Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI

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16. Abstract

The "Stakeholder vulnerability and resilience assessment of maritime infrastructure" served to investigate resilience at the Port of Providence and to stimulate dialogue around long-term planning. The Port of Providence, defined here as the Providence and East Providence waterfronts between the Hurricane Barrier and Fields Point, does not have a centralized planning body such as a port authority to plan for long-range climate change resiliency. Maritime transportation serves a critical role in the Rhode Island economy, providing energy products, raw materials, and revenue from scrap metal and other exports. Using the hurricane scenario and accompanying visuals to focus the conversation, port stakeholders described what they viewed as potential consequences and concerns for weeks, months, and years after the event. The researchers developed long-term resilience concepts to help workshops participants deeply consider the implications of Protect, Relocate, Accommodate, and Do Nothing strategies. The Protect scenario reduces storm risk by decreasing the probability of occurrence of impacts. Results suggest stakeholders agree that resilience planning could greatly reduce cost to the public and private sectors in Rhode Island and that there is a distinct need for leadership around this critical issue. The port community should create a new collaborative partnership to more directly address the issues of storm resilience planning. The stakeholders also supported further investigation into the costs and benefits of a new storm barrier to protect the entire Providence Harbor area. Port of Providence stakeholders felt concerned about these issues, but the current leadership vacuum leaves the transportation network, the community, and the private sector vulnerable.

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Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI

Table of Contents

Table of Figures

Table of Tables

Table of Appendices

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Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI

Executive Summary

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The *Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI* investigated resilience at the Port of Providence (Rhode Island) in order to stimulate dialogue around long-term planning. Results suggest stakeholders agree that resilience planning could greatly reduce cost to the public and private sectors in Rhode Island and that there is a distinct need for leadership around this critical issue.

The Port of Providence, defined here as the Providence and East Providence waterfronts between the Hurricane Barrier and Fields Point, does not have a centralized planning body such as a port authority to plan for long-range climate change resiliency. Maritime transportation serves a critical role in the Rhode Island economy, providing energy products, raw materials, and revenue from scrap metal and other exports. The Port of Providence supplies Connecticut, Massachusetts, and Rhode Island with petroleum products and handles bulk and break-bulk cargo totaling approximately 3.1 million tons (2010). Numerous ancillary businesses depend on the port's functionality, including trucking companies, rail service, manufacturing companies, ship repair facilities, marine pilots, and dredging companies, generating more than $200 million in economic benefits for the region and over 2,400 jobs.

Since the flooding from a major storm and associated damage will cause both short and long term disruptions in the state economy, public and private sectors have a significant stake in assessing proactive measures to avoid post-storm decline. Researchers at the University of Rhode Island (URI) assessed perceptions of port stakeholders through surveys, interviews, and a half-day workshop. They facilitated dialogue with key stakeholders using three tools 1) a storm scenario with local-scale visualizations, 2) three long-term resilience concepts, 3) and a decision support tool called *Wecision*. During the resilience workshop researchers used the modeling program *SLOSH* to develop detailed images demonstrating the inundation risk from a hurricane making landfall near the Port of Providence during a high tide and producing a 21-foot storm tide. The modeling showed that, of the 573 land acres in the study area, 490 acres (86%) would be inundated with water, affecting all waterfront businesses and the connecting land-transportation arteries. Repercussions of the flooding include Terminal Road, Allens Avenue,

and the on-ramp for Interstate-95 becoming impassable due to 9 to 12 feet of water, a submerged section of railway, and a significant debris field.

Using the hurricane scenario and accompanying visuals to focus the conversation, port stakeholders described what they viewed as potential consequences and concerns for the weeks, months, and years after the event. Stakeholders noted that loss of critical utilities (electric, water, telephone) in the weeks after the storm scenario event could cripple business, as well as have serious impacts on both Rhode Island Hospital and wastewater facilities, both of which are located nearby. Debris was characterized as having three distinct impacts: cleanup costs, obstructions to roads and navigation, and the potential for large objects to have a "battering ram" effect during the storm itself. Storm damage to road and navigation infrastructure could take months to repair, leading to disruptions in commerce. Stakeholders also noted bulkhead failure as a concern, which could lead to release of hazardous materials.

The researchers developed long-term resilience concepts to help workshops participants deeply consider the implications of *Protect, Relocate, Accommodate,* and *Do Nothing* strategies. The *Protect* scenario reduces storm risk by decreasing the probability of occurrence of impacts. To do so, it proposes relocating the existing Hurricane Barrier to a new location, south of Fields Point. *Relocate* also known as retreat, reduces risk by limiting the potential negative effects by moving structures away from the flood-prone area. The *Accommodate* concept proposed investment in a suite of strategies that would allow businesses to remain in place, but enhance resilience through upgrading, hardening, elevating, and flood-proofing infrastructure and buildings. Alternatively, the *Do Nothing* strategy would leave resilience levels as-is, resulting in the impacts identified by stakeholders in the "storm scenario" exercise.

The third tool researchers used in the workshop, *Wecision*, enabled stakeholders to weigh in on their preferences for various resilience goals (including ensuring business continuity, minimizing damage to infrastructure, minimizing damage to the environment, building public support for resiliency measures, minimizing insurance rates, fostering port growth, and protecting human safety). *Wecision* then helped experts assess the resilience strategies (*Protect*, *Relocate*, *Accommodate*, or *Do Nothing*) according to how well these strategies best met the identified resilience goals. Finally, *Wecision* aggregated the stakeholders' preferences on goals with how well each resilience scenario met each of seven goals to identify which strategies provided the greatest value to each stakeholder group. Results of the exercise showed that participants felt that the *Protect* scenario, of moving the hurricane barrier south of Fields Point, best met their seven goals, followed by *Relocate*, then *Accommodate*, and finally *Do Nothing.* Participants felt that the state government was most responsible for leading, funding and implementing resilience planning. While all agreed that the *Do Nothing* scenario was the least attractive option, *Do Nothing* is the current approach for long-term resilience planning.

Through the *Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure* workshop, researchers established the severity of a plausible hurricane in Providence and measured the consequences of such a storm on the transportation network of

the region. Though the workshop did not, by design, result in a concrete decision for action or specific plan, it represents an example of a pre-planning exercise necessary to lay the groundwork for future decision-making in the face of climate change related hazard events.

Six months after conducting the workshop, the researchers surveyed the stakeholders again to ascertain their favorability to the response scenarios (*Protect*, *Relocate*, or *Accommodate*). Overall, respondents most supported the *Accommodate* strategy, with "government" representatives, in particular, favoring it. Respondents representing "private business" had greatest support for the *Protect* strategy, which would include the construction of a new storm barrier south of Fields Point. Both government and business respondents felt that a new public/private collaboration, with strong leadership from the state, should take leadership responsibility for implementation of resilience measures. Results suggest that stakeholders see public-private informal collaboration as the best choice for implementing resilience. These results indicate that stakeholders think that the state should form and lead a collaboration to implement incremental, accommodate-like, strategies, in the short-term, focusing on sea level rise impacts, while considering long-term, protect-like strategies, for future hurricane impacts.

Specific recommendations emerging from this workshop methodology development include:

- Exercises that engage all stakeholders in long-range thinking around resilience serve as a critical first step toward good planning. **Workshops such as this should be conducted with different audience and in different transportation hubs around the state** (e.g., Galilee, Davisville, Newport).
- RIDOT should work with port stakeholders to **identify a lead agency for resilience planning**, beginning with convening an *ad hoc* group to determine next steps.
- The costs to the private and public sectors of a major hurricane hitting the Port of Providence are not well understood. **An in-depth study of the direct and indirect economic costs, as well as environmental implications, of a hurricane at the Port of Providence is critically needed**.
- Pursue further **research on the costs and benefits of large-scale changes to the waterfront to project from storms and sea level rise**. In particular, the concept of constructing a new hurricane barrier to protect the Port of Providence should be further developed and explored.
- **Maritime businesses need assistance in identifying and implementing "low-hanging fruit" resilience strategies.**

Shipping lines will turn to ports that are quick to return to business as usual after hurricanes. The state of Rhode Island and cities of Providence and East Providence can approach the challenges of storm resilience and climate change as a business opportunity: the inclusion of resilience planning in economic development is a business decision that will likely pay off. Stakeholders can also undertake individual actions to build resilience. For example, RIDOT could anticipate and pre-contract for debris removal that would result from a hurricane, or

businesses could implement data backup mechanisms to get them back up and running more quickly after a storm. Currently, the costs of a major storm to the State of Rhode Island are not well understood. The port community should create a new collaborative partnership to more directly address the issues of storm resilience planning. The stakeholders also supported further investigation into the costs and benefits of a new storm barrier to protect the entire Providence Harbor area. Port of Providence stakeholders felt concerned about these issues, but the current leadership vacuum leaves the transportation network, the community, and the private sector vulnerable.

Acknowledgements

Many thanks to the many port stakeholders who participated in this project on the steering committee and in the workshop. Thanks also to our graduate research assistants Eric Kretsch and Duncan McIntosh, seniors in Landscape Architecture Brian Leverriere and Emily Humphrey, and student volunteers at the vulnerability and resilience workshop Julia Miller (URI Coastal Fellow), Nicole Andrescavage, Zaire Garrett, Peter Stempel, and Emily Tradd. John Haymaker developed the *Wecision* tool utilized in this project.

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Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI

Final Report

Introduction

The purpose of the *Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI* was to: 1) help Rhode Island intermodal infrastructure stakeholders understand the potential impacts from hurricanes, and 2) facilitate dialogue that will ultimately lead to a more resilient port system. With funding support from the RI Department of Transportation (RIDOT) and the Federal Highway Administration (FHWA) and in coordination with the State Freight Plan Working Group, this one-year project assessed the stakeholder perceptions of vulnerability for the state's major maritime transportation infrastructure at the Port of Providence (Rhode Island), as well as their recommendations for long-term risk-reduction strategies. The project focused on the Port of Providence, defined as the water-dependent uses from Fields Point to the Hurricane Barrier, to develop and test a method for assessing vulnerability and stimulating resilience dialogue that can subsequently be used at other sites throughout the State.

Climate change has long been acknowledged as a "wicked problem" for planners and policy makers (Lazarus, 2008). The uncertainties in rates of climate change and lack of incentives for building resilience can leave decision-makers unsure as to which adaptation option(s) to pursue, on what timescale, and how to pay. Eventually, many communities will be forced to adopt so-called "transformational adaptation" strategies such as the construction of major new infrastructure, the reorganization of vulnerable systems, or changes in their locations (R. W. Kates, Travis, & Wilbanks, 2012). Such strategies can take decades or more to plan, design, reach consensus around, fund, and ultimately implement (Savonis, Potter, & Snow, 2014). Before any meaningful decisions on climate change resiliency can be made, however, a shared understanding of risks, consequences, and options must be generated and allowed to percolate through the decision making system to those who deal with such issues

This report presents results from a pre-planning exercise that engaged 30 Port of Providence stakeholders in storm vulnerability and dialogue about transformational approaches to hazard risk mitigation. The research group piloted the following three tools to initiate thought around long-term hazard resilience challenges for the port: 1) a storm scenario with local-scale visualizations, 2) long-term resilience concepts, 3) and a decision support tool called *Wecision*. This report describes the background, methodology, and key findings from the project.

Wicked Problems in Port Planning

Marine transportation is an integral part of the United States economy. Moving cargo by sea enables globalization and international trade. Maritime shipping provides a cheaper alternative to rail and truck transportation. In 2012, U.S. ports facilitated 75% of foreign trade by weight

and approximately 50% of overseas trade by value (Chambers & Liu, 2013). In 2006, over 200 million tons of coal, 125 million tons of crude petroleum, petroleum products, and chemicals were shipped by sea. The U.S. port system supported over 13.3 million US jobs (American Association of Port Authorities, 2007). Ports accounted for $3.15 trillion to U.S. Gross Domestic Product (GDP) (American Association of Port Authorities, 2007). The state of Rhode Island depends on and benefits from this national and international trade facilitated by Rhode Island ports.

Ports are inherently vulnerable to natural disasters such as hurricanes because they are located on the coast. With climate change and warming ocean temperatures, storms are predicted to increase in intensity (Knutson et al., 2015), and sea-level is predicted to increase between one and two meters by 2100 (IPCC 2013). Vulnerability is defined as the degree to which physical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts (IPCC 2013). Resilience is defined as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including ensuring preservation, restoration, or improvement of its essential basic structures and functions (IPCC 2013). Resilience to hurricane events can be achieved not only through physical improvements to property, but also through planning, policy adaptation and by cultivating public support. Port design greatly affects port vulnerability, but economic, social, and political factors are also relevant. Port resilience strategies and vulnerabilities should be the focus of future planning efforts in order to lessen the future economic impacts to the state of Rhode Island.

Seaport systems face a unique combination of natural hazard risks within the environmental, social, economic, and political landscape. They consist of complex and interdependent public/private decision-making governance structures (T. Notteboom & Winkelmans, 2002; T Notteboom & Winkelmans, 2003), and their geographical and intermodal requirements constrain them to environmentally sensitive and exposed locations (Becker et al., 2013). Natural hazards associated with climate change, such as sea level rise (Parris & Knuuti, 2012; Strauss, 2013) and more intense hurricanes (Bender et al., 2010), threaten the system as a whole, as well as the individual organizations that depend upon the functioning of the system. Individual organizations and agencies often do not have the proper incentives or understanding of the system's interconnectedness to justify investment in long-term resilience (Becker & Caldwell, 2015). Despite the availability of impact assessment tools and established methods for stakeholder engagement in vulnerability assessment processes, overcoming barriers to resilience investments for complex systems such as ports remains a significant challenge due to conflicting timescales, institutional uncertainties, and lack of resources (Eisenack et al., 2014; Ekstrom & Moser, 2014; Tompkins & Eakin, 2012). Although progress has been made, particularly with respect to changes in residential land use and building codes (Melillo, 2014; WRSE 2014; USACE 2015), few actions have yet been taken to protect the complex system of ports and shipping that facilitate the nation's maritime-based freight economy (Becker, Inoue, Fischer, & Schwegler, 2012; Ng et al., 2016).While port operators acknowledge the important role that climate change will play in future operations (Becker et al., 2012; Becker, Matson,

Fischer, & Mastrandrea, 2014), there are still few examples of plans, let alone implementation of plans.

Historical Hurricanes in Rhode Island

The Ocean State is no stranger to hurricanes. Since 1851, 37 hurricanes have passed within 50 miles of Rhode Island (Rhode Island Emergency Management Agency, 2014), which corresponds to a 22.8 % chance of a hurricane approaching Rhode Island in a given year. Twice in the past century Providence suffered a near-direct hit, from the unnamed Hurricane of 1938 and Hurricane Carol in 1954. Monetary losses from hurricanes on Rhode Island were estimated in 2012 using NOAA's HAZUS-MH computer model by the Northeast States Emergency Consortium to equal annualized losses of over $134 million statewide (Geophysical Fluid Dynamics Laboratory/NOAA, 2013). The Hurricane of 1938 alone was responsible for an estimated $2.3 billion worth of damage (Geophysical Fluid Dynamics Laboratory/NOAA, 2013), 564 deaths, and storm surge of 15.8 feet at the Providence tide gauge.

Impetus for the Study

Decision-makers often find it difficult to engage in a dialogue about high-risk, low-probability, events. Complex, "wicked," challenges require new ways of knowledge production and decision-making that involve new collaborations between scientists from many disciplines and actors from the private and public sectors (R. Kates et al., 2001). Such collaborations, including government interventions, actions by private firms, and non-governmental organizations, enhance coping capacity and reduce vulnerability (Adger, Hughes, Folke, Carpenter, & Rockstrom, 2005). Preston et al. suggest that individuals and organizations can serve boundary-spanning functions, "dedicated to translating between social worlds, building trust and mutual accountability, and acting as experts in the process of making science useful" (Preston, Rickards, Dessai, & Meyer, 2013, p. 154). "Boundary work" addresses such complex problems (Batie, 2008) through a "negotiation support process engaged in creating usable knowledge and the social order that creates and uses that knowledge" (Clark et al., 2002, p. 4621). In the field of sustainability science, boundary work consists of products and processes (i.e., boundary objects or decision support tools) that bridge communities, stakeholders, and disciplines, and links knowledge to action. Such tools allow groups with different perspectives, backgrounds, or motivations to work together without prior consensus (Star, 2010). In the concept developed by Star and Griesemer (1989), boundary objects may be material objects such as maps, repositories such as a collection of books, performances, computer operating systems, or may take many other forms (Star, 2010). Such "boundary objects" have been shown to provide an effective way to jumpstart challenging dialogue and ultimately lead to co-production of resilience strategies and more successful policy and implementation of coastal management decision-making (Bryson, 2004; Chapin et al., 2010; Few, Brown, & Tompkins, 2007; Tompkins, Few, & Brown, 2008; Ward, 2001).

The stakeholder vulnerability assessment created a boundary-spanning process using three boundary objects to facilitate knowledge exchange around storm resilience strategies by port

stakeholders (Liverman & Raven, 2010). The project created a forum for engagement and participation, an essential component of adaptation to climate change (Eakin & Luers, 2006; Wilbanks & Kates, 1999) at the local scale that is aligned to management decisions (Cash & Moser, 2000). In the Port of Providence case, there was no clear management decision to be made, thus the researchers considered the project a pre-planning exercise, which lays the groundwork for future decision-making around transformational adaptation to climate change and encourages individual businesses to make smaller investments on their own.

URI researchers working on the stakeholder vulnerability and resilience strategy assessment were guided by a steering committee comprised of state and federal representatives (Table 1). The steering committee guided the overall research agenda and identified port stakeholders included in the project. The steering committee vetted all materials used in conducting this research from survey and interview prompts to the workshop agenda. The research team facilitated the day-to-day research tasks, implemented the research design, and completed analysis.

Table 1 – List of steering committee members, titles, and affiliations.

The project's steering committee is comprised of government and academic representatives who guided the research objectives and design.

Name	*Affiliation*
Austin Becker (PI)	University of Rhode Island (URI)
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Melissa Long	Rhode Island Department of Transportation and Climate Change Committee
Julia Rosati	U.S. Army Corps of Engineers
Kevin Blount	U.S. Coast Guard
Chris Witt	Rhode Island Statewide Planning
Dan Goulet	Coastal Resources Management Council
Pam Rubinoff	URI Coastal Resources Center and Rhode Island Sea Grant
John Riendeau	CommerceRI
David Everett	Providence Dept. of Planning
Jeff Flumignan/ Bill McDonald	United States Maritime Administration
Eric Kretsch (Graduate Student)	University of Rhode Island

Study Area – The Port of Providence, Rhode Island

This stakeholder vulnerability and resilience strategy assessment pilot project focused on the Port of Providence (Figure 1), a small North Atlantic port in Rhode Island with high exposure to hurricanes, where stakeholders were likely to be familiar with storms, and where the research could prove relevant for their future planning efforts (Weiss, 1982). The Port of Providence is at risk for climate-related challenges, such as catastrophic storm surges and significant sea level rise (0.5 – 2.0 meters) over the next century (Sallenger Jr, Doran, & Howd, 2012; Tebaldi, Strauss, & Zervas, 2012). The Port of Providence includes waterfront lands in the Cities of Providence and East Providence. Though the state of Rhode Island has embraced climate adaptation planning in some of its policy and planning efforts (CRMC 2015; CRMC 2009; RISG 2015), little work has focused on the resilience issues facing the Port of Providence. Funded by the Federal Highway Administration (FHWA) and the Rhode Island Department of Transportation (RIDOT), this study brought 30 participants (herein called "the participants") together to develop methods that would engage the public and private sectors in a challenging, and potentially uncomfortable, dialogue around the risks from a major hurricane at the Port.

Figure 1 – The Providence Harbor study area

The study area represented by the red boundary, includes Interstate -195, businesses along Allen's Avenue and Shipyard Road, Save the Bay two waterfront terminals, and two terminal in East Providence.

There is no official port authority in Rhode Island and the State plays no direct role in managing port operations or centralized planning, though the State's coastal agency, the Coastal Resources Management Council, (CRMC) does regulate land use in the coastal area that the port occupies. Together the businesses that make up the Port of Providence[1] most closely resemble a private service port (PPIAF 2013). The Port of Providence supplies Connecticut, Massachusetts, and Rhode Island with petroleum products, and handles bulk and break-bulk imports and exports. Many businesses depend on the Port's functionality, including: trucking companies, Providence and Worcester Railroad, dredging operations, hospitals, institutions that use petroleum products for their power plants, manufacturing companies, marine pilots, and Rhode Island's T.F. Green International Airport, which depends on the Port for jet fuel. In 2010, the Port of Providence handled approximately 3.1 million tons of cargo (Fogarty & Ilacqua, 2010).

The study area for this project includes ProvPort, the main port terminal, and 23 other waterfront businesses and industries, which together, take up nearly 573 acres of waterfront in Providence and East Providence (Becker et al., 2010). ProvPort itself sits on nearly 105 acres of land that are owned by the City of Providence and operated by a five board member nonprofit organization, which contracts the services of Waterson Terminals LLC to operate and maintain the Port. ProvPort generated more than $200 million in economic benefits for the region and over 2,400 jobs were attributed to port activities in 2009 (PWWA 2010).

