• Provide flood risk reduction for a 1% annual chance storm event to the communities surrounding the IHNC by June 2011

• The IHNC is the linchpin in the system – the Achilles Heel – the highest risk area. It is the 1st Construction Contract Award for the 100-yr level Risk Reduction System.

• The Largest Civil Works Design-Build Cost-Reimbursable Project in Corps’ History.
IHNC Lake Borgne

• Awarded IHNC Lake Borgne Project to Shaw Environmental & Infrastructure, Inc., in April 2008 for $695,489,766

• National Environmental Policy Act (NEPA) Signed by Col Lee October 21, 2008

• Notice to Proceed (NTP) for Construction on November 3, 2008

• Ground Breaking December 4, 2008

• All Real Estate Acquired December 22, 2008

• General Walsh Issued Full NTP on January 14, 2009

• Overall Design ~63%
Define the Project
Shaw Evaluated Seven Different Gate Options

- Selected solution: sector gate in the “dry” construction
- Alternate solution: vertical lift gate
- Also considered innovative roller and visor gates

<table>
<thead>
<tr>
<th>Option</th>
<th>Alternative</th>
<th>Action / Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>G01</td>
<td>Sector Gate - “Dry” Construction</td>
<td>Selected as primary solution. Proven design, proven construction, and proven performance.</td>
</tr>
<tr>
<td>G03</td>
<td>Vertical Lift Gate</td>
<td>Selected as alternate solution. Demonstrated at Olmsted. Concerns with wind loads with gate in up position.</td>
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<tr>
<td>G02</td>
<td>Sector Gate - “Wet” Construction</td>
<td>Dropped – more costly than G01 and local construction contractors are not proficient with this method.</td>
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<tr>
<td>G04</td>
<td>Swing Gate – Steel</td>
<td>Dropped – does not meet operating timeframe or maintenance requirements. Concerns with opening under head.</td>
</tr>
<tr>
<td>G05</td>
<td>Swing Gate – Concrete</td>
<td>Dropped – does not meet operating timeframe. Concerns with opening under head.</td>
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<tr>
<td>G06</td>
<td>Roller Gate – Busbyan</td>
<td>Dropped – does not meet operating timeframe. Concerns with opening under head.</td>
</tr>
<tr>
<td>G07</td>
<td>Visor Gate</td>
<td>Dropped – current designs are not believed to be resilient and would be difficult to construct.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Gate Alternatives</th>
<th>Schedule Achievement</th>
<th>Cost</th>
<th>4 R’s Criteria</th>
<th>Team Confidence</th>
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<tbody>
<tr>
<td>G01</td>
<td>G G E M M M M E G G E G M M E E G M</td>
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<td>G03</td>
<td>G G E M H M M G G G E G L M G G G M</td>
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<tr>
<td>G02</td>
<td>G G G H M M M E G G E G M H G P G L</td>
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<td>G04</td>
<td>G G E M M M H G G G G G M M G G G M</td>
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<tr>
<td>G05</td>
<td>G G E M L M H G G G G G M M G G G M</td>
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<tr>
<td>G06</td>
<td>G G E M M M H G G G G G M H G G G M</td>
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<tr>
<td>G07</td>
<td>G G E H U H H P G U G G M H P P G M</td>
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</table>

