Climate Change Adaptation and Coastal Resiliency Plan (CRP)
Importance of Resiliency

• Climate impacts already being seen
• Sea level rise/greater frequency & magnitude of storms
• Decision making for port and port tenants
• Hurricane Marie—August 2014
  – Damage at Navy Mole and Pier F shorelines & rock dikes
  – Significant damage to breakwater—3 large holes and many other breeches
  – Access restricted to rail operations, critical facilities, fueling stations, etc.
Introduction

Project Goals
• Ensure resilience and business continuity in the Port
• Manage risks associated with climate change
• Identify most vulnerable Port assets
• Identify adaptation strategies to protect the Port

Project Benefits
• A more resilient Port able to continue operations under changed conditions
• More future-looking risk assessment process
• Long-term sustainable development
Project Approach

Phase 1: Data Gathering

Phase 2: Adaptation Strategies
## Stressors

<table>
<thead>
<tr>
<th>Climate Stressors</th>
<th><strong>Mid-Century</strong></th>
<th><strong>End-of-Century</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>+0.6°F–6.4°F in Long Beach</td>
<td>+4.1°F–8.6°F in California</td>
</tr>
<tr>
<td></td>
<td>+two- to threefold extremely hot days</td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td>~9% total rainfall on California Coast</td>
<td>Increased storm frequency/severity (20-year storm becomes 4–15-year storm) in</td>
</tr>
<tr>
<td></td>
<td>~13% days of rainfall on California coast</td>
<td>California</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+10–25% total rainfall per storm in California</td>
</tr>
<tr>
<td>Sea Level Rise (SLR)</td>
<td>11–24 in. of SLR in Los Angeles</td>
<td>37–66 in. of SLR in Los Angeles</td>
</tr>
<tr>
<td>Extreme Wind</td>
<td>Limited data available</td>
<td>Limited data available</td>
</tr>
<tr>
<td>Ocean Acidity + Temperature</td>
<td>~0.5 units pH in California waters</td>
<td>Warming of coastal waters</td>
</tr>
<tr>
<td></td>
<td>Warming of coastal waters</td>
<td></td>
</tr>
</tbody>
</table>
# Climate Science Review

## Impacts

<table>
<thead>
<tr>
<th>Climate Impacts</th>
<th>Coastal Infrastructure</th>
<th>Transportation</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Coastal flooding, erosion and damage from SLR, storm surge and high tides</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Altered sediment transport from SLR and changing coastal storm surge conditions</td>
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<td></td>
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<tr>
<td></td>
<td>- Inland flooding from increased peak flows, runoff, and more frequent/severe rainstorms</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>- Materials corrosion from lower ocean acidity</td>
<td></td>
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<tr>
<td></td>
<td>- Corrosion of coastal utilities from lower ocean acidity</td>
<td></td>
<td></td>
</tr>
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<td>- Coastal flooding, erosion, and damage from SLR, storm surge and high tides</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>- Inland flooding from increased peak flows, runoff, and more frequent/severe rainstorms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Landslides/mudsides from more frequent/severe wildfires and rainstorms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Materials degradation/failure from heat waves</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- $-7\text{--}8%$ transmission capacity on extremely hot days</td>
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<td></td>
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<tr>
<td></td>
<td>- Reduced hydropower generation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- $+50%$ residential demand in Los Angeles region</td>
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<tr>
<td></td>
<td>- $+100%$ residential demand in Central Valley</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- $+45%$ probability of wildfire affecting transmission lines in Los Angeles region</td>
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<tr>
<td></td>
<td>- $38%$ energy supply shortfall</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- $-7\text{--}8%$ transmission capacity on extremely hot days</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- $17%$ probability of electricity deficit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reduced hydropower generation</td>
<td></td>
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</tr>
</tbody>
</table>
Asset Inventory

Identified Port Assets

Risk Assessment

• Exposure
• Sensitivity
• Adaptive Capacity
SLR Inundation Mapping

Least Extreme (16” SLR)

Most Extreme (55” SLR + 100yr Storm Surge)

<table>
<thead>
<tr>
<th>SLR + SS Scenarios</th>
<th>16”</th>
<th>16” + 100yr SWEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16”</td>
<td>36”</td>
<td>36” + 100yr SWEL</td>
</tr>
<tr>
<td>55”</td>
<td>55”</td>
<td>55” + 100yr SWEL</td>
</tr>
</tbody>
</table>
## Inundation Mapping

### Six Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>16” SLR</td>
<td>2050</td>
</tr>
<tr>
<td>36” SLR</td>
<td>2070</td>
</tr>
<tr>
<td>55” SLR</td>
<td>2100</td>
</tr>
</tbody>
</table>

These scenarios are most appropriate for the Port based on lifespan of assets.