The Port is located at the northern end of Narragansett Bay, an ecologically sensitive estuary that provides breeding grounds for marine life in the region. The length and orientation of Rhode Island's Narragansett Bay, and its proximity to the Atlantic hurricane zone, make it susceptible to extreme storm surges from the southerly winds that are generated when a hurricane passes to the west of the Bay. As such, the Federal Emergency Management Agency (FEMA) considers Providence to be the "Achilles heel of the Northeast" (Rubinoff, 2007). A recent study estimates the hurricane return period for Rhode Island to be 24 years, with the "major" hurricane return period of 94 years based on historical data (USGS 2010). The most recent major storm, Hurricane Carol in 1954, produced 14.5 feet of storm surge in Providence. Most of the port lands in the study area are 3-10 feet above mean high water. A 25 foot hurricane barrier north of the port protects the downtown Providence area, but could result in higher storm-surge levels just south of the barrier at the port, as surge waters would accumulate in Providence Harbor instead of spreading throughout the low-lying region now protected inland of the barrier.

[1] More details on the study location and project methodology can be found at www.portofprovidenceresilience.org. The case location is also discussed in Becker et al 2015.

Existing Zoning and Government Regulation

State and local government land and water use zoning regulations shape both current and future uses of the Port of Providence. Zoning in the bay is reflective of riparian land uses. On both land and in the Bay, zones vary on a spectrum from open space and conservation to heavy industrial uses. Heavy industrial zones generally encompass uses that are incompatible with residential, recreational, or even some commercial uses due to safety, security, or environmental concerns. There are also mixed-use zones, where residential, commercial, and industrial may all be present.

The majority of the study area in the City of Providence is zoned "W3", meaning that only water-dependent heavy-industrial uses can be located along the waterfront (City of Providence, 2014). Water-dependent is defined as a use that relies directly upon proximity to water, such as oil imports and scrap metal exports; both uses rely on the water body to transport bulk products from ships to land or vice-versa. As of December 2014, Save The Bay, an environmental non-profit, and Johnson and Wales University (JWU) properties are now zoned I-2 (Educational Institutional District). Save The Bay is located within the study area, as it depends upon water access, while JWU is located just outside the study area, as it is not a water-dependent use (Providence Rhode Island, 2014).

The City of East Providence zones its waterfront through designations of Waterfront Sub-Districts. This study includes the sub-districts (south to north) of Kettle Point, Veteran's Memorial Park, and Bold Point Harbor (City of East Providence, 1998). Wilkesbarre Pier, operated by Capital Terminals, Inc., is located in the Bold Point Harbor sub-district. The Exxon Mobil Terminal, which is the only other maritime terminal in East Providence, is located south of Squantum Point. This terminal is not located in a sub-district, but is zoned I-2 for industrial uses. Descriptions of the waterfront sub-districts are below (City of East Providence, 1998):

- Kettle Point is a medium density residential, with ancillary commercial uses including restaurants, clubhouses, marinas and limited retail geared toward residents.
- Veterans Memorial Park is a medium density multi-family residential area along the Veterans Memorial Parkway frontage, with commercial and retail uses at the lower levels of the site, and marina uses at the waterfront.
- Bold Point Harbor is a mixed-use high density area of commercial, office, retail and high density multi-family residential uses. Hospitality uses, including hotels and lodging, cafes, restaurants, bars, and entertainment venues; marinas with limited support services; and water-transit related services are also permitted. Heavy commercial or industrial land uses are not permitted.

The Rhode Island Coastal Resources Management Council (CRMC) zones the State's waters according to water types that designate activities in the inland waters of Rhode Island (Figure 2). CRMC water type zones range from Type 1 (conservation area) to Type 6 (industrial and commercial navigation). Type 6 waters are designated for industrial waterfront activities or

commercial navigation. Waters surrounding the port are designated Type 6. The East Providence side includes Type 5 (recreational and commercial harbor area) and a portion Type 4 (multi-purpose waters). Wachemoket Cove is zoned Type 1 (Conservation) (Coastal Resources Management Council, Dec 2012). No Type 2 (Low Intensity Uses) or Type 3 (High Intensity Boating) are located within the study area boundaries.

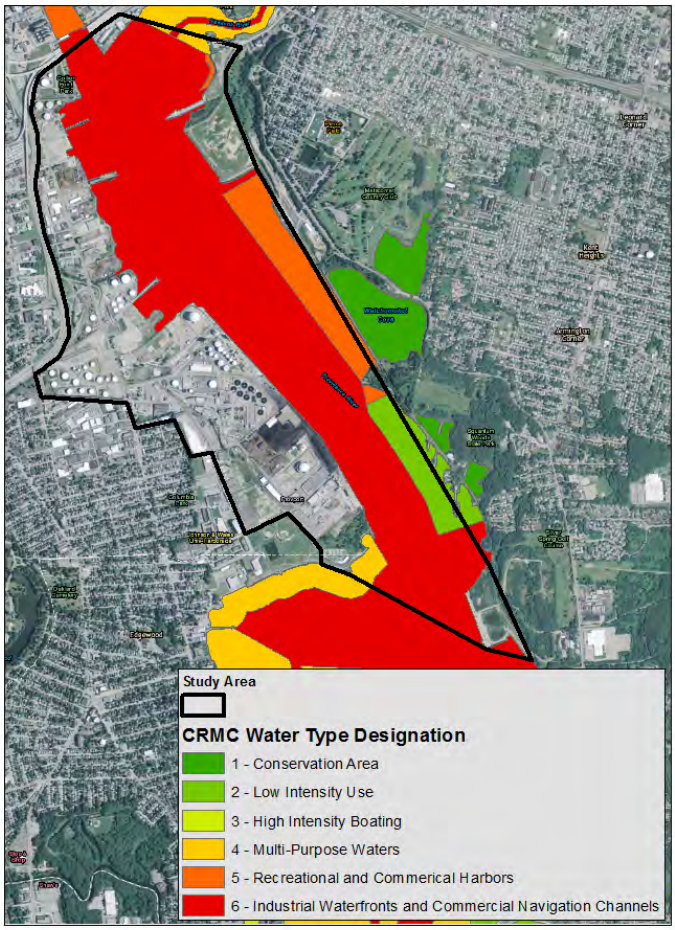


Figure 2 – Water type classifications

Coastal Resources Management Council (CRMC) water type classifications designate water uses and adjacent land uses. This figure shows the water type classifications in Providence Harbor.

Pre-Workshop Interview Results

The stakeholder vulnerability and resilience strategy assessment project began with pre-workshop interviews of representatives from water-related businesses operating within the study area, in order to gain background information about their business practices. Interviews focused on the role of transportation infrastructure to port stakeholders, current business resilience practices, and recruiting businesses for the workshop. The research team contacted 26 businesses identified through steering committee connections that operated within the port area and interviewed 15 representatives consisting of facility managers, presidents, CEOs, vice-

presidents, directors, chief-engineers, and public relations officers. Eleven businesses declined or could not find time available to participate in the interview. Interview sessions were between 30 minutes and an hour, and consisted of 21 questions and four sub-questions (Appendix 1). Representative names and organizations are kept confidential by the URI research team.

Port Businesses Background Data

The data provided in this section does not reflect all port business, but is limited to the 15 (of 26) interviewed at the start of the project. This data was used to tailor the research design and workshop methodologies so that the information gathered and conversations conducted were beneficial not only to RIDOT and URI researchers, but also to the Port of Providence business stakeholders.

Results show that port businesses have a long history of operating in Providence Harbor. Five businesses were established before the Hurricane of 1938, while one business was established between 1938 and Hurricane Carol in 1954. Four businesses were established after 1954 and four businesses did not know or did not provide a response. All businesses reported the expectation to operate in their current location for the next 10 years or more.

Eleven businesses reported owning their property and six reported their operations as independently operated. Seven businesses stated they have 1 to 19 employees, five businesses stated 20 to99 employees, and two businesses reported over 100 employees. One business representative was unaware of the total number of employees. Based on participant responses total employment of the businesses interviewed is between 600 and 2000 workers.

Researchers asked representatives to state the products that their operations handle within the study area. Most handle bulk or break-bulk products, seven businesses reported handling petroleum products including diesel, home heating oil, gasoline, jet fuel and others, while four businesses reported handling other energy products. One port business reported handling specialty items, including wind turbine parts used to build the Narragansett Bay Commission's three wind turbines. Port terminal operators handle no liquefied natural gas (LNG), but National Grid, Rhode Island's electricity and gas utility, operates a LNG peaking facility within the study area, which stores gas piped in from LNG terminals in Connecticut and New York State.

The Narragansett Bay Commission operates the Field's Point wastewater treatment facility located at the Port. This facility serves the metro-Providence area. Save The Bay, headquartered within the port area, offers educational boat tours to thousands of people each year.

The researchers asked business representatives to identify distribution and supply markets for their businesses and numerate what percentage of their products travel to different markets. Distribution markets are defined as the end location, and supply market as the starting location for the handled products within five areas (Providence Metro, Rhode Island excluding

Providence Metro, New England excluding RI, National excluding New England, and International) (Figure 3a, 3b).

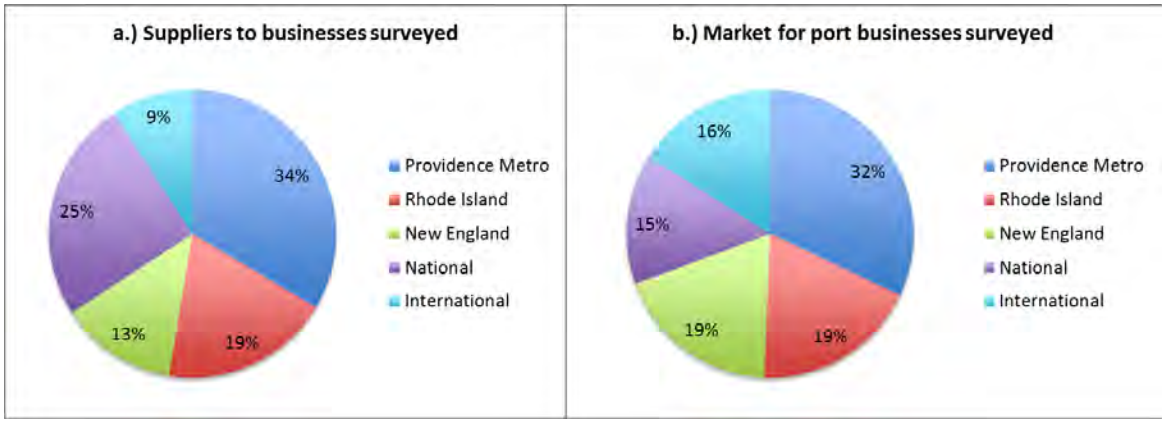


Figure 3a, 3b – Suppliers and market for port businesses

a.) Majority of the products supplied to port business originates in the Providence Metro area; however, port businesses receive products from a diverse set of locations. b.) Many of the products sold from port business also end up in the Providence area, but once again, port businesses' sales are

Nine businesses have more than 100 unique customers (individual purchasers), while 12 stated that 100 or more businesses rely on their services. This suggests a sizeable supply chain effect if port businesses were impacted, with port products reaching many customers and businesses beyond the port.

Transportation Infrastructure Dependence

Researchers asked port businesses about their use of specific transportation infrastructure, including access to the 40-foot deep shipping channel, road infrastructure, including Allen's Avenue and Interstate-95, and the Providence and Worchester Railroad (Figure 4). Save The Bay, though not an industrial use, is also water-dependent as it brings students and the public on boat rides for educational purposes. According to participant responses, annual vessel calls per business range from 15 to 250 per year. At least one representative stated if the 40-foot channel were lowered (to 30 feet or 20 feet) business could be facilitated with smaller ships, but at a higher cost. Businesses reported a dependency on road infrastructure (including Allen's Avenue and the entrance to I-95). Five businesses reported not being able to do business without rail, while eight stated they do not depend on or could find an alternate method to rail. Two businesses found that this question was not applicable due to the fact that their main operations were not located at the port.

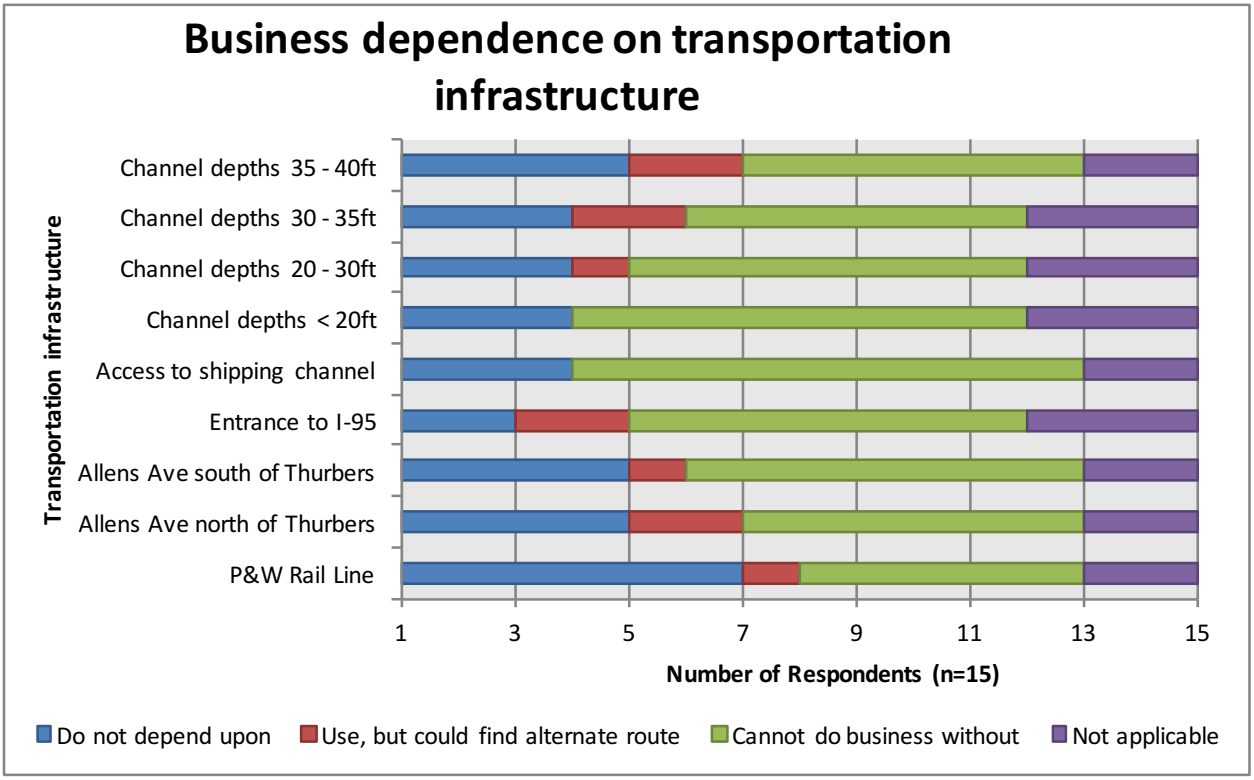


Figure 4 – Business dependence on transportation infrastructure

Transportation infrastructure dependence: 9 out of 15 businesses interviewed state that they could not do business without access to the 40-foot-deep shipping channel.

Port Business Resilience Practices – Baseline Study

Businesses are aware of many of the risks posed by hurricanes. As stated previously, six businesses interviewed were in existence during at least one of the last two major RI hurricanes (the 1938 Hurricane and Hurricane Carol in 1954). Thirteen participants had direct experience preparing a facility for a hurricane and eight attended at least one hurricane preparedness training in the last five years (one reported having had no experience, and six responded "did not know"). Business representatives reported participating in a range of 2 to 20 disaster-related trainings in the last five years, though the survey did not ask specifically about who sponsored these trainings.

Researchers asked business representatives to review a list of preparedness strategies and report the status of implementation at their facility by choosing one of five status categories: *not applicable*, *unable to do*, *not done*, *plan to do*, and *have done*. Preparedness strategies (Becker et al., 2012; Howe, 2011; Mansouri, Nilchiani, & Mostashari, 2010; Wasileski, Rodriguez, & Diaz, 2011; Webb, Tierney, & DAhlhamer, 1999) include:

- Backing up computer data
- Attending a meeting on hurricane preparedness
- Developing a disaster recovery plan

- Taking action to flood-proof or wind-proof facilities
- Setting up an emergency generator for use if electric power fails
- Raising electrical system components above Hurricane Carol storm surge level of approximately 15 feet
- Creating pre-storm service agreements to facilitate rapid cleanup
- Conducting emergency drills and training for hurricanes
- Creating hazardous materials spill recovery plan
- Conducting port structure stability analysis in compliance with FEMA guidelines
- Conducting a site-level analysis to understand potential inundation areas for various storm events
- Identifying off-site locations to store equipment or products in the event of an impending hurricane
- Initiating pre-storm agreements with vendors or customers to minimized business continuity interruptions
- Relocating businesses to a less vulnerable location
- Elevating property above a Hurricane Carol type of storm surge of approximately 15 feet

Participants reported that 10 of the 15 strategies have been implemented by at least seven of the businesses, leaving five strategies that have not been widely implemented at port area businesses (Figure 5). Only three strategies have been implemented by more than 11 businesses, suggesting that there are many strategies that could be focused on in the short-term to improve storm preparedness. The results also offer a baseline for post-workshop comparison.

Figure 5 – Resilience strategies practiced (pre-workshop)

Most business have backed up computer data, attended a meeting on hurricane preparedness, and identified and off-site location to store equipment or products; however, business have in general not created pre-storm service agreements to facilitate rapid clean up and raised electrical systems above storm surge levels (~15ft).

Vulnerability Assessment Workshop

This study partnered researchers from the University of Rhode Island with representatives of local, state, and federal government and the private sector to develop a process and test three tools. An expert steering committee made up of 12 state and federal agency representatives helped guide the research process. It culminated in a workshop on August 6, 2015, with 30 participants who represented 15 local maritime port-related businesses, three local planning departments, five state government agencies, four federal government agencies, and two academic or environmental groups (Table 3). The project "integrated best available knowledge, reconciled values and preferences, and created ownership for problems and solution options," core concepts and design principles for trans-disciplinary sustainability research outlined by Lang et al. (2012, p. 25).

Table 2 – Workshop participants

Private Firms	***Local Government***
Sims Metal Management	Providence Emergency Management Agency
Moran Shipping	City of East Providence Planning
Providence Working Waterfront Alliance	City of Providence Planning*
Narragansett Improvement	***State Government***
McAllister Towing	RI Coastal Resources Management Council*
Exxon Mobil	RI Statewide Planning
Schnitzer Steel Industries	CommerceRI*
Rhode Island Oil Heat Institute	Narragansett Bay Commission
Quonset/Davisville Development Corporation*	RI Dept. of Transportation
FM Global	***Federal Government***
National Grid	US Maritime Administration*
Hudson Asphalts	Federal Highway Administration*
Capital Terminals	US Coast Guard*
Motiva	US Army Corps of Engineers*
Northeast Pilots	***Academia/NPO***
P & W Railroad	RI Coastal Resources Center/RI Sea Grant/GSO*
Waterson Terminal Services/ProvPort	Save the Bay
Capital Terminal Company	

Workshop participants included business, government, and non-profit organization members. (Asterisk indicates that the organization is also represented on the project steering committee.)

To develop the methodology, researchers met with the steering committee three times before facilitating the pilot workshop with participants in Providence, Rhode Island, and input from the steering committee was solicited throughout workshop development. Recorded agendas, notes, and minutes of these steering committee meetings may be found in Appendix 1C. Workshop objectives developed in partnership with the steering committee included:

1. Understand and comment on a possible storm scenario's consequences for the Port of Providence area.
2. Review long-range resilience goals for the port.
3. Review transformational resilience concept alternatives for protecting the port community against storm damage.
4. Weigh importance of resilience goals and assess the potential of resilience concepts to meet these goals.
5. Assess this workshop methodology as a way to measure the port's vulnerability and initiate discussion on long-range resilience concept alternatives.
6. Identify collective action to be discussed now and recommendations for the future.

The half-day workshop was designed to allow participants to interact with, react to, and contribute to three decision support tools developed for the project[2] through several activities. First, participants learned from a representative from the Port of New York/New Jersey about Hurricane Sandy's impacts on the port. Mary Lee Clanton, Deputy Manager of the Port Planning Division at the Port of NY/NJ was responsible for development of long-range capital projects for the maritime assets located at five port facilities in the Port of New York and New Jersey. Clanton presented information about Hurricane Sandy's impacts on port infrastructure and economic impact, and discussed future resilience planning at the Port of NY/NJ. Next, participants discussed consequences to port interests from a hypothetical Category 3 hurricane directly hitting the Providence area in the near future. Participants then evaluated and prioritized resilience goals for port businesses and explored four long-term resilience concepts. Using the online decision support tool called *Wecision*, participants then assessed the four concepts with respect to goals and identified which alternative concepts provided the most value to different participants.

Development and Implementation of Decision Support Tools

Storm Scenario and Consequences for the Port Area.

Visualizations of storm surge and sea level rise play an increasingly important role in decision-making processes. Realistic portrayals of future conditions, such as inundation zones, help people localize and understand what are otherwise very abstract concepts (Lowe et al., 2006; Sheppard, Shaw, Flanders, Burch, & Schroth, 2013). When compared to traditional abstract maps, realistic visualizations can better communicate complex and nuanced information in a

[2] Workshop materials, including graphics and more information can be found at the project website: www.portofprovidenceresilience.org.

mode which humans have evolved to understand: imagery of the landscape. Since realistic visualizations create affective (emotional) responses on the part of the viewer, they may be more effective tools for communicating risk (Sheppard, 2015). Research has shown that cognitive understanding of risk alone may create misperceptions of risk when not aligned with an emotional response, thus this project utilized realistic visualizations as a tool for risk communication (Slovic, Peters, Finucane, & MacGregor, 2005).