Legend:
- **Excellent** or **Low**
- **Good** or **Medium**
- **Poor** or **High**
- **Uncertain**
Shaw Evaluated
12 Different Barrier Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Alternative</th>
<th>Action / Decision</th>
<th>Schedule Achievement</th>
<th>Sustainability</th>
<th>Adaptability</th>
<th>Cost</th>
<th>4 R’s Criteria</th>
<th>Environment</th>
<th>Impact</th>
<th>Team Confidence</th>
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</thead>
<tbody>
<tr>
<td>L09</td>
<td>Braced Concrete Pile Wall</td>
<td>Retain as primary solution. Provides robust system that can be constructed by local resources. Low O&amp;M.</td>
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<tr>
<td>L01</td>
<td>Large (e.g., 54’ diameter) Caisson</td>
<td>Retain as alternate solution. Provides robust system with low O&amp;M.</td>
<td>U G E M L M L E E G E E M H G P P L</td>
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<tr>
<td>L02</td>
<td>Dumbbell Caisson</td>
<td>Dropped - variant of L01. Can be re-evaluated if primary solution is not selected for further design.</td>
<td>U G E M L M L E E G E E M H G P P L</td>
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<td>L03</td>
<td>Open Cell Sheet Pile</td>
<td>Dropped - corrosion concerns with the sheet pile, high costs, and global stability concerns.</td>
<td>G G E M M M M G G P G G L M G G G S L</td>
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<tr>
<td>L04</td>
<td>Earthen Levee</td>
<td>Upped - high cost for acquiring and placing the clay and high cost for settlement. Also, resilience concerns from overtopping. Work will be significantly impacted by adverse weather.</td>
<td>P U E H H H H P P E G G H L G E P L</td>
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<td>L05</td>
<td>Pile-Supported Levee</td>
<td>Dropped - see L04. Savings from smaller levee footprint offset by higher cost for the piles.</td>
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<tr>
<td>L06</td>
<td>Jet Grout Wall</td>
<td>Dropped - high cost for grouting/deep soil mixing and concrete wall. Also, significant amount of site construction potentially impacted by adverse weather.</td>
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<td>L07</td>
<td>New T-Wall</td>
<td>Dropped - high cost for robust T-wall with piles, slow installation, and significant amount of site construction potentially impacted by adverse weather.</td>
<td>P G E H L M L E G G G G L M G G E L</td>
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<tr>
<td>L08</td>
<td>Boxed Steel Sheet Pile-Wall</td>
<td>Dropped - corrosion concerns with the sheet pile.</td>
<td>G E E M M M M G G P G G L M G G E E L</td>
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<td>L10</td>
<td>Earth Levee with Soil Mixing</td>
<td>Dropped - see L04. Savings from smaller levee footprint offset by higher cost for the deep soil mixing.</td>
<td>P U E H M H M P G E G P H L G G P L</td>
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<tr>
<td>L11</td>
<td>Hybrid Box Levee with T-Wall</td>
<td>Dropped - difficult to attain Advance Measures; hybrid box cannot be cost-effectively built to an elevation to attain the Advance Measures so will still need T-Wall. See L04 for soil placement and L07 for T-wall concerns.</td>
<td>P G E M M M M G G G G G M M G G G</td>
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<tr>
<td>L12</td>
<td>Open Cell Sheet Pile with Earthen Levee</td>
<td>Dropped - see L03 and L04.</td>
<td>G E E M H M H P G G G G G M M G G G L</td>
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- Selected solution: braced concrete pile wall
- Alternate solution: large diameter caissons
- Earthen levees discarded because of settlement, clay availability and resilience
- T-walls dropped because of high cost for T-walls, slow installation, and potential adverse weather impact
Lake Borgne—
Project Alignment

North Access Bridge
GIWW & Barge Gates
Floodwall
Bayou Bienvenue Gate
Transition T-Walls
MRGO Closure
IHNC Program

Seabrook

Lake Borgne

Interior Walls

One Team: Relevant, Ready, Responsive, Reliable
Boring Locations
Model Study Area
Model Mesh
(existing conditions)
Overtopping Analysis: Franco & Franco Method

- Calculates overtopping
- Maximum allowable storage capacity behind IHNC HPP is 226.5 million ft³.
- Input: 1% Chance of exceedance values of $H_S$, $T_P$, Storm Water Level (SWL), wall height, wall length, and wall type coefficient.
- Output: Run through Monte Carlo analysis to produce 50% and 90% Monte Carlo confidence intervals.
Wave Loading - Goda Method

• Calculates the pressure distribution created by breaking and non-breaking waves on vertical walls.

• AECOM analyzed forces using 1% chance of exceedance values for $H_s$, $T_p$, and SWL.

• Input: 1% chance of exceedance values of $H_s$, $T_p$, SWL, wall height, and wall type coefficient.

• Other Input: 0.2% chance of exceedance values of $H_s$, $T_p$, and SWL.

• Output: Run through Monte Carlo analysis to produce 50% and 90% Monte Carlo confidence intervals.
Wave Flume
Floodwall Physical Modeling
Overtopping Physical Model
Dredging Vehicle
Cutter Head Dredge
Access Channel
Design Investigations

• Pile test program
• Field Verification Test
• Non-linear Incremental Structural Analysis (NISA)
• Physical Model – GIWW Sector Gate
• Physical Model – Barrier Wall
• Approach Wall Vessel Impact Analysis
• Navigation Simulation
• Navigation Physical Model
Pile Test Program
Pile Test Program
Pile Load Tests
Barrier Flood Wall
Final Protection
Barrier Flood Wall
MRGO Section
Progress Photos

66” diameter spun cast piles
Gulf Coast facility, 6 October 2008
Floodwall Closure System

- 18" Closure Piles
- Jet Grout Columns
- Grout

One Team: Relevant, Ready, Responsive, Reliable
Place Plumb Piles
Place Closure Piles
Place Battered Piles
Place Precast Cap Beam
Cast-In-Place Joints
Wall
GIWW Sector & Barge Gates Open Positions
GIWW Sector &
Barge Gates Closed Positions

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Swing Gate-
Bayou DuLarge
Maintenance Bulkhead

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Questions?