36” scenario = high-end projection for 2070 and most-likely projection for 2100.
Vulnerability Profiles

Profiles created for

- Piers
- Transportation
- Critical Facilities
- Utilities
- Breakwater

What’s included in each Vulnerability Profile

**Introduction:** Review of asset location, photograph, summary, and site characteristics

**Climate Stressors:** Description of asset vulnerabilities due to potential SLR and storm surge, extreme temperatures, extreme winds, increased precipitation, and ocean acidity change

**Thumbnail Inundation Maps:** Thumbnail inundation maps illustrating the following scenarios:

- 16-inch, 36-inch, 55-inch SLR
- 16-inch, 36-inch, 55-inch SLR + 100-year Storm Surge
Pier Infrastructure

- Piers S and D first to be inundated (16” SLR).
- Piers A and B include low-lying areas that could flood if overtopping occurs.
- Piers F, G, J, and T not inundated, but may be isolated.
Transportation Network: Rail

- Rail cargo movement stops as soon as inundation occurs.
- Rail speeds slow when temp. reach 90 degrees.
- Rail on Piers S and D first to be inundated (16” SLR).
Transportation Network: Road

- Road traffic stops after few inches of inundation (pending vehicle type).
- Piers S and D roadway first impacted (16” SLR) and may prevent movement of cargo and access to facilities.
Critical Facilities

- Access to Pier S Fire Station #24 and Pier D Foss Maritime will be impacted (16” SLR).
- Extreme heat may cause electrical outages and area-wide brown-outs.
Utilities

Least vulnerable

- **Freshwater**: valve vaults could be impacted.
- **Sewer System**: lift/pump stations could be impacted.
- **Communications**: cables, joints, and splices could be impacted.
Utilities

Most vulnerable

- **Stormwater**: If outfall area is inundated, the water cannot drain and will contribute to further flooding in the area. Rising groundwater due to SLR will exacerbate this impact. If pump station locations are inundated, they will no longer operate.

- **Electrical systems**: Electrical system components that could be impacted by flooding include switchgear, substations, transformers, switchboards, panel boards, and building/facility lighting. Extreme heat could cause grid outages.
Breakwater

- Long Beach breakwater is most vulnerable section (based on historical storm conditions).
- Future storm events may occur outside the range of historical observations.
Project Approach

Phase 1: Data Gathering

Phase 2: Adaptation Strategies
Adaptation Strategies – Selection Process

• Develop long list of 50+ strategies

• Port workshop – Assess & prioritize strategies

• Develop 5 strategies & concept designs
Adaptation Strategies – Selection Process

Types of Strategies

**Governance**
- Overarching port policies, integration into plan documents, manuals, guidelines, etc.
- Design Criteria

**Initiative**
- Informational gaps
- Support Port’s current efforts
- Stakeholder engagement

**Physical Infrastructure**
- Modification & enhancement of existing structures
- Asset/location specific
## Adaptation Priority Strategies

### Five Prioritized Strategies

<table>
<thead>
<tr>
<th>Governance</th>
<th>Initiative</th>
<th>Physical Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Addressing climate change impacts through various Port policies, plans, and guidelines</td>
<td>3. Piers A &amp; B Study – combined impacts of riverine and coastal flooding around Dominguez Channel</td>
<td>4. Terminal Island shoreline protection</td>
</tr>
<tr>
<td>2. Adding climate change analysis to the Harbor Development Permit process</td>
<td></td>
<td>5. Terminal Island SCE electrical substation protection – evaluation of multiple strategies</td>
</tr>
</tbody>
</table>

*Additional future strategies to consider were also analyzed, but to a lesser degree.*
Strategy #1: Addressing climate change through Port policies, plans, and guidelines

Adding climate change language to existing Port documents

Overarching Plans & Policies

Design Guidelines
## Strategy #2: Adding sea level rise analysis to Harbor Development Permit Process

### HDP Application

**Text insertion:**

<table>
<thead>
<tr>
<th>Sea Level Rise and Storm Surge Vulnerability Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: Guidance for Incorporating Sea Level Rise and Storm Surge into Port of Long Beach Harbor Development Permit (HDP) Applications is available upon request.</td>
</tr>
</tbody>
</table>

1. Using the Port Coastal Vulnerability Zone Map (found at the end of this application form), is the proposed project subject to temporary flooding and/or permanent inundation? Yes___ No___  
   If the answer to question 1 is YES, please answer the next three questions. If the answer to question 1 is NO, please skip the remainder of this checklist.