To stimulate thinking about long-term risk, the researchers created a scientifically-credible Category 3 hurricane scenario based on historical data and a Sea, Lake and Overland Surges from Hurricanes (*SLOSH*) (NHC 2015) model analysis (Figure 6). Using GIS and Google Earth, the researchers produced 3D visualizations of a 21-foot storm surge showing inundation levels along the Providence waterfront from the Fox Point Hurricane Barrier, south to Fields Point, including the East Providence waterfront. Three dimensional images of specific properties along the waterfront from a number of perspectives and a flyover video allowed participants to see details of properties of concern to them. In small groups, participants reported out on the potential cascading consequences of this event in the weeks, months, and years after the event, as well as their top concerns. Participants were instructed to focus on long-term consequences, as opposed to what might happen on the day of the event.

Hurricane Effects on Upper Narragansett Bay

Destructive forces of hurricanes are threefold: wind, rain, and storm surge, but by far the most powerful and destructive threat to coastal areas is from the abnormal rise in water caused by pressure and wind forces, known as storm surge. As a hurricane spins over the open ocean, its extreme low pressure allows a dome of water to rise directly beneath the storm, in what is known as the *inverted-barometer effect*. This effect can raise the level of the sea beneath the storm by as much as one centimeter cm for every one 1 mb drop in pressure. The majority of storm surge is driven, however, by winds which, via friction, transfer energy to the ocean creating currents in the direction of the wind that penetrate deep (100s of feet) beneath the surface. As the storm approaches land, the deep currents are pushed upward by the decreasing depth, creating an abnormal rise of water most pronounced on the east (in the Northern Hemisphere) or right side of the storm – first by the continental shelf, then more dramatically by the local bathymetry as the storm surge reaches the coast. Storm surge is also driven by the forward speed of the storm, which may arrive ahead of the storm itself, and can last between 6 and 12 hours in duration, depending on the speed of the storm. In the case of Narragansett Bay, the wide, south-facing opening allows the surge to funnel into the Bay and pile up at the head of the bay, creating the potential for the most extreme storm surge heights at the north end, or head of the bay. The actual water level experienced at the coast will be a combination of the storm surge and the normal local tide cycle, known as the storm tide, with wind-driven wave action on top of this level.

While uncertainty remains in predicting how climate change will affect hurricane frequency, climate models agree that the Atlantic basin will see an increase in hurricane wind speed and

rainfall rates, with wind speeds approximately 4% stronger for every 1° C increase in sea surface temperature, and a model-projected rainfall increase near 20% by 2100 (Geophysical Fluid Dynamics Laboratory/NOAA, 2013).

Hypothetical Category 3 Hurricane Scenario

The researcher team created a storm scenario to help participants consider both the cascading consequences of a Category 3 type of storm event, as well as the effectiveness of various resilience strategies. Based on historical evidence, our extreme yet plausible storm scenario consists of a hypothetical Category 3 (111-129 mph) Hurricane "X" traveling north at 40 mph, and approaching Rhode Island from the south on 3 August 2015 at 11:00 am with a high tide. For the Northeast U.S., a Category 3 Hurricane has a return period of approximately 60 years (Ginis, 2006), or a 1.7% chance of impacting the region in a given year. Hurricane "X," represents a 'direct hit' for Providence and represents a storm comparable to the 1938 hurricane, but shifted approximately 80 miles east or comparable to Hurricane Sandy had Sandy not taken its famous 'left-hook' into New Jersey. Hurricanes produce damages from three components: wind, rain, and storm surge. As a Category 3, Hurricane "X's" winds would be expected to cause "devastating damage," according to the Saffir-Simpson wind scale (Table 3).

Table 3 – Saffir-Simpson Scale

Category	Winds (mph)	Destruction
1	74-95	Very dangerous winds will produce some damage
2	96-110	Extremely dangerous winds will cause extensive damage
3	111-129	Devastating damage will occur
4	130-156	Catastrophic damage will occur
5	>157	Catastrophic damage will occur

The National Hurricane Center uses the Sea Lake and Overland Surges from Hurricanes (*SLOSH*) to forecast storm surge in real time when a hurricane threatens. *SLOSH* solves the governing set of fluid dynamics physics equations over a grid that represents the bathymetry of a particular "basin of interest." The parameters of a storm's atmospheric pressure, size, forward speed, and track data are input to create a model of the wind field which drives the storm surge. Hindcast analyses of *SLOSH* accuracy has found *SLOSH* to be accurate to within 80%, and for surge

forecasts of over 12 feet, model errors have been found to be less than 2 feet 79% of the time given best input parameters (Glahn, Kurkowski, & Shaffer, 2009).

To model the surge for our hypothetical Hurricane "X," researchers used *SLOSH* Display Program (v. 1.67). Using the pv2 basin, we modeled the Maximum Envelope of Water (MEOW) for the following parameters; direction = North, Category = 3, Speed = 40 mph, Tide = High (5ft) Tide. These parameters yielded a MEOW of approximately 21 feet above the NAVD-88 elevation at the Port of Providence. This storm tide height lies at the threshold of the design criteria for the Fox Point Hurricane Barrier, and represents the maximum surge the barrier was designed to withstand before overtopping. About 86% (490 acres) of the study area would be inundated by at least one foot of water in this scenario.

While *SLOSH* is computationally efficient, able to resolve flows affected by barriers, gaps, and passes, and capable of reproducing Kelvin waves resulting from coastal reflective processes, it does not explicitly model the impacts of waves on top of the surge nor does it account for normal river flow or rain flooding. Although researchers for this project did not model the rainfall from the hypothetical storm, a statistically similar storm, the 1938 hurricane, produced 10 – 17 inches of rainfall across the Connecticut River Valley, causing some of the worst flooding ever recorded in that area. Similarly, wave heights were not modeled for this project. However, U.S. Army Corps of Engineers' North Atlantic Coast Comprehensive Study (NACCS) coupled wave and current models (ADCIRC and STWAVE) to produce simulated wave heights for a 100-year event in the North Atlantic Ocean basin. The models indicate that Port of Providence could expect 6 – 10 foot waves from such an event.

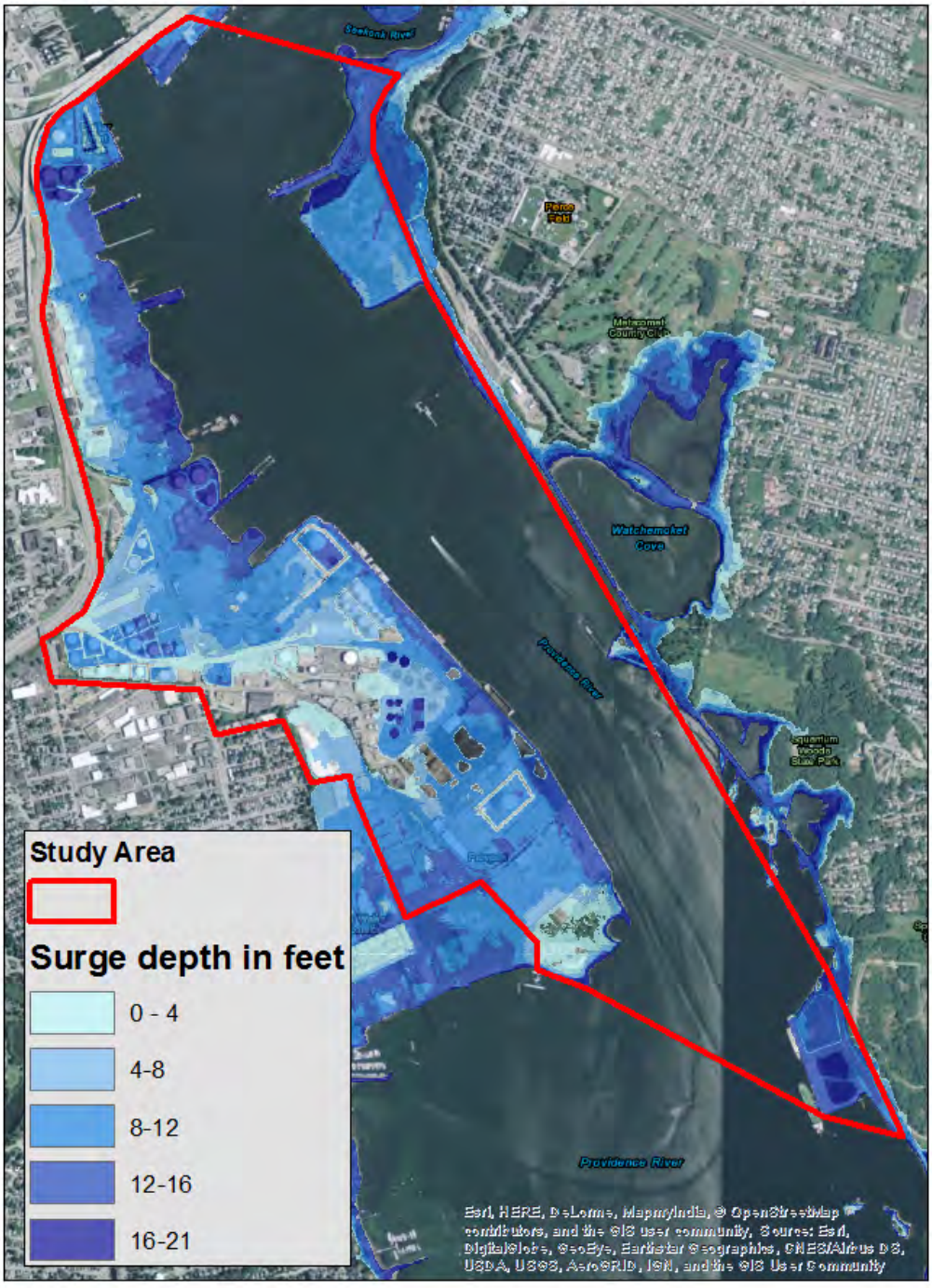


Figure 6 – Results of *SLOSH* model showing 21 foot storm surge in Providence Harbor.

Image with results of a SLOSH model showing a 21 feet storm surge in the Providence Harbor. The northern portion of the port is heavily inundated by water and 86% of the study area has at least one foot of water over it.

Figure 7 – 3D storm visualization of Motiva Enterprises Terminal on the west side of Providence Harbor looking north (Image: R. McIntosh).

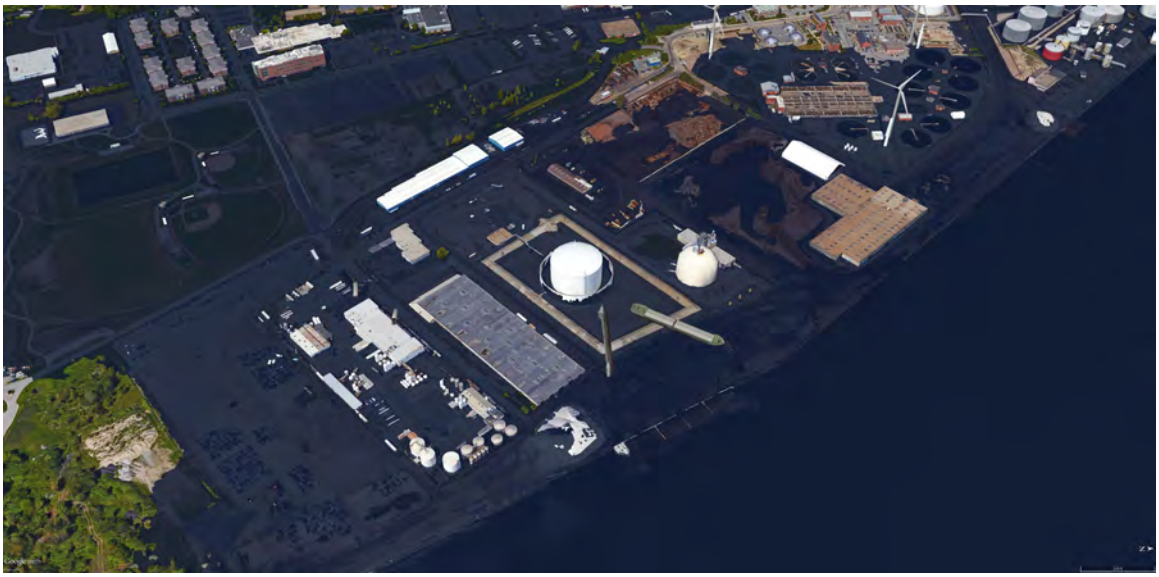


Figure 8 – 3D visualization ProvPort on the west side of Providence Harbor looking west (Image: R. McIntosh and B. Laverriere).

Figure 9 – 3D storm visualization of Sprague Energy on the west side of Providence Harbor looking northeast toward the Eastside of Providence (Image: R. McIntosh)

Workshop discussion on impacts from storm scenario

In small groups, participants reported out on the potential cascading consequences of this hypothetical storm event in the weeks, months, and years after the event, as well as their top concerns. Participants were instructed to focus on long-term consequences, as opposed to those of concern on the day of the event.

Weeks following event

Participants noted that loss of critical utilities (electric, water, telephone) in the weeks after the storm scenario event could cripple business, as well as have serious impacts on both the hospital and wastewater facilities. In particular, they noted that Rhode Island Hospital's back up energy supply, stored within the flooded area, would become inaccessible. Participants expected environmental impacts from raw wastewater discharge and possible spills from oil and chemical storage facilities. These impacts, they noted, could linger for months or years following such an event.

Debris proved to be a top concern, both in terms of cleanup and the damage that debris would cause to port infrastructure. Debris includes trees and branches, construction materials from destroyed structures, ships and boats, docks, tanks, and many other objects. Participants were conflicted on how much of a problem the scrap metal at Metals Recycling, Inc., might present as a potential source of debris. According to participant conversation, scrap metal reacted to salt water inundation during the 1954 hurricane, causing fires at the scrap metal facility at India Point in Providence. Debris was characterized as having three distinct impacts: cleanup costs,

obstructions to roads and navigation, and the potential for large objects to have a "battering ram" effect during the storm itself.

Months following event
Storm damage to road and shipping infrastructure could take months to repair, leading to disruptions in commerce. Debris in the channel, as well as displacement of navigational aids and sedimentation, would require extensive surveying and clearing before the port could be reopened for normal commerce. Participants also noted bulkhead failure, resulting in erosion due to a release of shored-up material as a concern. Bulkhead failures could result in permitting delays and lost business. Furthermore, as much of the land in the study area is brownfields, and contaminated with hazardous material, a bulkhead failure or other erosion event could lead to release of hazardous materials. Erosion along the banks of the Seekonk River and Narragansett Bay could also contribute significant sediment loading, requiring dredging of the 40-foot navigation channel. Participants agreed that many of these impacts would have long-term effects on the port.

Years following event
Participants felt certain that the storm scenario would result in environmental impacts to Narragansett Bay for years after the event, and that economic impacts would be felt for years after the storm scenario. However, participants felt unsure of the magnitude of these impacts, nor the specific impacts of concern. One participant asked, "would our businesses be as attractive as they were before the storm?" There was also concern that port land would not be as marketable for new development if the port were perceived to be vulnerable to such catastrophic storm damages. Participants stated financing reconstruction was likely to have negative impacts on businesses and the State of Rhode Island.

Three Long-range Resilience Concept Scenarios

Scenarios have long been used to help people think about the future (Pulver & VanDeveer, 2009). Carbon emissions scenarios, for example, drive climate models that produce a variety of environmental conditions that may unfold over the next century and beyond (Melillo, 2014). Scenarios have also been used in visioning the future for business (Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005) and public processes around land use and comprehensive planning (Xiang & Clarke, 2003) to stretch people's thinking about a range of plausible futures. The project employed a form of scenarios to present three long-range resilience alternatives and help workshops participants deeply consider the implications of each.

In a semester-long studio class with students from the Landscape Architecture Department at the University of Rhode Island (URI) in Fall 2014, researches and students developed the three broad, long-term, archetypal concept scenarios for building resilience of the Port of Providence: *Protect*, *Relocate*, and *Accommodate* (Cheong, 2011; IPCC 2012; Tol, Klein, & Nicholls, 2008). The Landscape Architecture studio finished in December of 2014, and in January of 2015 a design team developed the resilience concepts used in the workshop. Over four months of

work, the design team developed the three long-term resilience concepts that could be implemented at the port. Each concept featured a different approach to resilience, defined in this study as "the ability to bounce back to normal operations after an extreme event," from a long-term planning perspective. This research used 2050 as the planning horizon, thus emergency response options (e.g., improvements to evacuation routes) were not included in the concepts. Naturally, any actual strategic approach would likely combine aspects of all three design concepts, but these concepts were meant to stimulate discussion and were, by necessity, simplified versions of what would inevitably be very complex projects. All three were expected to be cost intensive, and funding mechanisms were not discussed explicitly, as the purpose of the workshop was not to make a particular decision, but rather to begin the challenging dialogue about long-term resilience. Each concept included graphic representations and conceptual examples, as well as an overview of pros and cons developed together with the project steering committee (See Appendix 1), which offered suggestions about how to shape the concepts, as well as the overall advantages and disadvantages of each. All of this information was presented to workshop participants and included in handouts, followed by discussion. The following sections describe each concept in more detail.

Protect concept

The *Protect* concept reduces storm risk by decreasing the probability of occurrence of impacts (Tol et al., 2008). To do so, it proposes relocating the existing Hurricane Barrier to a new location, south of Fields Point, which would protect the Port of Providence area (Figure 10). The United States Army Corps of Engineers (USACE) constructed the existing barrier in the 1966 to protect the downtown Providence area (Morang, 2016), but it leaves maritime infrastructure in the study area exposed. The *Protect* concept envisions the construction of a new barrier and berm system, with a similar design to the Maeslatkering Barrier in the Port of Rotterdam, at Fields Point along the southern edge of the study area (for discussion of barrier options, see (Dircke, Jongeling, & Jansen, 2012; USACE 2013). The *Protect* design concept would span the mouth of Providence Harbor, tying into the existing elevation in Providence and East Providence. The floodgate could be closed in the event of a storm, effectively protecting Providence Harbor from forcing associated with hurricane level storm surge and wave action. When open, the gates would rest on dry docks on the east and west sides of the harbor entrance. To close the gates the arms would be floated so that they may swing closed to meet in the center of the channel. A multipurpose levee located along the shoreline incorporates an earth berm and green wall along the landside, and a living shoreline along the waterside. A pedestrian/bike path might run along the top of the levee, and bleachers could be located on a portion of the landward side for viewing the adjacent sports fields.

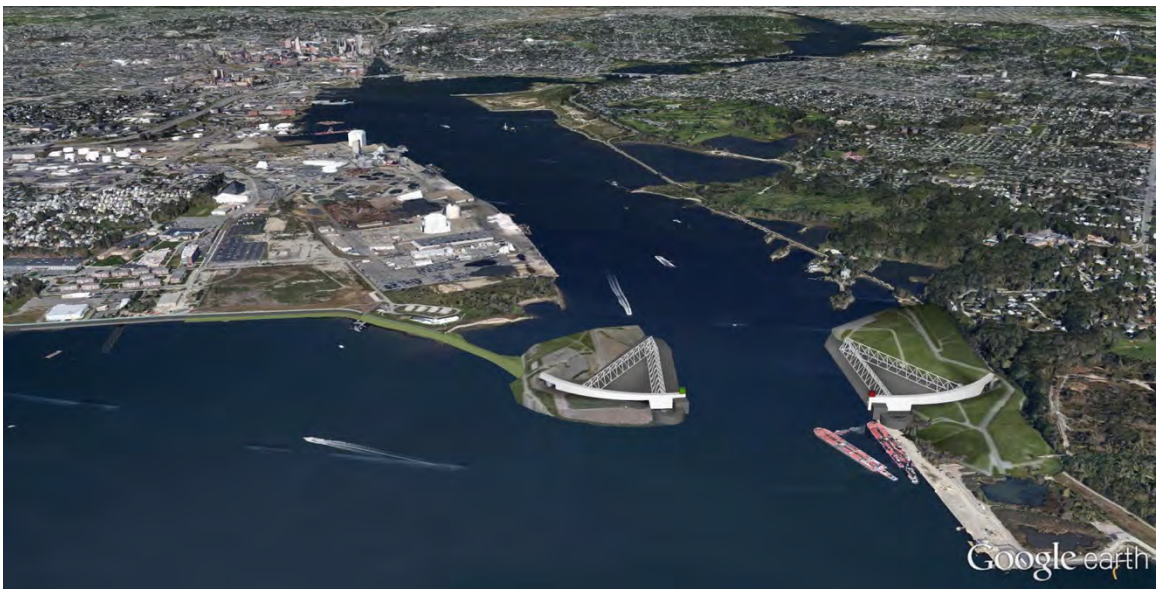


Figure 10 – The *Protect* concept

The Protect concept shows a new barrier located south of the study area at Fields Point. The design is based on the Maeslatkering Barrier in the Port of Rotterdam. (Image: URI Landscape Architecture)

Relocate concept

Relocate, also called "retreat" in climate change literature, reduces the impact of a storm event by moving structures away from the flood plain (Tol et al., 2008). Historically, relocation has occurred after an event, when structures are damaged, abandoned, and rebuilt in an area further from shore or more protected . Relocation may be more appropriate for non-water dependent uses such as residential housing, as opposed to water dependent coastal infrastructure. However, in some cases infrastructure such as lighthouses (e.g., Cape Hatteras Light in North Carolina) have been moved back away from an eroding bluff. The *Relocate* concept proposed moving some or all of the current industrial uses in Providence Harbor out of harm's way. It suggested that other locations around Narragansett Bay could provide a less exposed area from which to do business, while still providing the infrastructure requirements such as access to highway, rail, navigation channels, pipelines, to operate. The current Exxon Mobil petroleum facility in East Providence provided an example of such a location, where the berthing facility is located along the water's edge but the petroleum product is piped upland and stored in a tank farm located well away from the floodplain at an elevation of 50 feet (Figure 11).

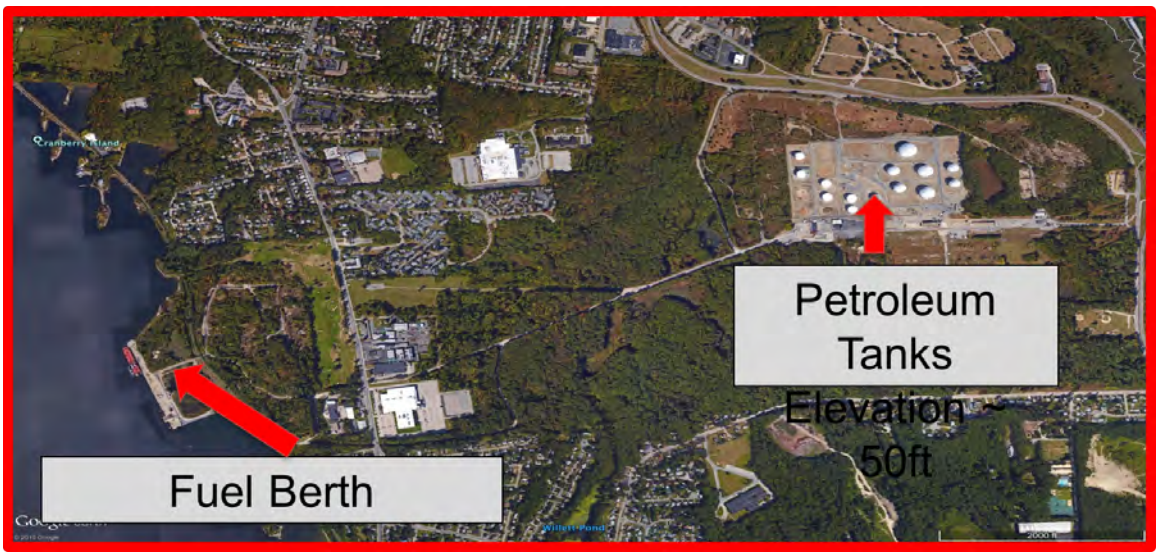


Figure 11 – The *Relocate* concept would move some or all existing uses out of the flood plain.

In this example, a petroleum terminal's tanks are located upland at elevation 50', while the berth remains at sea level. The product is piped from the berth to the tanks.

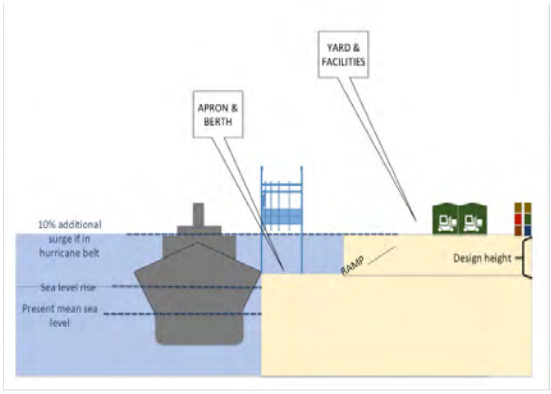
Accommodate concept

The *Accommodate* concept proposed a suite of strategies that allow businesses to remain in place, but enhance resilience through upgrading, hardening, elevating and flood-proofing infrastructure and buildings (see e.g., (MassPort, 2014) . Properties would be retrofitted to withstand significant flooding. Through smart planning and improved practices, debris impacts could also be limited, decreasing physical and environmental damage. The *Accommodate* concept proposed a major investment on a property-by-property basis (Figure 12). Options that were discussed included:

- elevating buildings
- constructing breakaway walls
- flood-proofing utilities
- creating floodable first floors
- elevating land under structures
- elevating critical utilities (e.g., power, water, sewer)
- raising backup generators, air conditioning units and oil or gas tanks above the base flood elevation or onto roof of building
- Flood-proofing building foundations
- using flood/salt-water tolerant construction materials
- sealing around utility entry points
- installing waterproof bulkheads
- installing pumps with backup generators to pump out excess water
- reinforcing windows and doors

- covering piles of material with debris tarps and strapping
- constructing storm water retention ponds

Elevate Utilities and Generator



Elevate Land

Flood berms

Flood proof utilities

Figure 12 – The *Accommodate* concept proposes major investment to armor individual structures and properties in place throughout the study area.

Examples shown here include elevating utilities, elevating the land itself, and construction of new flood berms.

Do Nothing

In addition to the three resilience concepts, the research team included a *Do Nothing* concept that would leave resilience levels as-is. The storm scenario exercise enabled participants to discuss details of *Do Nothing* (Figure 13), as did the examples of Hurricane Sandy damages provided by the Port of New York/New Jersey. *Do Nothing* is, of course, a default alternative that would incur significant expenses in the event of a storm, but no additional expense until that time. The research team discussed the pros and cons of "Do Nothing," along with the pros and cons of each of the other concepts.

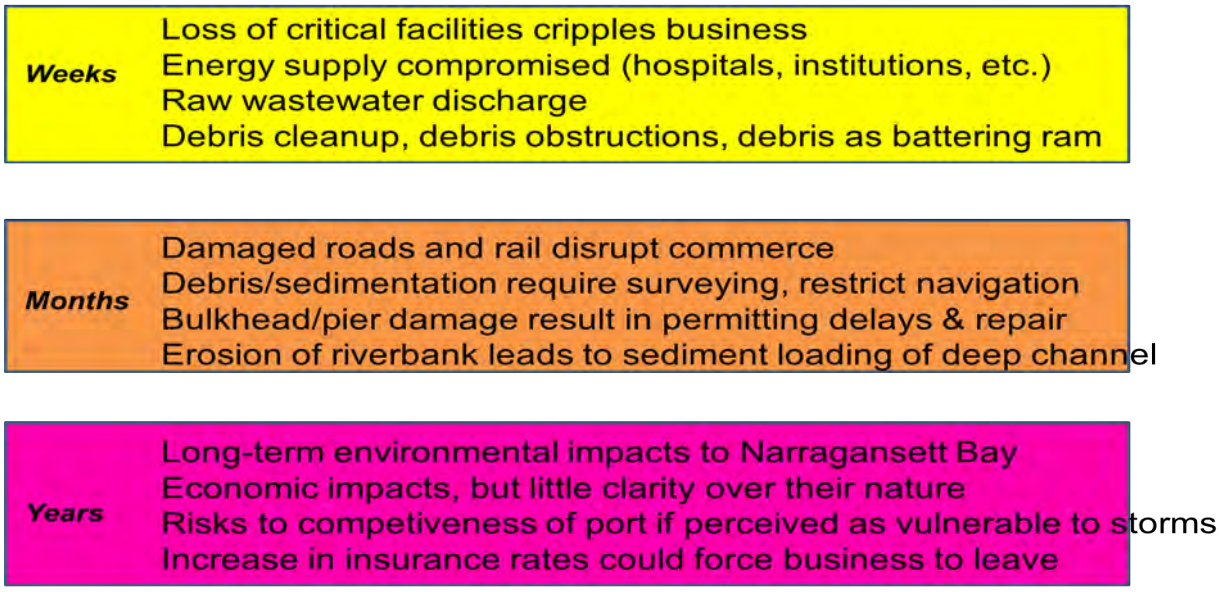


Figure 13 – The *Do Nothing* concept was included for participant evaluation. This figure shows examples of the storm impacts identified by workshop participants.

Wecision Support Tool

The research team utilized a collaborative decision process tool called *Wecision* (*www.Wecision.com*) to facilitate a deeper dive into the relative advantages and disadvantages of each resilience concept (Figure 14). Decision support tools such as *Wecision* have been used to help people understand complex problems with multiple, and conflicting, objectives (Keeney & Raiffa, 1993). Originally created as a tool for choosing optimal designs for large-scale infrastructure projects such as train stations based on stakeholder preferences (Haymaker & Chachere, 2006), the researchers adapted the tool to generate discussion and explore resilience concepts. *Wecision* uses a cloud-based platform that helps facilitators gather stakeholders and experts into a social-network community around an issue; guides stakeholders through the definition and prioritization of goals; helps to define alternatives and assess the impacts of each alternative on each goal; and aggregates this information to quantify and compare the amount of value individual alternatives provide to groups of stakeholders Resulting graphs represent participant preferences, scenario impacts, and stakeholder value, and assisted in a collaborative consensus building and decision-making process. While *Wecision* can be used more fully to allow groups of people to collaborate in real-time to formulate all aspects of a decision, for this workshop, the organizers conducted much of the work of preparing the *Wecision* model in collaboration with the steering committee ahead of time.

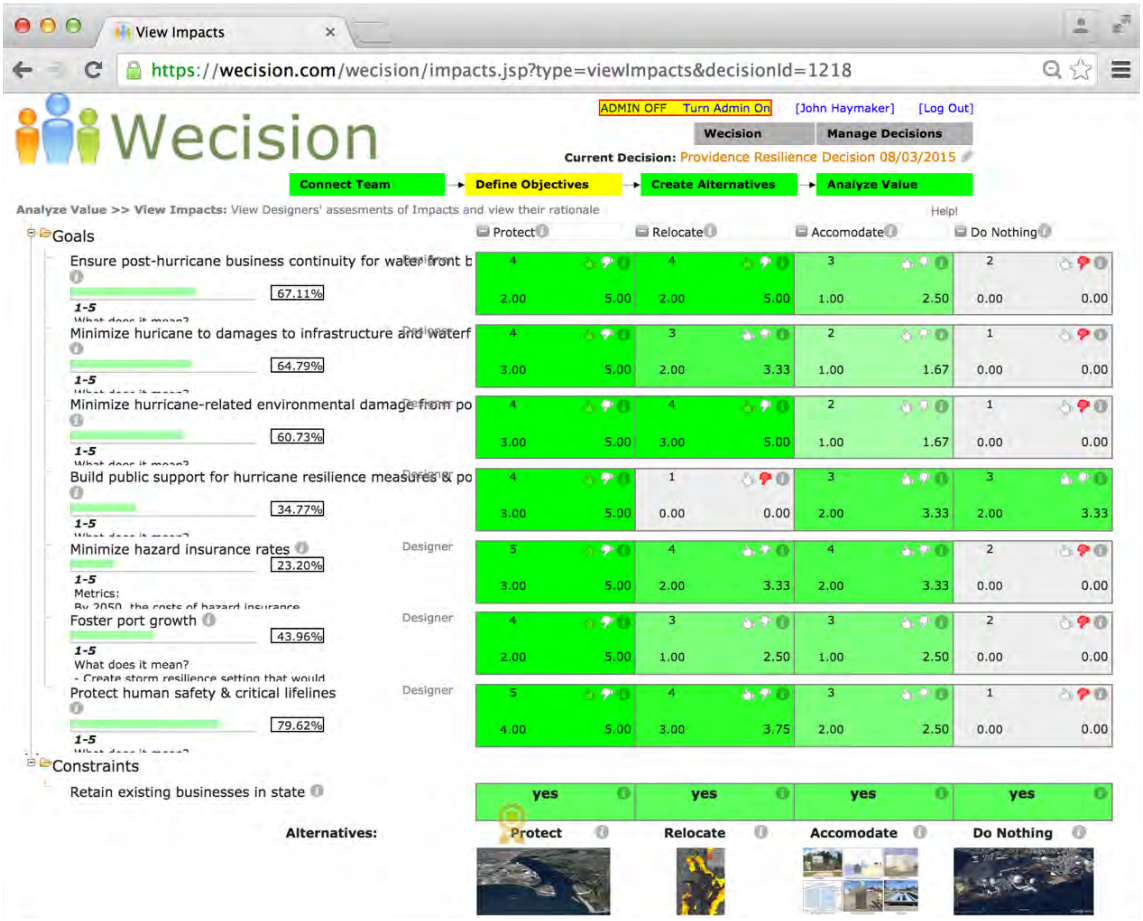


Figure 14 – An example of the *Wecision* interface utilized by participants during the workshop.

This figure shows the workshop participants inputs to the Wecision exercise.

Resilience goals

To generate discussion, the research team proposed seven "long-term resilience goals" for the port participants to assess against the four resilience concepts (see Appendix 2 for definitions and metrics for each goal). The resilience goals captured themes and concerns for businesses. Participants discussed and agreed on the following goals:

1. Ensure post-hurricane business continuity for waterfront business.
2. Minimize hurricane damages to infrastructure and waterfront business.
3. Minimize hurricane-related environmental damage from port uses.
4. Build public support for hurricane resilience measures & port operations.
5. Minimize hazard insurance rates.
6. Foster port growth.
7. Protect human safety and critical lifelines.

Researchers asked that the seven most important goals be considered for the exercise, though there were of course more that were mentioned. The team began the *Wecision* exercise by presenting the storm scenario, the goals and the resilience concept alternatives. Participants used personal computers to log onto *Wecision* and rate their preferences, or priorities, with respect to the seven resilience goals. Participants discussed each of the four resilience concepts scenarios and evaluated them against the seven resilience goals using a 1-5 metric defined for each goal (as outlined in Appendix 2). Participants weighted the importance of each goal, according to their individual preferences. Participants input their preferences "on the fly" using personal computers, while a facilitator led them through the exercise. *Wecision* calculates stakeholder value by multiplying the stakeholder's preferences for goals with the scenarios impact on those goals. Therefore, Alternatives that performed well for goals with high stakeholder preferences received higher value scores. Alternatives that performed poorly on highly preferred goals, or that performed well on less important goals, received lower value scores.

Results of the Workshop

The tools utilized in the workshop stimulated discussion and deep thought about a very challenging topic. Though participants were familiar with emergency response, they were less accustomed to thinking beyond a storm event to consider the long-term consequences, such as environmental damage to the Bay, the interdependencies between businesses, and the cascading consequences that a major event could have on the port industry as a whole. The resilience concepts helped participants imagine what may lie ahead, as the impacts of climate change are felt more profoundly in the port area. As participants moved from considering the impacts of the storm to considering the potential strategies, they quickly grasped the complexities inherent in pro-active planning. At the end of the exercise, *Wecision* aggregates participants' opinions of how well each resilience concept alternative met each of the seven goals, as well as weighting those goals based on participant's assessment of goal importance (Figure 15). Results showed in real time that participants felt that the *Protect* strategy best met their goals, followed by the *Relocate*, then *Accommodate,* and finally *Do nothing*. In Figure 15, each bar, which represents the total score the strategy received, is broken into individual goal scores, which represent how well this strategy reaches a particular resilience goal. This allows for analysis of which strategies better meet particular goals. For example, participants felt that both *Protect* and *Relocate* would each perform similarly for the goal "Minimize hurricane related environmental port damage."

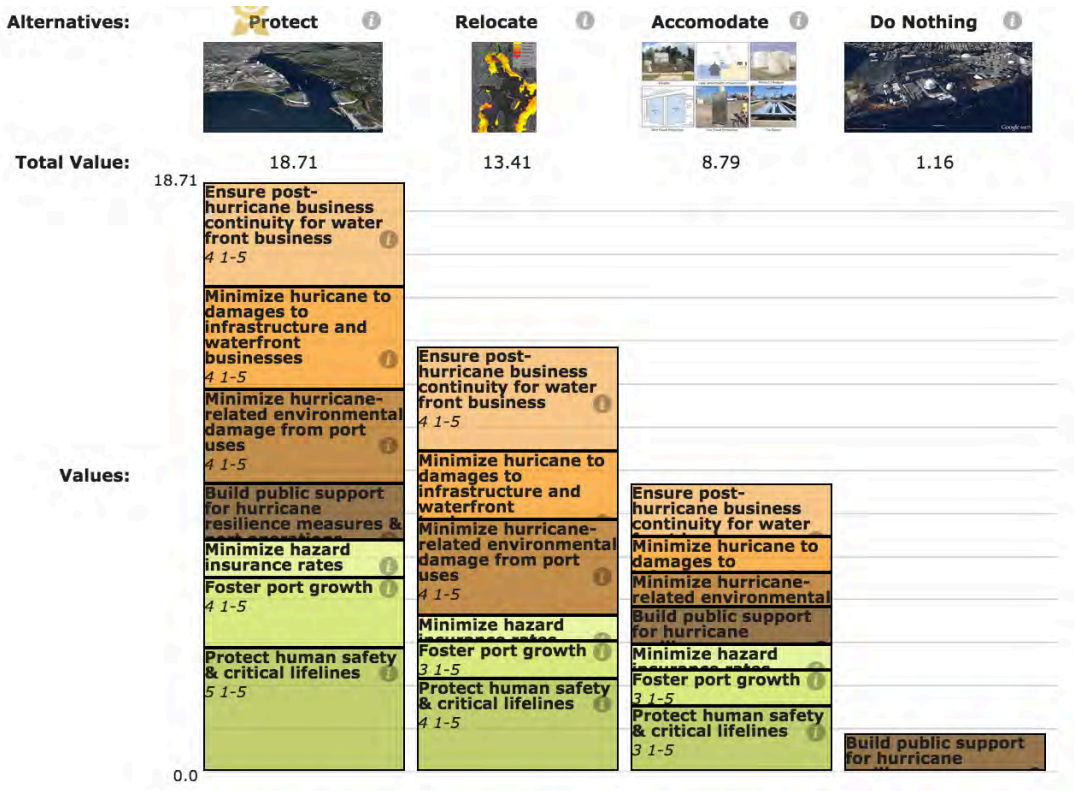


Figure 15 –Output of the *Wecision* exercise.

The thickness of each color bar represents how well the alternative would meet the resilience goal. Here, we see that Protect was identified as best meeting the goals of participants.

The participant discussion that followed focused on the efficacy and cost of the resilience strategies, as well as a general distaste for the *Relocate* option, despite the results of the *Wecision* exercise, which showed it as the second most preferred option. Robust conversation following the exercise raised a number of important questions, including:

- How much would these strategies cost to implement?
- Who pays? And, in what proportions?
- How much would a major storm hitting the port actually cost?
- Who (or what organization) is best positioned to take the lead?

The questions have no easy answers. However, like many coastal communities, the Port of Providence stakeholders will need to start thinking deeply about them in the coming decades, as sea levels rise and the threat of tropical storms intensifies. This workshop exercise began as a dialogue and the researchers suggest that it lays the groundwork for future planning efforts.

Post-Workshop Survey Results

Workshop results suggested that participants felt someone should lead the way in adaptation planning and implementation. However, there was no consensus on who this leader ought to be, prompting researchers to conduct a follow-up survey focused on leadership and the workshop's effectiveness. The goals of the post-workshop survey were to:

- Explore support for implementation of resilience concepts.
- Explore expectations of resilience funding sources.
- Explore respondent sense of urgency to implement resilience.
- Explore who port respondents see as responsible for implementing resilience within the study area.
- Measure changes in preparedness that may be a result of workshop discussion.

In this phase of the project, the researchers engaged 31 Port of Providence business, government, NGO, and quasi-public representatives. Twenty-six representatives responded to the post-workshop survey invitation, 25 completed the survey in full, 13 representing business or NGO and 12 from government. Of those who responded, nine reported operating facilities within the study area and 14 were interested in port operations for economic, regulatory, emergency response, or planning reasons. The survey began in early February, 2016 and concluded in March, 2016.

Respondent Support for Resilience Strategies

In the post-workshop survey, researchers asked respondents if they would support the implementation of the three resilience concepts explored in the workshop (*Accommodate*, *Protect*, and *Relocate*). Respondents answered on a 1-5 scale, with one being *strongly-disagree*, two being *disagree*, three being *neither disagree or agree*, four being *agree*; and five being *strongly-agree*.

As a whole, (business and government respondents together), results show a preference for the *Accommodate* strategy, over *Protect* (2^{nd}) and *Relocate* (3^{rd}). Individually, business respondents had the greatest support for *Protect*; while government stakeholders favored *Accommodate.* Government stakeholders showed some support for all strategies. The two stakeholder groups are divided in terms of their preference for the *Relocate* strategy, with government respondents showing some support and business respondents being strongly against.

Results obtained here differ from those obtained using the *Wecision* program in the half-day workshop (described earlier). *Wecision* results showed *Relocate* was the second highest ranking strategy. This survey differs from the *Wecision* survey, however, in that here we are just asking for stakeholders to state their support. The difference suggests that while relocation of

businesses may be an effective way to reduce storm vulnerability, it would not be feasible given the strong opposition from the business community (Figure 16).