2. What is the potential maximum lifespan (functional working life) of the equipment and/or development (i.e., is the life of the asset or project over 15 years)? _____

3. Is there a risk that the asset could be damaged or its maintenance or operation disrupted if flooded? Yes____ No____

4. If you have considered potential adaptation or mitigation measures, please describe them here:  
   ____________________________________________  
   ____________________________________________  
   ____________________________________________  
   ____________________________________________
Strategy #2: Adding sea level rise analysis to Harbor Development Permit Process

Coastal Vulnerability Zone Map—36” SLR and 36” SLR + 100 year storm
Strategy #3: Piers A & B Study – Combined Impacts of Riverine and Coastal Flooding
Strategy #3: Piers A & B Study – Combined Impacts of Riverine and Coastal Flooding

Potential Impact (under extreme conditions)

Digital Elevation Model (DEM) of High/ Low Elevations and Major Pathways of Inundation

Potential Extent of Impact Based on Elevations of 10.6 feet-NAVD and 15.3 feet-NAVD
<table>
<thead>
<tr>
<th><strong>Strategy #4:</strong> Pier S Shoreline Protection</th>
<th><strong>Strategy #5:</strong> Pier S Substation Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Retrofit existing sea wall at the low-lying overtopping points at berths S100 - S101 to prevent overtopping and inundation, which would protect all land behind it including substations, Fire Station #24, and railways.</td>
<td>• Evaluation of multiple options: temporary/permanent barricade, raise, or relocate.</td>
</tr>
</tbody>
</table>
Strategies #4 and #5: Pier S Shoreline or Substation Protection

Strategy #4 – Focus on shoreline protection

16” SLR

Overtopped seawall

SCE Substation
Strategies #4 and #5:
Pier S Shoreline or Substation Protection

Strategy #5 – Focus on critical substation protection only

16-inch SLR

SCE Substation Study Area
Strategies #4 and #5: Pier S Shoreline or Substation Protection

Strategy #4 – Retrofit existing seawall

Planning level cost estimate: $1.1m
Strategies #4 and #5: Pier S Shoreline or Substation Protection

Strategy #5 – Temporary / permanent protection options

- Aquafence
- Steel sheet pile wall
- Tiger Dam
- Reinforced concrete cantilevered wall
Strategies #4 and #5: Pier S Shoreline or Substation Protection

Strategy #5 – Temporary / permanent protection options

- Aquafence
  - Planning level cost estimate: $250k

- Tiger Dam

- Steel sheet pile wall

- Reinforced concrete cantilevered wall
  - Planning level cost estimate: $1.1m
Next Steps

Near-term Recommendations – Next 5 Years

- Implement Strategy #1 – Addressing climate change impacts through Port policies, plans, and guidelines
- Implement Strategy #2 – Adding sea level rise analysis to the Harbor Development Permit process
- Assess potential for a near-term solution for Strategy #5 – Terminal Island substation protection to address temporary inundation. Alternatively, Strategy #4 – Protection of Terminal Island shoreline could be implemented, which would then protect all assets on Piers S and T.
- Continue to review and consider “future consideration” strategies based on climate impacts and need.
Next Steps

Long-term Recommendations – 5 to 20 Years

✓ Review latest climate science and, if necessary, update the CRP
✓ Implement Strategy #4 – Terminal Island shoreline protection (if not already implemented).
✓ Continue to review “future consideration” strategies based on climate impacts and need.
Lessons Learned

• Timing is important – don’t wait for the best data
• Sensitivity to vulnerability among Port tenants must be considered
• Collaboration with local agencies, organizations, academia is/will be important
• Staff input/support is essential
• There may be multiple adaptation options which require careful assessment
• Extreme weather events help highlight the potential impacts
• Adaptation is crucial

August 2014 - Hurricane Marie