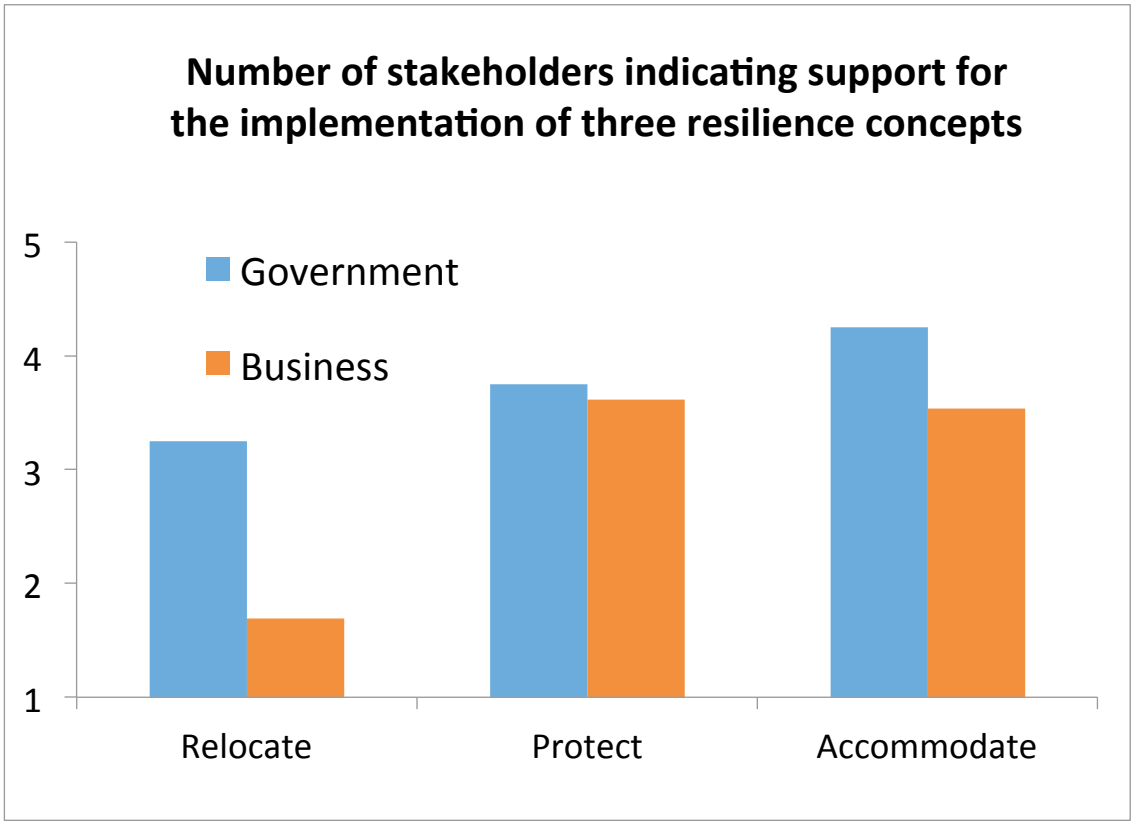


Figure 16 – Support for the implementation of the resilience concepts.

Respondent Expectations of Funding Sources

University of Rhode Island researchers asked respondents to evaluate the responsibility of private business, local government, state government, and federal government in funding the implementation of resilience within the port. Respondents answered on a 1-5 scale; one being *not responsible at all*, two being *less responsible than others*, three being *just as responsible as others*, 4 being *more responsible than others,* and five being *entirely responsible.* A score of five represents maximum responsibility (in which all respondents see that organization as entirely responsible for funding implementation). Scores greater than three indicate greater responsibility, while a score below three indicates less. Overall, respondents viewed the state as most responsible for funding the implementation of resilience; both government and business respondents found the state most responsible. However, disagreements between the respondent groups existed in their view of the responsibility of other funding sources (Figure 17). Government representatives viewed private business as having greater responsibility. This disconnect in perceptions of responsibility may contribute to the lack of leadership thus far in resilience planning.

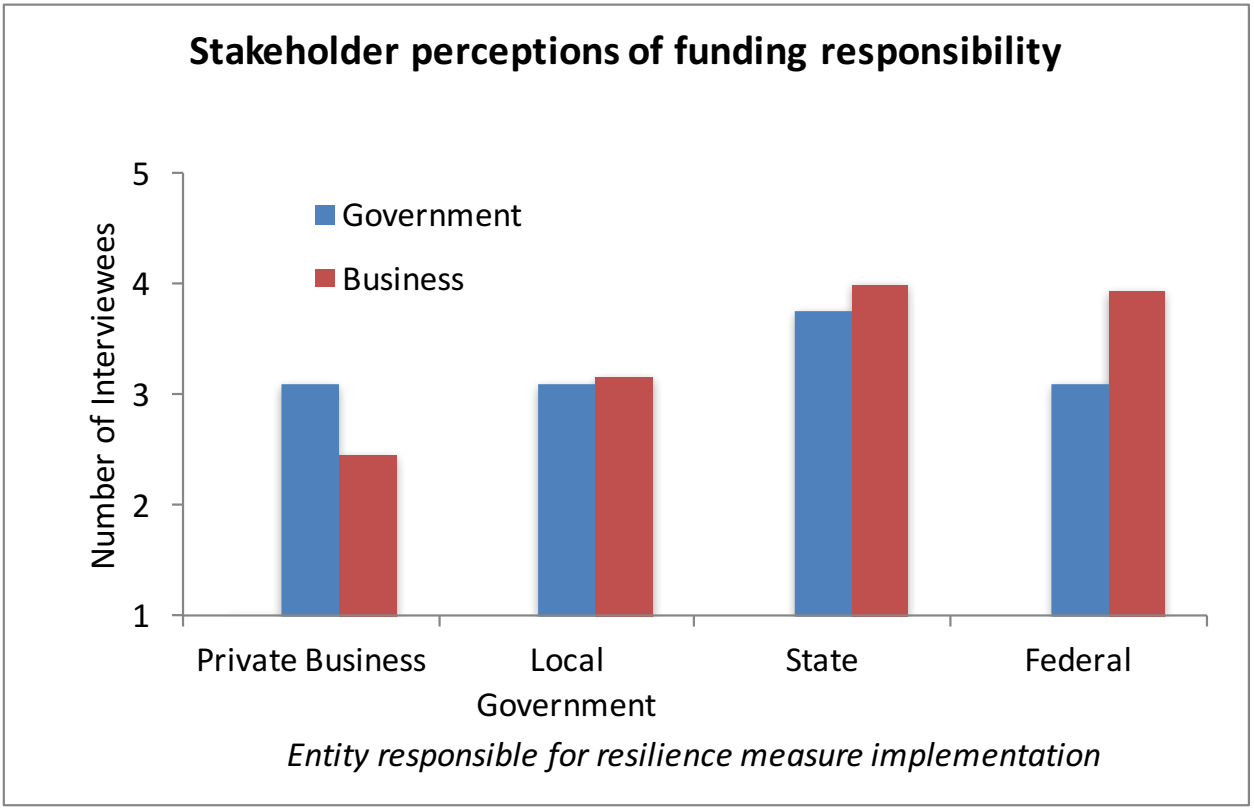


Figure 17 – Respondent perceptions of funding responsibility for resilience

Sense of Urgency

Researchers examined respondents' sense of urgency in the implementation of resilience by asking them to respond to the statement, "Port of Providence businesses should initiate long-term planning." Response options were *now*; *within the next two years*; *in 2-5 years; in 5-10 years; in 10+ years.* The researchers found that 21 of 25 respondents stated *now* or *within the next two years* (14 answered *now*; 7 answered *in the next two years*). No respondents stated *in 10+ years*, suggesting that most respondents see resilience planning as a pressing and urgent issue.

Responsibility for Implementation

To investigate who respondents see as responsible for implementing resilience strategies within the study area, URI researchers presented respondents with seven possible paths that port leadership could take to implement resilience, as follows: *port business independently; port businesses in collaboration; public-private informal collaboration; public-private formal collaboration (i.e. special committee on port resilience);* and *local; state; and federal lead* (Figure 18). Researchers also asked respondents to evaluate the responsibility of these leadership forms to implement the *Protect*, *Relocate*, and *Accommodate* strategies presented in the workshop. Also included was resilience as a general concept, combining aspects of all three resilience strategies.

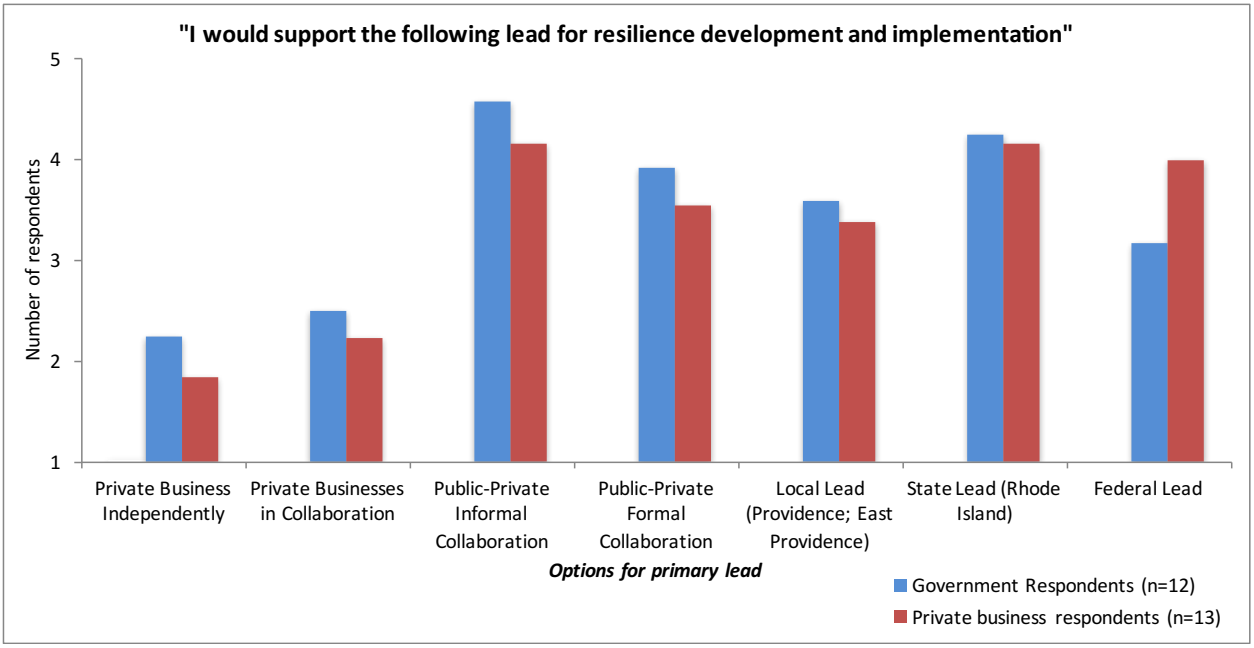


Figure 18 – Responsibility of leadership formation to implement resilience within the study area.

Results suggest that respondents see a public-private informal collaboration as the best choice for implementing resilience, though they also supported a state-led effort. When asked about which organizations should have responsibility to implement resilience strategies, respondents reported that the Rhode Island Coastal Resources Management Council, a state level organization, is responsible. However, they had a variety of answers suggesting that they see many organizations as playing a role in the implementation of resilience. Respondents also identified "Port Authority," "Harbor Commission," and "Collaboration" as responsible, although these organizations do not currently exist,[3] suggesting that perhaps a new collaborative organization would be best according to participants. Researchers also found differences between government and business respondent groups, specifically in their view of the federal government's responsibility. Business representatives found the federal government more responsible than did government respondents.

Survey results also suggest *state lead* as the preferred option to implement the *Protect* concept, followed by local, then federal lead. Respondents identified *Business independently* and *Collaborative efforts* as less responsible for implementing *Protect* strategies. Results from open-ended questions identified the U.S. Army Corps of Engineers and other state and federal organizations as responsible. In comparison to general resilience implementation, respondents showed that government organizations are more responsible for implementing the *Protect* strategy. Government and business representatives showed differences, government

[3] A new Providence Harbor Management Commission was just forming at the time this research took place

respondents see responsibility as being equal over all leadership types, while business stated government (in particular state and federal) as responsible.

When asked about the implementation of *Relocate,* respondents identified a state-led effort as the best option. Low support for this strategy, however, influenced how respondents viewed responsibility. In this case, only a state-led effort was considered responsible. This was also partially confirmed in open-ended responses, because respondents mentioned CommerceRI, a state organization responsible for economic development within the state of Rhode Island, as one of the organizations responsible for this strategy. Respondents also mentioned city governments (Providence and East Providence) as responsible organizations. Government respondents viewed *Relocate* as a strategy for which many organizations (public and private) share responsibility, while business respondents saw *Relocate* as a strategy for which government organizations are primarily responsible for implementing.

In the *Accommodate* strategy, respondents viewed all leadership forms and many organizations as responsible for implementation. This is intuitive, due to the fact that the *Accommodate* strategy can be implemented piecemeal at all levels of port governance, from independent businesses to federal government actions. Respondents perceived public-private informal collaboration as the best option for implementing this strategy. Open-ended responses supported this conclusion because a variety of organizations including businesses independently and government organizations were mentioned as responsible. Results suggest that business needs to play a greater role in the *Accommodate* strategy than any other strategy.

Overall, respondents felt different organizations were responsible for the implementation of different strategies. Stakeholders expected the state and federal government to play a larger role in *Protect*, and they expected business to play a greater role in *Accommodate*. The lack of consensus around which strategy to pursue, or which combination of strategies, can ultimately lead to a lack of action taken on any approach.

Post-Workshop Preparedness, Changes from the Baseline

To assess changes to business hurricane preparedness resulting from the workshop, the researchers asked respondents if they completed the same preparedness actions as asked in the initial survey (Figure 19). Nine of the 26 respondents to this survey represented businesses also interviewed in the pre-workshop survey.

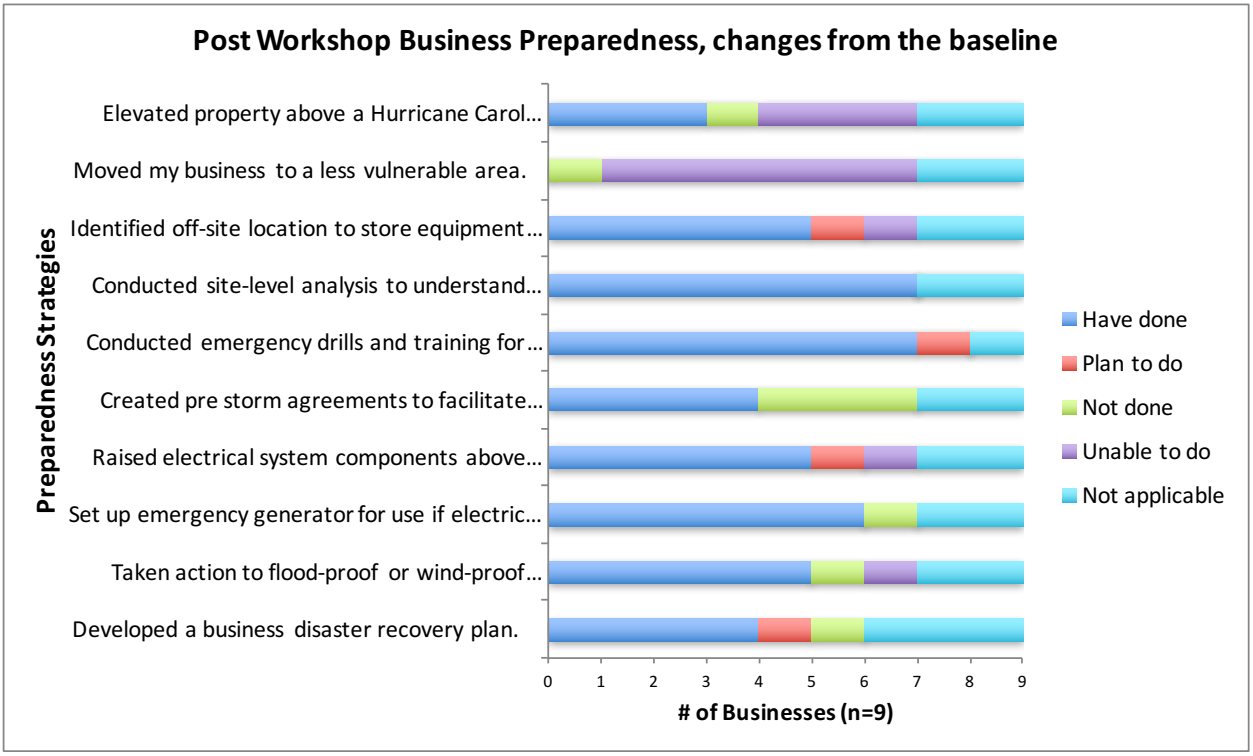


Figure 19 – Post-workshop survey responses regarding storm preparedness measures in place

Post-workshop Survey Conclusions

- The number of resilience options contributes to complexity and influences inaction because respondents view different organizations as responsible depending on the strategy.
- Respondents from different sectors (public vs. private) have different ideas about which organizations should be responsible for leading resilience actions.
- Overall, the State is perceived to play a major role in implementing resilience strategies. However, a collaborative organization is recommended based on the number of organizations perceived as playing a role.
- Respondents see resilience planning as an urgent matter which should begin within the next two years.
- Respondents see state or federal government as responsible for funding implementation strategies.

Based on these conclusions, the researchers recommend that a state agency, such as RIDOT or CRMC, continue a collaborative effort to begin informal dialogue. Informal dialogue should include discussion on which strategies are politically, socially and economically feasible for the Port of Providence, allowing for organizations involved in port operations to identify possible contributions to planning and implementation.

Discussion and reflection on the research project

How Decision Support Tools Aid in the Discussion of Complex Ideas

Decision support tools can engage participants in a challenging conversation about long-term (pre)planning for low-risk, high consequence events such as a major hurricane. In Rhode Island, this conversation was unprecedented. Although state decision-makers and planners engage in regular dialogue around emergency response planning (for example, as spearheaded by the Rhode Island Emergency Management Agency and the U.S. Coast Guard) and land use (e.g., *LandUse 2025* Rhode Island Statewide Planning's Land Use Plan), the likely consequences of a major hurricane have not been planned for, despite concerns expressed by workshop participants before this research project took place (Becker et al., 2014). Much infrastructure and land use planning were carried out over the 20th century using historical storm surge data (CRMC 2009 In review) and pre-climate change, future conditions could be expected to follow the same probability curves as past conditions (Milly et al., 2009). Since past flood-level probabilities were presumably taken into account in the design and planning, there would have been no need to consider making dramatic changes to the built environment to accommodate unprecedented events. However, with climate change, such discussions suddenly become imperative, especially given the long timelines necessary for infrastructure development and its immense expense (Savonis et al., 2014).

Previous research, (Becker & Caldwell, 2015; Becker et al., 2014) and these workshop results suggest a number of reasons that participants find such dialogue so challenging and further reinforce the "wicked" nature of the adaptation challenge for this coastal community. Many of the general principles outlined by Rittel and Webster (1973) in their seminal paper aptly describe the challenge faced by decision-makers in Providence and help explain why this dialogue is so difficult for participants to enter into in a meaningful way (Table 4). Many participants had different perspectives on defining the actual problems associated with storm hazards. Though all expressed familiarity with hurricane preparations, few had experienced a major hurricane and none had a frame of reference for how wind, surge, and waves would affect the harbor. Many participants were unclear of their roles in implementing resilience strategies and some even expressed concern that they would assume liability simply by acknowledging the risks. Even with the resilience concepts presented in the workshop, participants found it difficult to agree on the "goal" or "end objective" for a resilient port. Though discussion focused on one potential Category 3 storm scenario, it was not lost on participants that other storms of different magnitudes could present a different set of outcomes. The implications of significant sea level rise, for example, would not be addressed through the *Protect* scenario, which provided a storm surge barrier, but not a means to protect infrastructure from inundation under increasing high tide levels. Such uncertainties quickly become difficult to model and require the application of different techniques, such as game theory (Hazelrigg, 2012; Von Neumann & Morgenstern, 2007) . Other characteristics of "wicked problems" and how they apply to the Port of Providence situation are further outlined in Table 4.

Table 4 – Port resilience as a "wicked problem" (based on Rittel and Webster, 1973)

Characteristic	Wicked Problems	Port of Providence Challenge	Contribution of this project
The Problem	No agreement exists about what the problem is/ Each attempt to create a solution changes the problem / the end solutions are not true or false, but rather better or worse with winners and losers	The problem of hurricane and sea level rise risk for the port of Providence, in itself, is very difficult to define and bound. Providence has experience numerous major hurricanes (e.g., 1817, 1885, 1938, 1954), there has not been such an event in recent memory. None of the participants witnessed such a major storm hit the area, though many could recall hurricanes with far less power (e.g., Hurricanes Sandy, Irene, Bob, Floyd). In addition, the port area has seen significant development since the last big hurricane in 1954.	Coming together around one storm scenario, with visualizations and input from experts, allowed participants to better understand the complex nature of the problem and the interconnectedness of the long term consequences of a major hurricane on an unprepared port system.
Stakeholder roles	Many stakeholders are likely to have differing ideas about what the "real" problem is and what its causes are	Business owners sometimes fear that a discussion of risk can result in liability or culpability should an event occur and damages result. Some felt that acknowledging the true threat would leave them responsible for investing money to reduce these risks.	The workshop and survey activities helped participants see the range of resilience strategies that could be implemented by private business (e.g., raising utilities) and the public sector (e.g., building a storm barrier). This broke down the "siloed" nature of the system and underscored the co-benefits of resilience investments.
The "stopping rule"	The end is accompanied by stakeholders, political forces, and resource availability. There is no definitive solution	Bounding the problem to a particular storm surge or level of sea rise can, in and of itself, be a major barrier to engaging in dialogue about solutions. How much protection is enough? Is a Category 3 hurricane the proper scenario to plan for? Why not a Cat 1 or Cat 4? Even if investments are made to protect the port against that Category 3, sea level rise and climate change will most likely only increase risk levels over the next several centuries.	The exercise helped stakeholders think about the long term implications of resilience strategies and to recognize that almost all solutions are temporary. This, though, helped them to see that investments must be considered in the context of the working life of the resilience measure implemented and that there is likely no "permanent" solution.

Nature of the problem	Solution(s) to problem is (are) based on "judgments" of multiple stakeholders, thus there is no one "best solution" that can be quantifiably assessed. The problem is associated with high uncertainty as to system components and outcomes	In Providence, the issue of storm resilience is hard to pin down as "one problem" that can be resolved. Hurricanes result in a range of consequences, depending on wind speeds, storm surge, wave action, and precipitation. Different parameters will impact different stakeholders. Thus, differentiating the "wind problem" from the "surge problem" can be difficult for a group to undertake. The long-term nature of the scenarios presented in the workshop also did not align well with the normal planning and investment cycles for business and even government.	Through the use of the storm scenario, participants in the workshop were able to share their perceptions and concerns and find common ground around understanding the nature of the problem.
Symptom of another problem	Resolving the wicked problem begins with a search for causal explanations of another problem	Though hurricanes have occurred in the past, the projected intensification and rising sea levels is a symptom of the larger climate change problem which is well outside the scope of Port of Providence stakeholders	Though not explicitly addressed in this project, exercises such as this (focused on resilience or adaptation) can lead to deeper levels of concern for the causes of the problem, which are exacerbated by CO2 emissions and links to global warming.
Fuzzy mandates	Wicked problems do not have clear actors with responsibility to resolve the problem Often require a "champion"	Despite assembling an expert steering committee and including all waterfront business interests in the study area, no clear leader for long-term resilience planning emerged before, during, or after the workshop.	The project clearly identified a leadership vacuum for resilience initiatives around the Port of Providence. A first step toward solutions is identifying that the problem exists and beginning a dialogue around which agencies or businesses are best poised to address it.

The resolution of wicked problems, the move toward transformational adaptation, and the development of a resilient port system are confounded by yet another problem: there is, as yet, no clear decision to be made. Funding for resilience investments has not been secured, consensus around which types of resilience strategies to pursue has not been reached, and the problems and solutions have not yet been clearly identified. However, long-term preplanning can begin by planting seeds, sparking debate, and stimulating thinking about transformational concepts that ultimately would take decades to implement.

Decision support tools as a bridge – what was effective and what needs improvement?

The tools created for this project bridged these challenges by providing participants with a common focus that emphasized the regional and cascading implications of storms and storm resilience. As a communication device they allowed for both the invention of knowledge and a semblance of social order within a collaborative setting (Jasanoff, 2004). However, there were limitations in each of them that are worth discussion (Table 5).

Perhaps the largest challenge in the use of these tools lay in the time allotted to carry out the workshop. At the start of the project, the research team planned to spend a full day with workshop participants. This would have allowed each tool to be fully developed and explored. As the workshop date approached, some participants made it clear that they could spend a half-day, but not a full day. This presented a number of challenges and forced the team to make compromises around each of the three tools. For example, the team would have liked to have spent 30 to 45 minutes on an exercise in which participants would develop and find consensus around their own set of resilience goals. The team also would have preferred to spend additional time in small group discussions around the pros and cons of the long-term resilience concepts. Finally, the team had to greatly reduce the amount of time spent on orienting the participants to using the *Wecision* tool, resulting in some confusion around using the tool and a lack of time for discussing the results.

Table 5 – Pros and cons of decision support tools used in workshop

Tool	Short description	Pros	Cons
Storm Scenario	Plausible, but extreme, storm event with 3D visualizations of local context	Participants considered their own property in the context of the storm Successful prompt for dialogue on wide range of direct impacts and cascading consequences Elicited robust exchange between participants around interconnectedness of infrastructure and services Helped participants to think "long term" about impacts in weeks, months, and years	Participants requested a "probabilistic" scenario, as opposed to a deterministic 3D visualizations could not effectively show wave, wind, and related impacts (e.g., debris fields) Some participants did not believe that such an event could occur Some participants "shut down" because the event was so extreme that they felt nothing could be done to reduce impacts Research team could not incorporate "costs" in anything but the vaguest of terms.
Long-range resilience concepts	Three transformational concepts (*Relocate*, *Protect*, *Accommodate*) presented in detail with pros and cons in order to generate discussion about potential for large-scale investment in resilience	Participants considered game changing strategies outside the normal scope of public/private planning	Participants found it difficult to consider efficacy of concepts without considering the expense and who would pay for them Transformational concepts are very difficult to simplify and incorporate into a 4-hour workshop. Many nuances, many questions were raised
Wecision	Web-based software multi-attribute criteria decision support tool	Allowed participants to provide real-time feedback, anonymously, during the workshop. Promoted deeper thinking about the resilience and *Do Nothing* concepts Participants	Tool was difficult to train people to use in the limited available time As articulated in this case, did not incorporate costs, due to complexity of cost estimation

Individually, the tools worked well, but nevertheless could be improved. The dialogue around the storm scenario, for example, raised a number of concerns that participants had not previously discussed as a group, but without laying blame or directly assigning responsibility for assuming the risk. The storm scenario visualizations brought these issues to light, without boxing any particular agency or business into the corner of having immediate responsibility to reduce that risk, thus allowing for a freer flow of ideas. Though ultimately "someone" will need to address the issues raised, the visualizations allowed for discussion in a non-threatening and collaborative environment, laying a foundation for future decision-making exercises.

Although many participants found the visualizations engaging and plausible, some felt that the scenario was either too extreme to be realistic, while others would have preferred a probabilistic scenario. The steering committee supported the creation of a deterministic scenario that would result in a surge that comes up to but does not overtop Providence's Hurricane Barrier. Anything worse would result in a game-changing event that would flood out the entire downtown area. Some participants indicated that they would have preferred a scenario that utilized a probabilistic model (e.g., a 1-in-500 year event), as they felt more familiar with probabilistic models. In addition, the visualizations did not adequately represent many of the real damages that would likely occur. Debris, destroyed buildings, boats torn from moorings, and other likely impacts could not be represented with a degree of accuracy that would make them credible. As advancements in visualization technology make it possible to use increasingly realistic visualizations it is important to further understand the implications and effectiveness of these types of tools.

The discussions around the long-term resilience concepts exposed participants to the very real possibility that the landscape around the port might need to change dramatically over the next several decades. Rather than simply posing the problem, these concepts opened the door to discussion about transformational ideas such as the construction of new barriers and the relocation of some businesses. Participants discussed how most incremental strategies (e.g., elevating utilities, building with floodable first floors) would be effective up to a point, but still fall far short in the event of the storm scenario presented, with its 6.4 meters of surge. On the other hand, participants still found it difficult to consider the strategies without some context for cost and who would pay. In designing the concepts, researchers deliberately avoided estimating costs due to the high number of variables involved, including time horizons, scale, and system complexity. Future work should find a way to integrate some approximation of cost, as well as options for how costs might be distributed. For example, the idea of a split between public, private, and public/private investment could be introduced in order to better understand stakeholder preferences under a variety of cost-split scenarios.

Finally, the *Wecision* tool served as an entry point to a nuanced discussion around resilience concepts. The value lay in providing an objective reflection of the participants' own evaluation of the effectiveness and benefits of the resilience concepts that could be reflected back in real time. However, the absence of a quantifiable metric for the effectiveness of the various

concepts, the lack of integration of costs, and the difficulty in assigning "who pays" left some participants feeling that the implementation of the tool did not go far enough.

Recommendations and further action

As this project served as a pilot, University of Rhode Island researchers asked participants questions about what was successful and what could be improved in the workshop methodology. Participants felt that the use of visualizations improved discussion of impacts. The visualizations promoted collaboration and conversation among group members. Participants also liked that the discussion on impacts was broken down into time frames, because it encouraged them to differentiate between consequences in the immediate aftermath of the storm and those consequences that would impact business and the environment for months and years.

Recommendations to improve workshop methodology

- Allow for more discussion time, less presentation
- Provide estimates of costs and benefits for the resilience concepts
- Use a probability based storm scenario, as decision-makers are typically more accustomed to thinking about the 1% or 0.2% probability event, as opposed to a hypothetical storm.
- The workshop needed more time. Four hours was not enough to cover the material and meet all objectives.
- The *Wecision* software needs to be smoother; improve logistics as well as give more guidance, offer more time for explanation and interaction. Modifications to *Wecision* may include:
    1. Add probability or uncertainty based logic, which would be consistent with sound decision-making literature
    2. Improved categorization of participants
    3. Add more time to explain *Wecision* and present results.
    4. Reducing logout issues in the *Wecision* tool.
    5. Improved user interface guidance and feedback is needed while users complete the model.
    6. More thought and research is needed in terms of the specific goals and alternatives under consideration.

Workshop participants expressed concern over the costs of implementing long-term transformative and incremental resilience strategies. There was concern for the burden of costs and the long-term economic sustainability of the Port of Providence. However, participants expressed the need to begin the formal discussions on future planning. Substantial dialogue between members of the port community to discuss the funding of resilience implementation is needed. Participants called for an external agency (such as RIDOT) to organize and facilitate

these discussions. RIDOT is in a position of leadership and could motivate these discussions incorporated into improvements to marine related transportation infrastructure.
The next steps in this project are to improve and refine the workshop methodology and implement hurricane resilience workshops in port communities around the state of Rhode Island. Specifics include:

- **Refine workshop tools**, *Wecision* interface, and workshop methodology.
- Develop **more robust disaster visualizations and models**.
- Conduct **additional workshops** in Providence and other Rhode Island area ports.
- Conduct a one-year **follow-up study** with participants to identify workshop impacts on business planning.

Recommended actions for RIDOT

- Conduct additional exercises that engage all stakeholders in long-range thinking around resilience serve as a critical first step toward good planning. **Workshops such as this should be conducted with different audience and in different transportation hubs around the state** (e.g., Galilee, Davisville, Newport).
- Work with port stakeholders to **identify a lead agency for resilience planning**, beginning with convening an *ad hoc* group to determine next steps.
- The costs to the private and public sectors of a major hurricane hitting the Port of Providence are not well understood. **An in-depth study of the direct and indirect economic costs, as well as environmental implications, of a hurricane at the Port of Providence is critically needed**.
- Pursue further **research on the costs and benefits of large-scale changes to the waterfront to protect from storms and sea level rise**. In particular, the concept of constructing a new hurricane barrier to protect the Port of Providence should be further developed and explored.
- **Develop a database of stakeholders and experts** to serve as consultants and invite to future discussions.
- **Develop a database of standard resilience goals** to consider when designing long-term projects.
- **Develop database of alternative resiliency proposals** indexed by performance with respect to resilience goals
- Develop a **network of experts** able to propose and analyze alternative resiliency plans.
- **Maritime businesses need assistance in identifying and implementing "low hanging fruit" resilience strategies, such as:**
  - Backing up computer data
  - Attending a meeting on hurricane preparedness
  - Developing a disaster recovery plan
  - Taking action to flood-proof or wind-proof facilities
  - Setting up an emergency generator for use if electric power fails

- Raising electrical system components above Hurricane Carol storm surge level of approximately 15 feet
- Creating pre-storm service agreements to facilitate rapid cleanup
- Conducting emergency drills and training for hurricanes
- Creating hazardous materials spill recovery plan
- Conducting port structure stability analysis in compliance with FEMA guidelines
- Conducting a site-level analysis to understand potential inundation areas for various storm events
- Identifying off-site locations to store equipment or products in the event of an impending hurricane
- Initiating pre-storm agreements with vendors or customers to minimized business continuity interruptions

Conclusion

The research project utilized three decision support tools to help facilitate stakeholder dialogue around the "wicked challenge" of developing a more resilient Port of Providence, in Providence, Rhode Island. A storm scenario with 3D visualizations, three long term resilience concepts, and an online decision support tool called *Wecision* were used in a day long workshop with 30 port stakeholder participants. The workshop engaged stakeholders in deep thought and discussion among business, environmental, and policy decision-makers. The ultimate goal was to better represent the physical impacts from a major storm event, and the social, environmental, and cultural constraints of resilience strategy options available for the Port of Providence.

The workshop results suggest that participants found that the process engaged them in critical thinking to better understand the risk and complexity inherent in implementing a meaningful resilience strategy. Though it did not, by design, result in a concrete decision for action or specific plan, *Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure* functions as an example of a preplanning exercise necessary to lay the groundwork for future decision-making in the face of climate change related events. The researchers argue that without decision support tools, stakeholders and decision-makers could not effectively engage in dialogue around the challenge of long-term planning for natural hazard adaptation. Use of local-scale visualizations and a "storm scenario" can effectively engage stakeholders with the problem and how it will impact *their* property. This helps them see how high the water might go, what parts of their infrastructure might be submerged, and to get a better sense of how storm surge at a neighbor's property might result in consequences, like debris, on their own buildings and piers. The resilience concepts, though big picture and not part of a current decision-making process, helped participants understand the magnitude of the storm issues and to begin dialogue around what eventually may need to happen in the Port of Providence to protect it from major storm events and keep business up and running. Finally, the *Wecision* tool allowed participants to think more deeply about the costs and benefits of the various resilience concepts and begin to form some opinions around which they might prefer.

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Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot Project for the Port of Providence

Appendix 1 - Steering Committee meeting agendas, notes, and minutes

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This appendix contains agendas, notes, and minutes recorded by researchers to document Steering Committee involvement in research development. For each meeting researchers developed an agenda that guided discussion. This agenda usually focused on one or a few research issues confronting the research group. In these meetings URI researchers presented:

- Preliminary stakeholder identification
- The storm scenario
- The resilience concepts
- Research methods, including survey and interview drafts
- Proposed port of Providence resilience goals
- The workshop agenda
- Workshop results analysis and stakeholder feedback on methods

The Committee made suggestions of improvement to the above areas, vetted and made alterations to proposed research methods. Researchers used notes from meetings to develop meeting minutes, which were then returned to the committee for additional edits and approval. Minutes are the official results of each Steering Committee working sessions. Proposed solutions and alterations were then incorporated into the research design and final products.

Contents:

Vulnerability Assessment of RIs Key Maritime Infrastructure Kickoff Meeting
Agenda
Aug. 5, 2014 1000 – 1200
RI Dept. of Transportation (Providence)

Invited participants:
Thomas Queenan, Dan Goulet, Grover Fugate, Austin Becker, Rick Burroughs, Chris Witt, Evan Matthews, Colin Franco, Jeff Willis, John Riendau, Deb Rosen, Michael Sock, Correy Bobba

I. Intros
II. Overview of the project (Becker)
III. Identification of steering committee members
IV. Identification of steering committee chair
V. Guiding questions that need to be answered
   a. Target group(s) – suggest "users of the waterfront"
   b. Bounding the study area
   c. Vulnerability perceptions only OR include resilience strategies?
VI. Timeline for project
VII. Meeting schedule

State of Rhode Island and Providence Plantations
2 Capitol Hill, Providence RI 02903
Sign – In - Sheet

PROJECT: Vulnerability Assessment of Ports R.I. CONTRACT NO: —

SUBJECT: Tech Panel Kick off Meeting DATE: 8/5/14

MEETING LOCATION: RIDOT TMC

NAME	ORGANIZATION
Mike Sock	RIDOT
Austin Becker	URI
Paul Goulet	CRMC
Chris Witt	RI Statewide Planning
Corey Bobba	FHWA
John Riendeau	Commerce RI
Deborah Rosen	URITC
Colin Franco	RIDOT
Evan Matthews	Port of Davisville/QDC
Patrick Hanley	Lincoln Hinz School

VULNERABILITY ASSESSMENT FOR MARITIME INFRASTRUCTURE: PILOT METHOD DEVELOPMENT FOR THE PORT OF PROVIDENCE
RIDOT-Funded URI Research Project through URITC

Initial Technical Panel Meeting

August 6, 2014

Attendees: Austin Becker [PI](URI), Corry Bobba (FHWA), Colin Franco (RIDOT Materials and Quality Assurance), Dan Goulet [PI](CRMC), Patrick Hanley (Quonset Development Corp), Evan Matthews [PI](Quonset Development Corp), John Riendeau [PI](CommerceRI), Deborah Rosen (URI Transportation Center), Michael Sock (RIDOT M&QA), Christopher Witt [PI](RIDOA Statewide Planning)

Absent w/Regrets: Thomas Quenan [PI](RIDOT, Intermodal Planning)

Meeting Minutes

- Prof. Becker provided some details on his background and noted Prof. Richard Burrough's as his Co-PI. He followed with an overview of the propose project:
  - The goal is to provide answers to what happens when a major storm event hits the RI waterfront.
  - The project would try to assess potential consequences and suggest mitigation strategies.
  - The work would revolve around the concerns of stakeholders.
  - The pilot will be the Port of Providence, defined as the Allens Avenue area. Initiating the project will require defining the actual scope of the area to be studied.
  - The stakeholders will have to be identified in this meeting; stakeholder buy-in may require some help from the panel.
  - Initial interviews with the stakeholders will identify concerns; some interviews have already taken place as part of a previous effort.
- Storm scenarios will be shown as a map, with a text description.
  - The PIs will work with RDV (from New Hampshire) for flood visualizations; company is good with remote coordination; the visualizations are a good tool to assist with assessment.
  - The project will not look at waves, but the water velocity and the effects of wind-driven water.
  - It was noted that Quonset is somewhat safer when underwater because the water protects it.
- The project results may impact building codes, to lessen vulnerability of structures, although these types of assessment are outside of the project scope.
- It was suggested that an oceanographer may be required to support the project, but this is outside of the project budget.
- It was noted that a team at URI (inc. Dr. Becker) submitted a proposal to the Department of Homeland Security to conduct a project that looks at detailed disaster dynamics, but that is beyond this project's scope; however, the project may benefit if the proposal is funded
- Risk reduction strategies can run the range of doing nothing to building barriers; no more than ten would be provided, but most likely would be in the three to five range.
  - A first pass will be used to start the conversation.

  - The strategies may be complex factors.
- The project will tailor decision support tools, which will be based on priorities developed from stakeholder input.
- Externalities will need to be considered, both positive and negative.
- Workshops in the policy simulation lab at URI will be conducted to walk the stakeholders through the scenario; multiple sessions may be necessary.
- The project timeframe is anticipated to be one year.
- Immediate needs are to define the potential Steering Committee members and Stakeholders [provided during the meeting]
- In other efforts, work was community-based, not system-based and not visualization-based.
- The project will look at time after event to recover (resiliency) of other modes (not there or damaged)
  - It was noted that only Providence can currently support fuel intake
  - Any events that would take out the ports would affect more of the RI infrastructure and there is an inherent lack of redundancy
- Need to have people who provide financing (policy makers), so their input is needed from the start (Steering Committee/Stakeholders)
- Project scope should include Providence Metro w/East Providence.
  - It was noted that ports are distinct from marinas and marinas would not be included in this pilot project
- Redundancy strategies are important, but the complexity means the process needs to be targeted. "Redundancy" may be considered as one of the strategies
  - Would a more elaborate redundancy study be warranted?
- Have other agencies ranked critical infrastructure?
  - Ports are not looked at as critical, by definition
- The Governor's new Climate Change Council might be looked at as a clearinghouse for information.
- Planned contacts:
  - The PI should work with the Freight Committee and insurance industry, probably as Stakeholders.
  - Melissa Long should be brought into the discussions as RIDOT's rep on the Climate Change Council.
  - Ed LaBlanc (Coast Guard Waterways Manager) should also be contacted.
  - A representative from private industry outside of RI may be included on the Steering Committee, to help provide a return on investment for ports infrastructure (stakeholders who will be participating in the study should not sit on the steering committee)
  - A federal rep should be included on the Steering Committee (Senator Whitehouse's aide?).
- The hierarchy will be:
  - Technical Panel → Steering Committee → Stakeholders.
- Evan Matthews volunteered to chair the Technical Panel

- A separate person will need to be selected as the Steering Committee chair (I thought Evan was also chair of steering committee? Maybe I misunderstood.)
-
- Next steps:
  - Technical committee will give final review of proposal
  - Technical committee will meet before the end of August to give final approval and/or recommend changes
  - Technical committee will draft "official invite letter" for steering committee members
  - PI will draft deliverables and budgeted amounts and submit to Technical Committee
  - Full steering committee will meet in September to discuss details, timeline, etc..

[P] – Technical Panel Member, [PI] – Principal Investigator

THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF THE ENVIRONMENT AND LIFE SCIENCES
THINK BIG WE DO
DEPARTMENT OF MARINE AFFAIRS
1 Greenhouse Road, Suite 205, Coastal Institute Building, Kingston, RI 02881 USA p: 401.874.2596 f: 401.874.2156 cels.uri.edu/maf

9-30-14

Dear Colleague:

On behalf of the Federal Highway Administration, RIDOT, URI, and the URI Transportation Center, I would like to invite you to participate as a member of a steering committee overseeing a year-long project entitled, "**RESILIENCE ASSESSMENT FOR MARITIME FREIGHT INFRASTRUCTURE: PILOT METHOD DEVELOPMENT FOR THE PORT OF PROVIDENCE.**" The purpose of the project is to create a method for conducting stakeholder-based assessments of public/private infrastructure's vulnerability and resilience to storm events on the scale of Superstorm Sandy and inform the decision making process.

The research project is being conducted by Prof. Austin Becker and Prof. Rick Burroughs, both at the University of Rhode Island, and being funded through a grant from RIDOT and the Federal Highway Administrations in coordination with other multimodal State Freight Movement efforts. The research itself includes the following steps, the details of which will be refined in partnership with the project steering committee (see also detailed proposal attached):

1) Invite key stakeholders of Providence Harbor to participate in two interviews and a workshop to establish context from the perspective of individuals and through the workshop to create shared expectations;
2) Create a "storm scenario" to be used as a thought prompt to collect key information on impacts and consequences at the workshop;
3) Create a portfolio of hypothetical resilience strategies that could be implemented to reduce storm risk for the users of the Harbor;
4) Tailor a "decision support tool" to be used to help elicit objectives, priorities, and concerns of stakeholders at the workshop;
5) Conduct a workshop at URI to integrate storm scenarios, resilience strategies, and desirable courses of action for Providence;
6) Follow up with stakeholder interviews to assess individual views at the completion of the process.

As a steering committee member, you would be expected to participate in a monthly (or as determined by the committee) 1-2 hour meeting to provide your expertise and guidance

U.S. Department of Transportation Federal Highway Administration
RI DOT
urit uri transportation center

Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Method development and pilot project for RI

Steering Committee Kick-off Meeting
October 30, 2014 1:30 – 3:30
Location: Quonset Davisville Corporation Annex
Meeting Notes

In Attendance: Evan Mathews (QDC), Austin Becker (URI), Rick Burroughs (URI), David Everett (Providence Planning), Kevin Bount (USCG), Pam Rubinoff (URI GSO/RISG/CRC), Chris Witt (RI Statewide Planning), Eric Kretsch (URI Grad Student & Note taker), John Riendeau (CommerceRI), Dan Goulet (CRMC)

Call-in: Julie Rosatti (USACE), Katherine Touzinski (USACE), Jeff Flumignan (MARAD)

Regrets: Melissa Long (RIDOT), Corey Bobba (USDOT/FHWA), Ames Colt (BRWCT/Govs Office)

Agenda

- Introductions
- Overview of the project
  - Motivation for the study
  - Background
  - Main questions & deliverables
  - Committee structure & study area
  - Storm scenario
  - Project timeline
  - Major deliverables
  - Role of the steering committee

Discussion Questions

- **What questions do you have about the project?**
  - Is storm surge all you are going to look at or are there others? Think about other hazards and how port will react.
    - For this exercise we are looking at just looking at storm hazards and sea level rise.
      - The method could then be applied to another hazard.
      - We are looking at long-term prevention of damage rather than short-term response strategies after a hurricane.
    - USCG does mitigation plans and workshops for spill and terrorism disasters.
  - Can you look at something happening now and then in the future including sea level rise? It might be an eye opener for people.
    - (Austin – if we are including anything further we would be over topping the barrier, and then we are into a whole other level, SLR might just increase the chances of that happening.) Sea level rise will increase damage. Even without it, our analysis will show how severe hurricane damage could be in the short term.
  - Do we need to include other scenarios? Smaller scale floods have impact on long-term infrastructure issues. Is there going to be a component?
    - (Also brings in financial incentives, how do we get stakeholders involved when after these events the federal government comes in with a lot of money.
    - You need to start thinking about the budgets of the ports. Need to look at competition; if jurisdictions start requiring certain projects or upgrades, it becomes a competitive issue, in which anything above market hurts the ports of RI. Life cycle is to 2100
    - Ports should be doing maintenance and when they do they should be taking these things into account (SLR, other types of flooding)) We are committed to complete a hurricane scenario with sufficient detail so that stakeholders will have an effective thought prompt. Details about the types of failures (pipes and others) will emerge during the workshop.
  - (How granular will the flood modeling be?
    - Austin – The modeling will not be accurate enough for "planning purposes," but will be good for thought prompt.
  - If pipes are under water will they fail?
    - Austin – These things I hope will come out in the stakeholder meetings.)
- **Who should we include as "stakeholders"?**
  - RI EMA as stakeholder, are responsible coordinator to natural and man-made disasters, the have ESFs (Emergency Support Functions) prioritize. This will help us understand infrastructure and how it is viewed today. Will it change priorities?
  - Maybe also include insurers, private companies will also go back and look at insurance companies. Will insurers rethink things? It generates questions that run up the tree and will create dialogue.
  - Include PEMA (Pete Gaynor), their plans are specific to Providence, the federal mandates are not specific. Energy users we might need to include (RI Hospital, NBC)
  - What are the roles of private and public partners in these responsibilities? Where does the port rank in prioritizing emergency response? Knowing this might be beneficial to private partners' inclusion in this.
  - USACE-Pete O'Donnell
  - Exxon/Mobil. We get oil out of New York; they couldn't ship so we needed to get oil from other areas. Tanks have 3-day capacity.
  - Luis Aponte will be a stakeholder

- Steering committee members proposed the following additional contacts during the completion of the study: list of names or organizations from the above or as in table 1.

- **In what specific ways is this project relevant to your needs?**
  - Imbalance of shipping is something that we need to change. We can't rely completely on NY. From resilience stand point how do we get more cargo flowing into the region.
  - Helps prioritize RISG priorities. Help inform other projects going on. Will help to identify ways were RISG might be able to extend outreach to stakeholders.
  - A replicable tool would be really useful to extend to other stakeholder groups
  - Understanding what issues we need to deal with first and what businesses we need to bring back first.
  - Important for highlighting the importance of the area to the city of Providence the region. Examples, bunker oil for RI Hospital.
  - An economic model would be very relevant, one that is adaptable and flexible. Tells people what is this costing the state/day of port shutdown? How many people are out of work?
    - Austin – Not in proposal, but it could be, but we need to assess the abilities/boundaries of proposal. (We are following up with people at URI about feasibility)
    - There is another round of DOT proposals, this might fit.
  - What does a response look like? Information to manage expectations of tenants; information on what agencies are supposed to do what, so things just happen. Planning tools and strategies that can be used for future construction/planning.
- **What would you hope to know at the conclusion of the project? Use statements from Table 1 below to answer this?**
  - What should private companies be asking their insurers?
    - Economic tools would be useful, politicians don't have engineering/science background, but having tools as an education piece would help.
  - Who do you think should be responsible for dealing with these things?
  - How much do we think it would cost to implement these risk reduction strategies?
    - Austin – I think we could come up this in some sense, but wouldn't want to go to far.
  - It should show what would happen in these situations. Who does what and when is important. Who is responsible? Making sure recovery is addressed is important. A good response plan may be a more cost effective way to mitigate.
  - Are there issues with standing regulations?
    - Example, Jones Act?

- We need to understand how the E. Prov. Terminals will be hit. How much supply will we have (how many days of supply)? How much per day is the loss (this derives the amount of money FEMA would give the area)?
- Austin - Do you think they would give us data if they stay anonymous?
  - The numbers would have to stay anonymous. Maybe through a third party. You could also ask them what they feel comfortable giving us? Look at public records (customs)
- We are looking for who would be the most important to bring back after a hazard first
- Where does Providence rank on the list of regional ports (compared to NY, Boston, etc.)?
- Which types of products have redundancy (sourced from multiple locations)?
- Documentation of the project so it can be incorporated into how the USACE looks at these things.
- Would like to see effectiveness of dealing with stakeholders; would like to see something longer than 2 months. How will this translate to different sectors?
- Is there a threshold to when the stakeholders would just move from property rather than dealing with this again?
- Need a debris model and a better understanding of the impacts of debris
  - Austin – might not be in purview of project.
- What are the impacts from the interruption of commerce? Business disruption is huge

- **General Comments**
  - (USACE has GIS database that might be useful to project, gives incited to vulnerable populations/area
    - Social
    - Infrastructure
    - Environmental and culture
    - Rolled these together into an index, this might be useful for project
  - N. Atl. Study – USACE developed parametric costs, won't be exactly right, but might help people think about alternative. Katherine and her ? have looked at assessing vulnerability. Having assessment method available
  - USACE, is also working on a project with the Marine Trans System
  - Kevin – RVD Systems -- computer simulations of storm surge. Tom Guthlein
  - Jones Act was waived for aftermath of Sandy
  - An alternate location to URI may be best for holding the workshops, because URI is far, NTEC might be good, JWU?)
  - USACE resources worth considering include GIS based data on social, infrastructure, environment, and culture for ports; a North Atlantic Study on costs and vulnerability; and a project on Marine Transportation Systems. Other possible contributions may come from RVD systems (Tom Guthlein). Workshop location should be for the ease of participants perhaps at JWU instead of URI.

- **Next Steps**
  - These notes will help develop survey questions and materials.
  - Define stakeholders
  - Proposed Meeting Date: December 4th, 2014

Table 1 -- Summary of discussions

Summary of Discussion
What questions do you have about the project?
• Is storm surge all that will be analyzed? What about time periods?
• Do we need to include other scenarios? i.e. Smaller more frequent floods.
• How do we get stakeholders involved in there own preparations when the federal government provides money after disaster events?
• How granular with the flood/surge modeling be?
• If pipes/infrastructure is under water will they fail?
Who should we include as stakeholders?
• RIEMA, PEMA
• Energy users (i.e. RI Hospital, NBC)
• USACE – Pete O'Donnel?
• Exxon/Mobil, Citgo?
• City of Providence
In what specific ways is this project relevant to your needs?
• Help prioritize Sea Grant priorities. Help inform other projects. Extend outreach.
• Replicable tool that we can apply in other areas for different stakeholders.
• Understanding what we (USCG) need to do first in recovery (i.e. what businesses we need to bring back first, in order to speed recovery).
• Help the City of Providence highlight that area's importance to city/state.
• Possible economic model???
• Inform and manage recovery expectations of tenants at Prov and Quonset/Davisville.
What would you hope to know at the conclusion of the project?
• What should private companies be asking their insurers?
• Who does what, where and when. A good plan.
• How much would it cost to implement strategies (used for comparison)
• Issues with standing regulations
• Understanding of how terminals will be impacted. Value in Dollars/day.
• Where Providence ranks on a regional list.
• What products have redundancy (in regards to sourcing from multiple areas)
• Project documentation so it can be incorporated into other projects (i.e. interactions with stakeholders, etc.)
• Is there a threshold at which stakeholders would decide to not move back into port after disaster?
• What are the impacts to state commerce?
• Modeling (surge, debris, etc.)

Timeline

Table 2 - Timeline

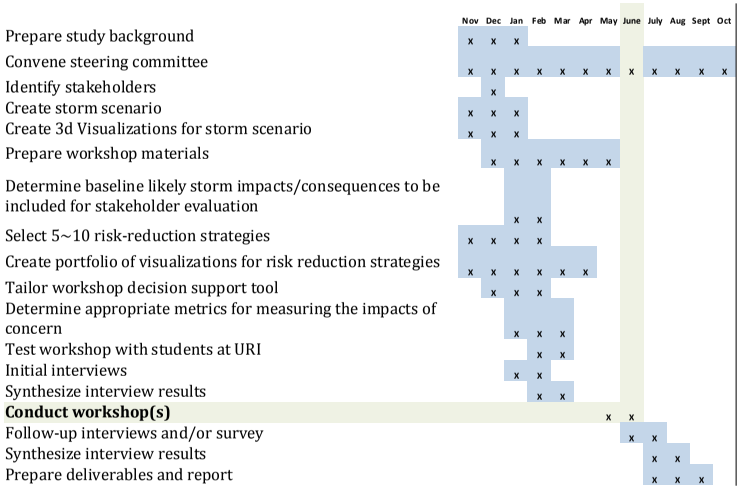

Table 3 -- Committee members

Name	Affiliation	Role	Email
Deb Rosen	URI Transportation Center	Technical	
Mike Sock	RIDOT	Technical	
Tom Queenan	RIDOT	Technical	
Colin Franco	RIDOT	Technical	
Melissa Long	RIDOT & EC4	Steering	
Julie Rosati	USACE	Steering	
Kevin Blount	USCG	Steering	
Chris Witt	RI Statewide Planning	Steering	
Dan Goulet	CRMC	Steering	
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Pam Rubinoff	CRC/GSO/RISG	Steering	
John Riendeau	CommerceRI	Steering	
David Everett	Providence Dept. of Planning	Steering	
Jeff Flumignan	MARAD	Steering	
Evan Matthews	Quonset/Davisville	Steering and Technical Chair	
Corey Bobba	FHWA	Steering & Technical	
Austin Becker	URI	PI	
Rick Burroughs	URI	PI	
Eric Kretsch	URI	Grad Assistant	

Stakeholder vulnerability & resilience strategy assessment of maritime infrastructure: Method development and pilot project for Rhode Island

Steering Committee Kickoff Meeting
Date: Oct. 30 Time: 1:30 - 3:30
Location: Quonset Davisville Corporation Annex, 95 Cripe Street, N. Kingstown, RI
Conference call in number is 866-588-5787 conference code is 9684125388

Please direct questions to Austin Becker

Agenda

- Introductions
- Overview of the project
  - Motivation for the study
  - Background
  - Main questions & deliverables
  - Committee structure & study area
  - Storm scenario
  - Project timeline
  - Major deliverables
  - Role of the steering committee
- Discussion questions
- Next steps
  - Next meeting date (proposed Dec. 4)

Table 1 -- Committee members

Name	Affiliation	Role	Email
Deb Rosen	URI Transportation Center	Technical	
Mike Sock	RIDOT	Technical	
Tom Queenan	RIDOT	Technical	
Colin Franco	RIDOT	Technical	
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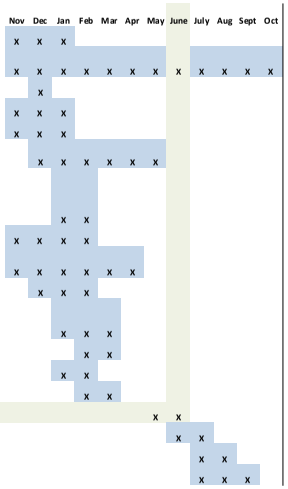
John Riendeau	CommerceRI	Steering	
David Everett	Providence Dept. of Planning	Steering	
Jeff Flumignan	MARAD	Steering	
Evan Matthews	Quonest/Davisville	Steering and Technical Chair	
Corey Bobba	RIDOT	Steering & Technical	
Austin Becker	URI	PI	
Rick Burroughs	URI	PI	
Eric Kretsch	URI	Grad Assistant	

Discussion Questions

1. What questions do you have about the project?
2. Who should be included as "stakeholders?"
3. In what specific ways is this project relevant to your needs?
4. What would you hope to know at the conclusion of the project?
5. Who is missing from the steering committee?

Timeline



I. Intros
II. Overview of project
   a. These assessments are going to be required, but there is not real guidance for how to do it

III. Central question
   - What are the perceived impacts of Hurricane Sandy type event on the Providence Maritime Freight System (PMFS)?
   - How do a variety of potential resilience measures meet the needs/objectives of PMFS stakeholders?
   - How do firms preferred strategies align with gov't sponsored strategies?

Define terms
   Impacts
   Bound the PMFS – who is in who is out?
   Objectives/needs

IV. Role of committees
   a. Technical
   b. Steering
      i. Reality check of our assumptions
      ii. Assistance with stakeholder participation
   c. Client

V. Stakeholders – people/organizations who regularly access the sites within the study area (inc. trucking, rail, shipping agent, etc.)
   a. Option 1 – Actual Users (22 businesses)
   b. Option 2 – Any organizational interest that accesses the site regularly (1/month)
   c. Option 3 - All of option 2 + public sector representatives

VI. Timeline

VII. Survey
   a. Individual actions

VIII. Workshop
   a. Individual vs. collective action
   b. What does the private firm do? Intent to invest?
   c. What do the firms collectively think is appropriate?
   d. What do we learn about collective thinking across gov't?
   e. Objectives –
   f. Gov't?
   g. Private sector vs. public sector?

H1

IX. What do the gov't actors see as most useful? Ask the steering committee.
X. Assessment of private stakeholder needs
XI. What is the collective wisdom about what the gov't should do?
XII. Private industry could do?
XIII. 3 universe model
   a. individual firm
   b. firms together
   c. gov't should do
XIV.

I. Intros
II. Overview of the project
   a. Role of committees
   b. Storm scenario of concern – Cat 4
      i. Visualizations
   c. Example of getting whacked from Gulfport
   d. Part 1 – Perceived impacts of storm
   e. Part 2 – Assessment of resilience measures
III. Discussion points
   a. What we hope to accomplish
      i. Simulation of event
      ii. Individual wisdom from firms
      iii. Collective wisdom from workshop experience
      iv. Developing a tool for conducting these assessments
      v. Replicable methodology

IV. We want from them
   a. Take away
      i. Understand the project
      ii. Answers to their questions
   b. What do we need from them
      i. Who should be included in stakeholders?
      ii. What would you hope we can find out through this project?
      iii. How do we ensure that the project is relevant to your needs?
      iv. How will this information fit into your jurisdiction and mandate?

H2

Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Method development and pilot project for RI

Updates for the steering committee
12-1-14

To the steering committee:
We wanted to catch you up on developments with the project since our last meeting. Given the holidays and general end of semester busyness, we will postpone our next meeting to early January.
Since our last meeting, we have:

- Officially hired grad student Eric Kretsch to assist with the project. Eric was the note taker at the last meeting
- Been in discussions with our colleague (John Haymaker) at AREA Research about customizing the the WeCision software tool that we plan to utilize in the stakeholder workshops. We have several meeting scheduled with John.
- Iterated around the major topic areas and questions to be included in the stakeholder workshops
- Developed a draft survey instrument for pre-workshop interviews/surveys
- Made some inquiries with other faculty at URI with respect to the cost/impact assessment that we discussed at our last meeting. We are exploring the possibility of a "scoping exercise" for this project as part of a student course that will be offered in the spring 2015 semester. The scoping exercise would allow us to develop a proposal for assessing the economic impact of a port closure for a period of days/weeks/months post storm. Stay tuned.

Please note the following dates:

Dec. 12 – Landscape Architecture and Marine Affairs Graduate students to present the final results from the Fall 2014 studio on a resilient Providence waterfront. 1:30 – 3:30 at the Providence Dept. of Planning.

Jan. 8 (To be confirmed) – Next steering committee meeting to review:
- Final list of stakeholders
- Survey instrument draft
- Workshop overview

Jan. 16 – John Haymaker will be in Rhode Island and we will be working on development of the WeCision tool. You are welcome to join us, please let me know it it's of interest.

Many thanks for your continued support on this project,

Austin, Rick, Evan

Introducing

Wecision Enterprise
Collaborative Decision Process

Our cloud-based decision process model and intuitive user interfaces enable collaborative construction and management of decision processes, including:

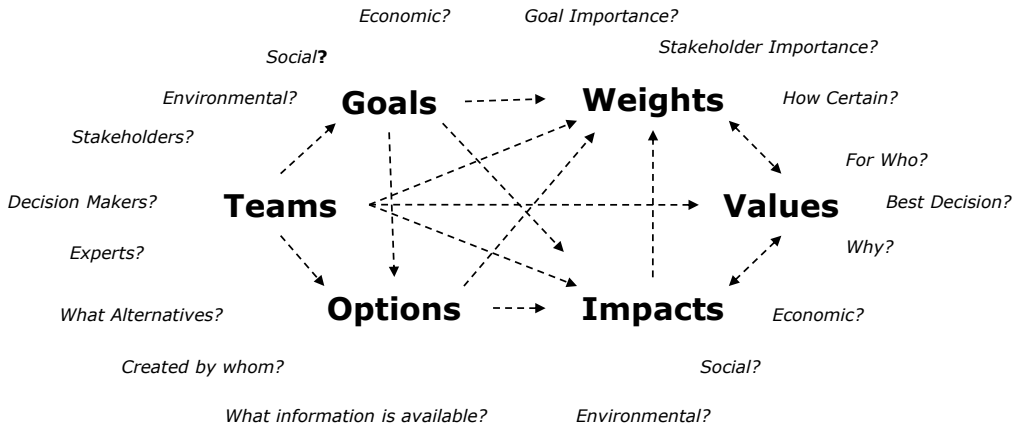
Choosing by Advantages
Assign roles, identify factors, create alternatives, analyze attributes, and calculate and weigh the importance of advantages.

Weight Rate and Calculate
Assign roles, prioritize factors, create alternatives, assess impacts, and calculate and tradeoff multi-stakeholder value.

And customized Decision Processes to meet your needs.

Wecision is a product of Design Process Innovation dpi

Every good decision requires efficient and effective processing of information.

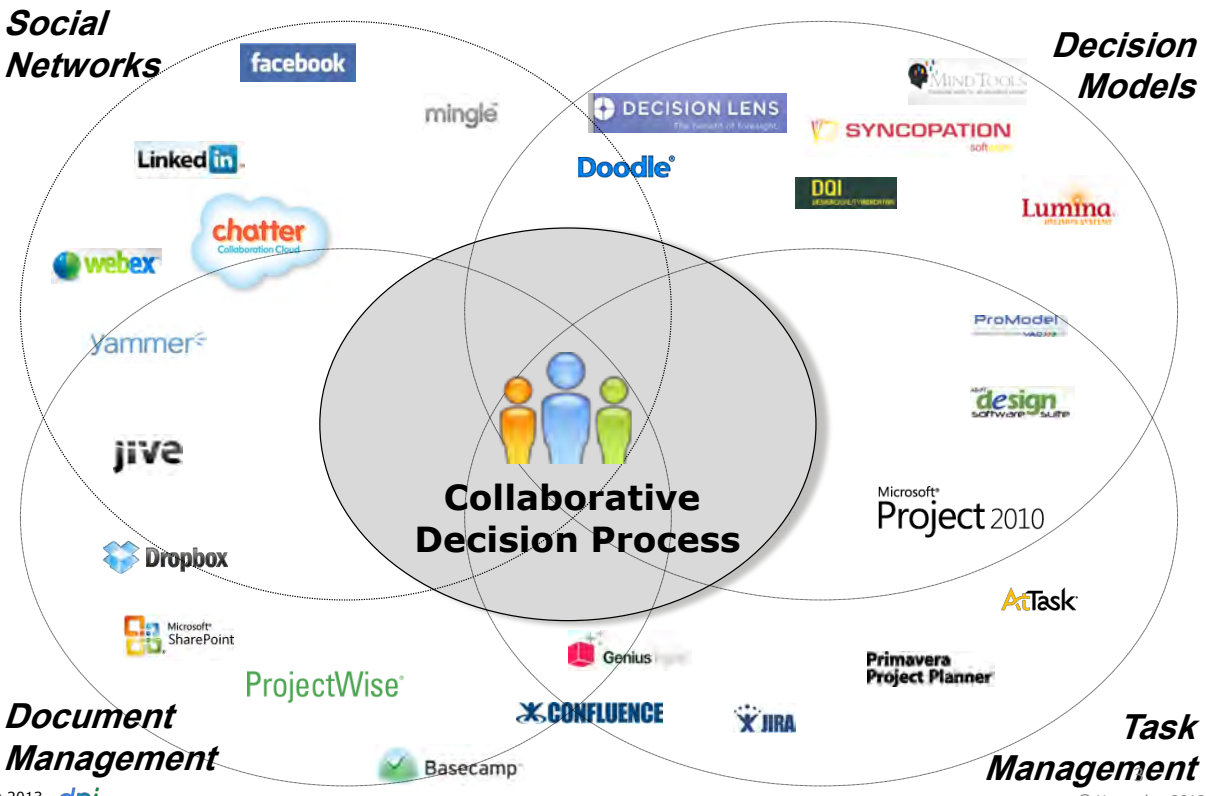


Gathering, processing, and communicating all this information is difficult.
Decision makers often take shortcuts or make mistakes
Leading to less efficient and effective decisions

J2

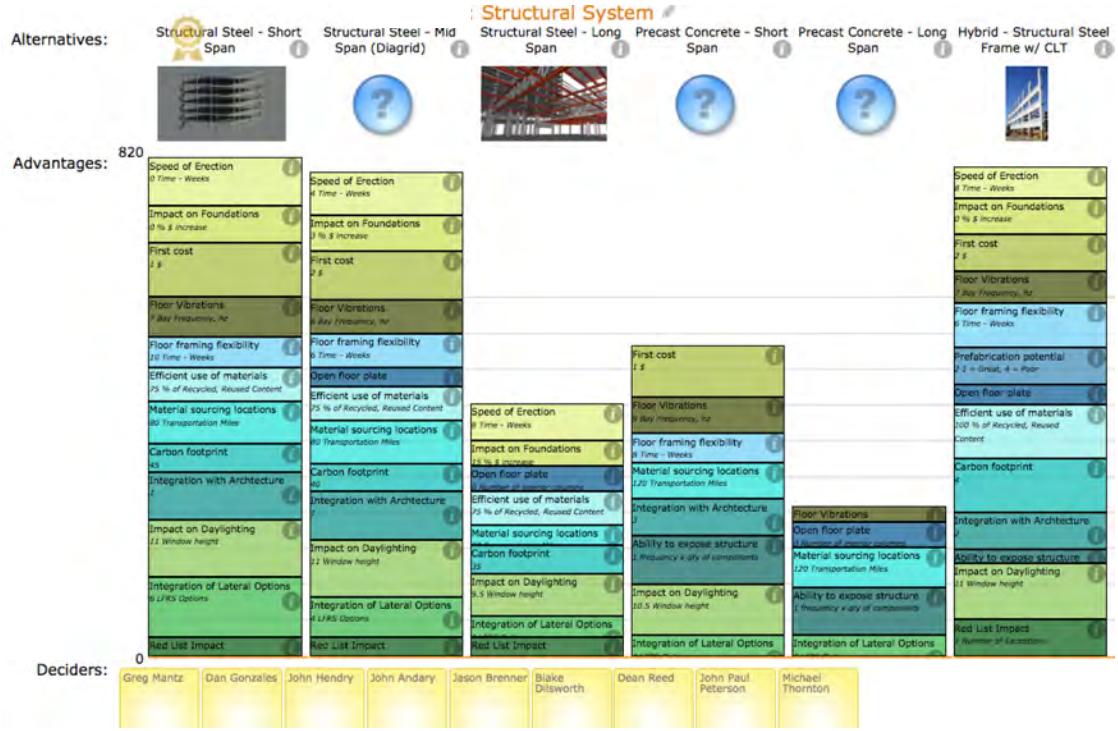
Emerging Landscape

Wecision is a new tool leveraging the intersection of emerging trends.



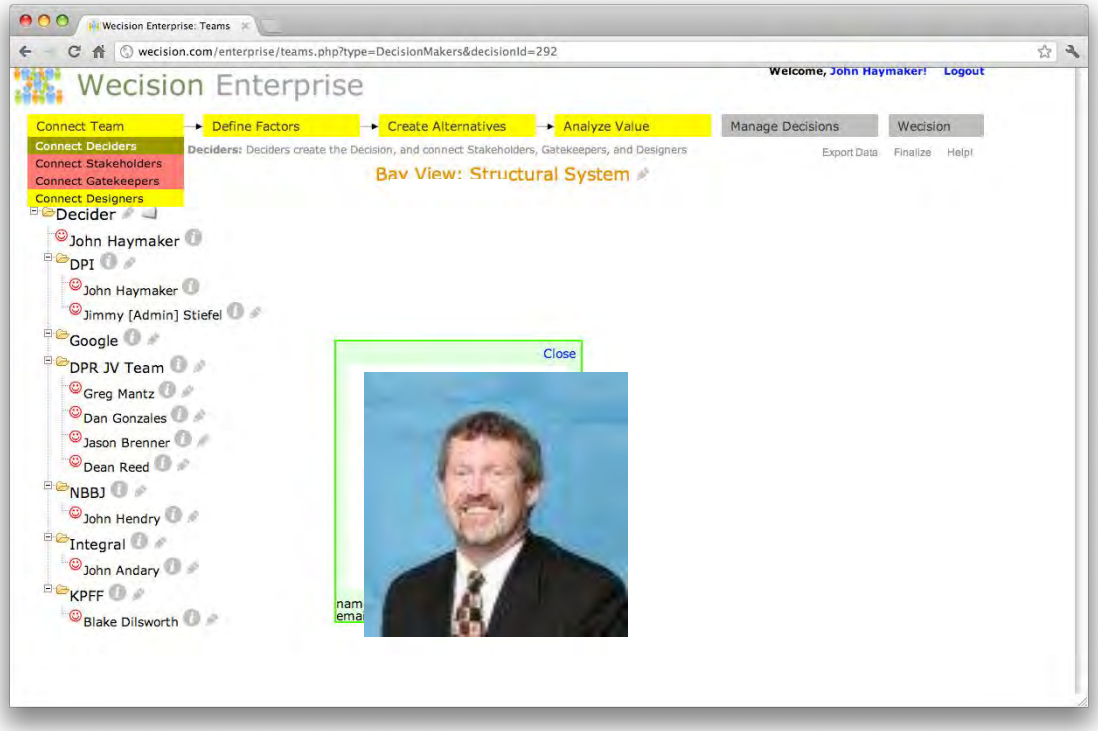
Choosing by Advantages Case Study: Corporate Campus

An IPD contract to design and deliver a large corporate campus.



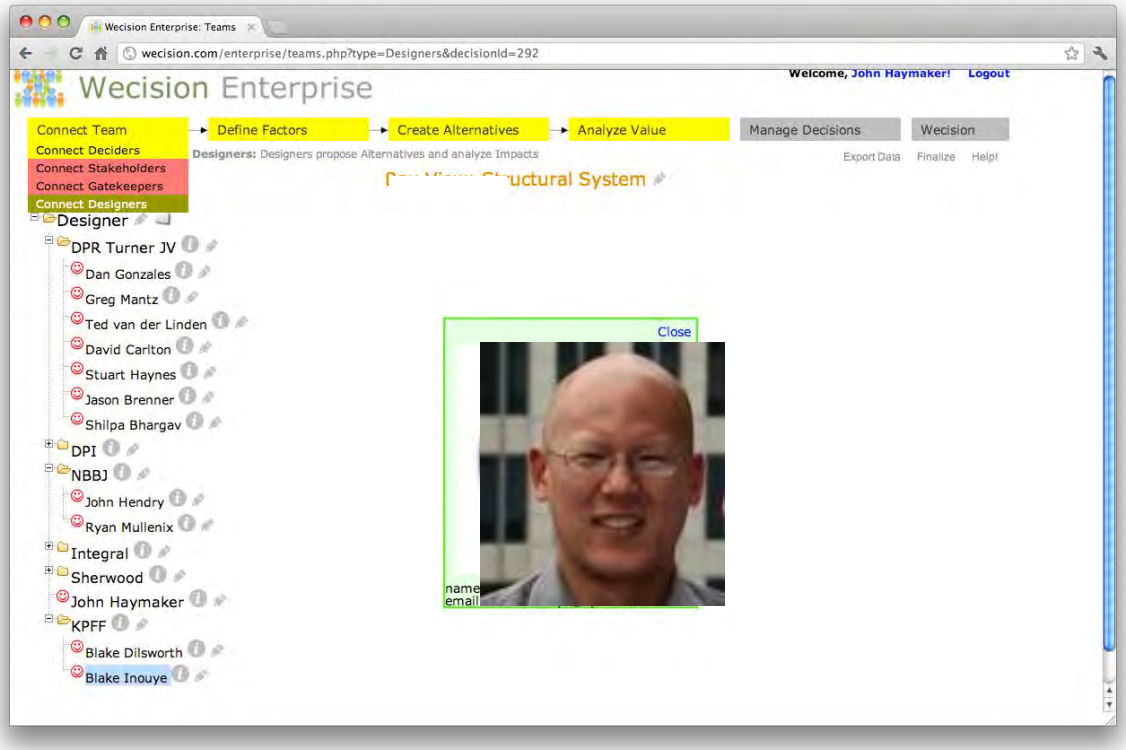
J4

Wecision CBA – Step 1 – Connect Deciders



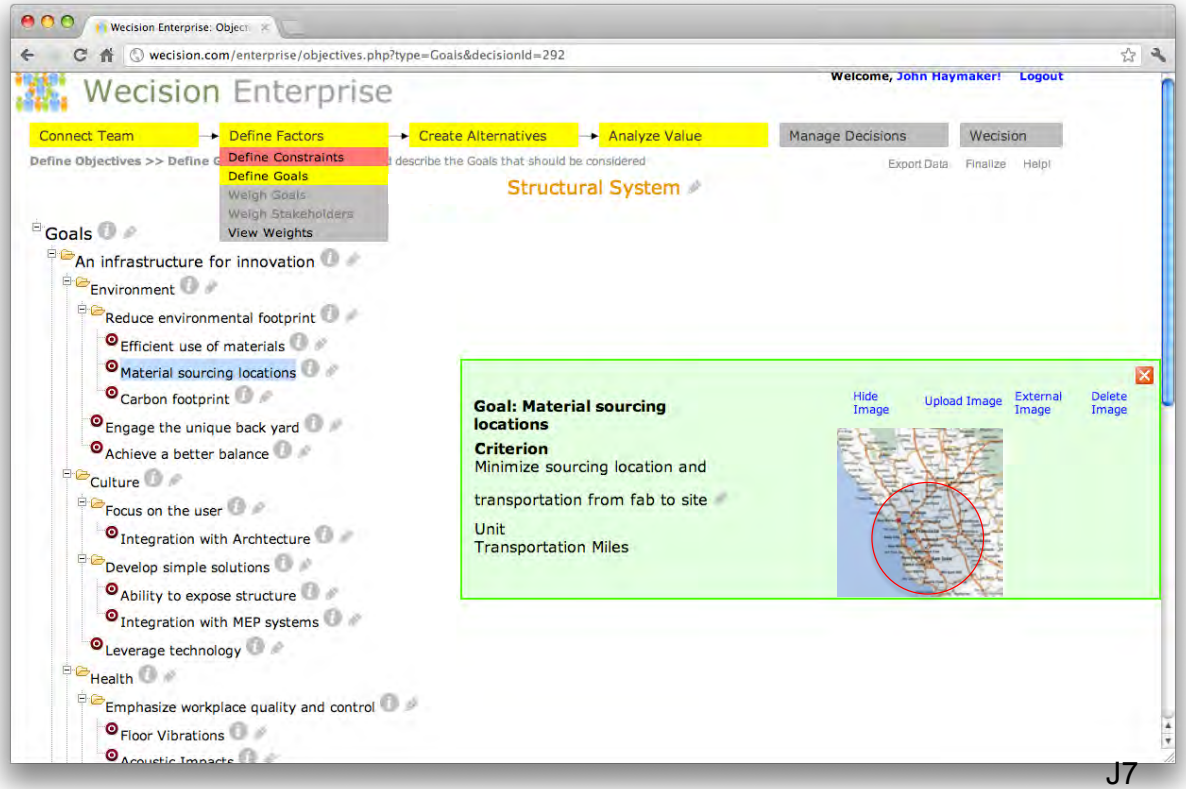
J5

Wecision CBA – Step 1 – and Connect Designers



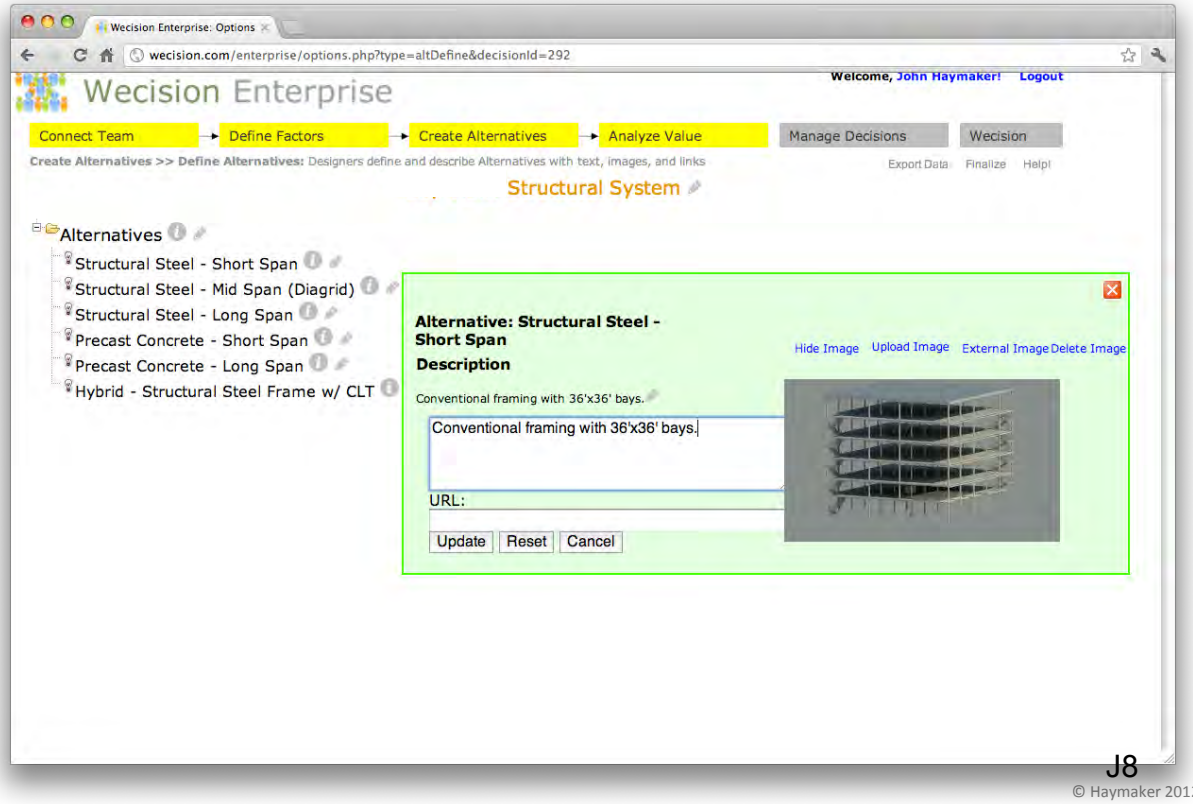
J6

Wecision CBA – Step 2 - Define Factors



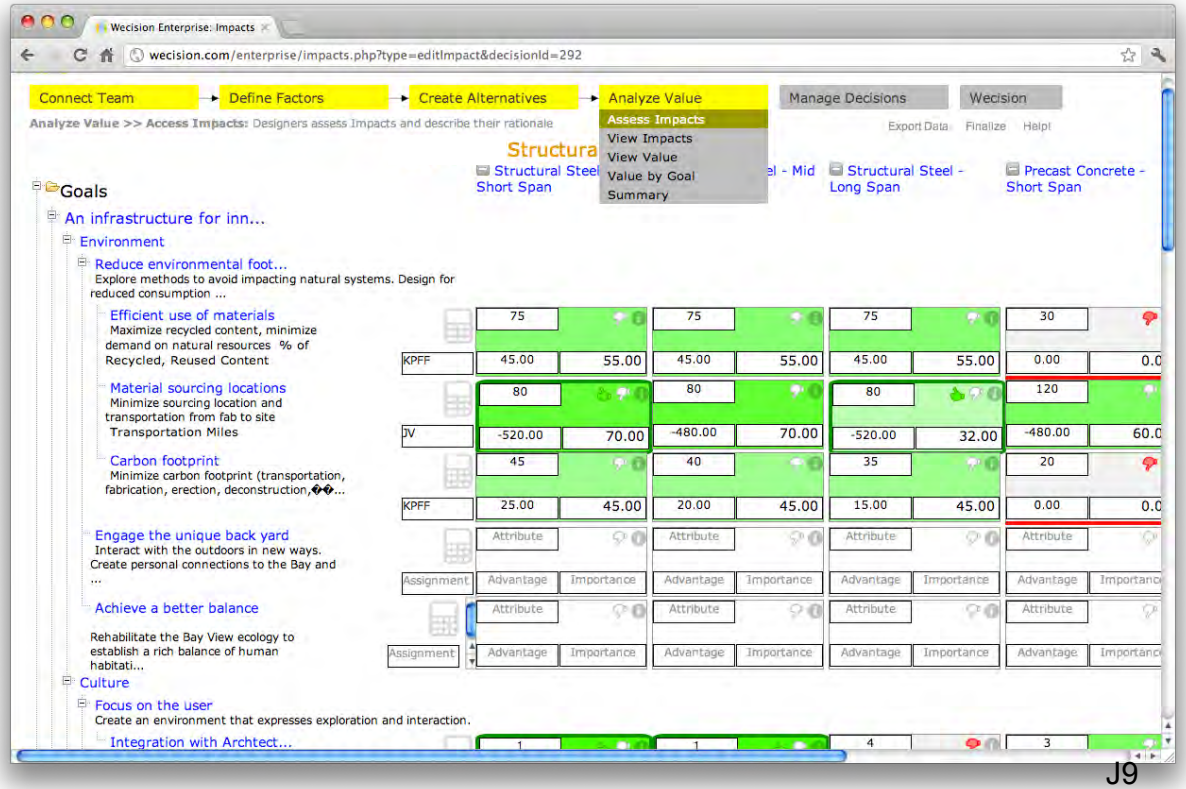
J7

Wecision CBA – Step 3 – Create Alternatives



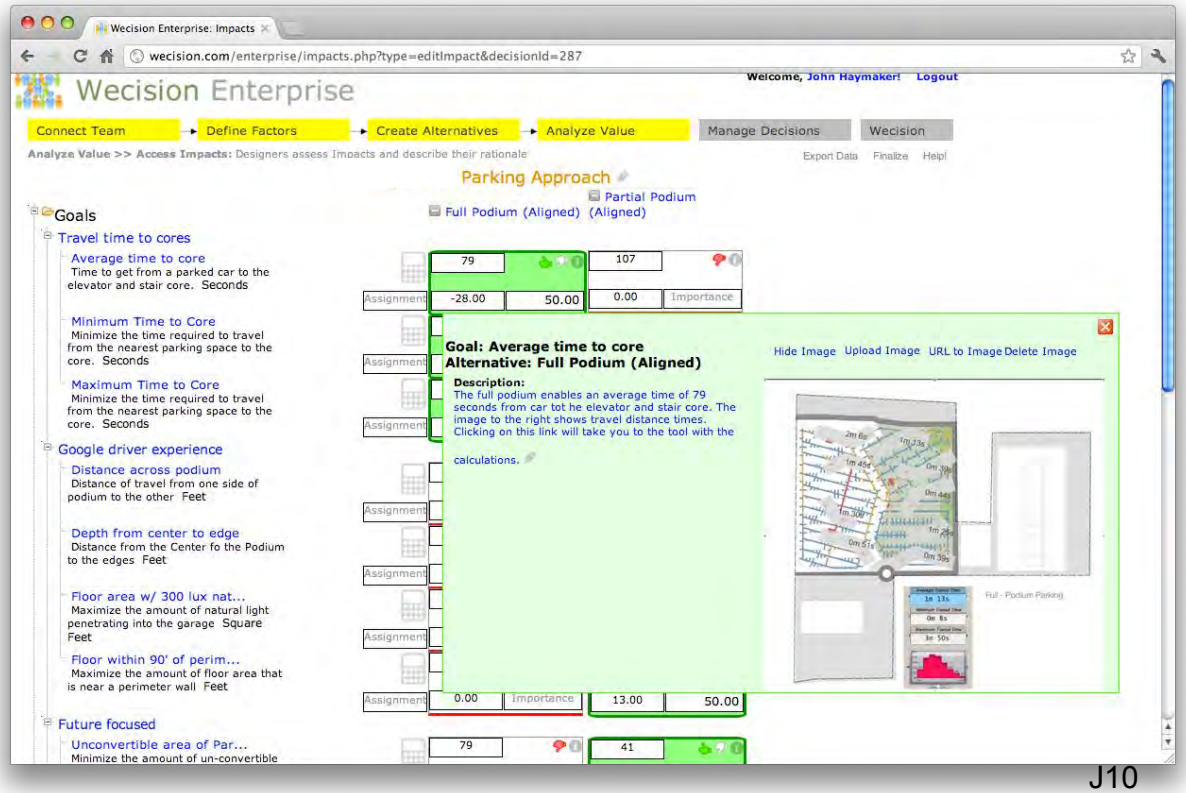
J8

Wecision CBA – Step 4 - Assess Impacts



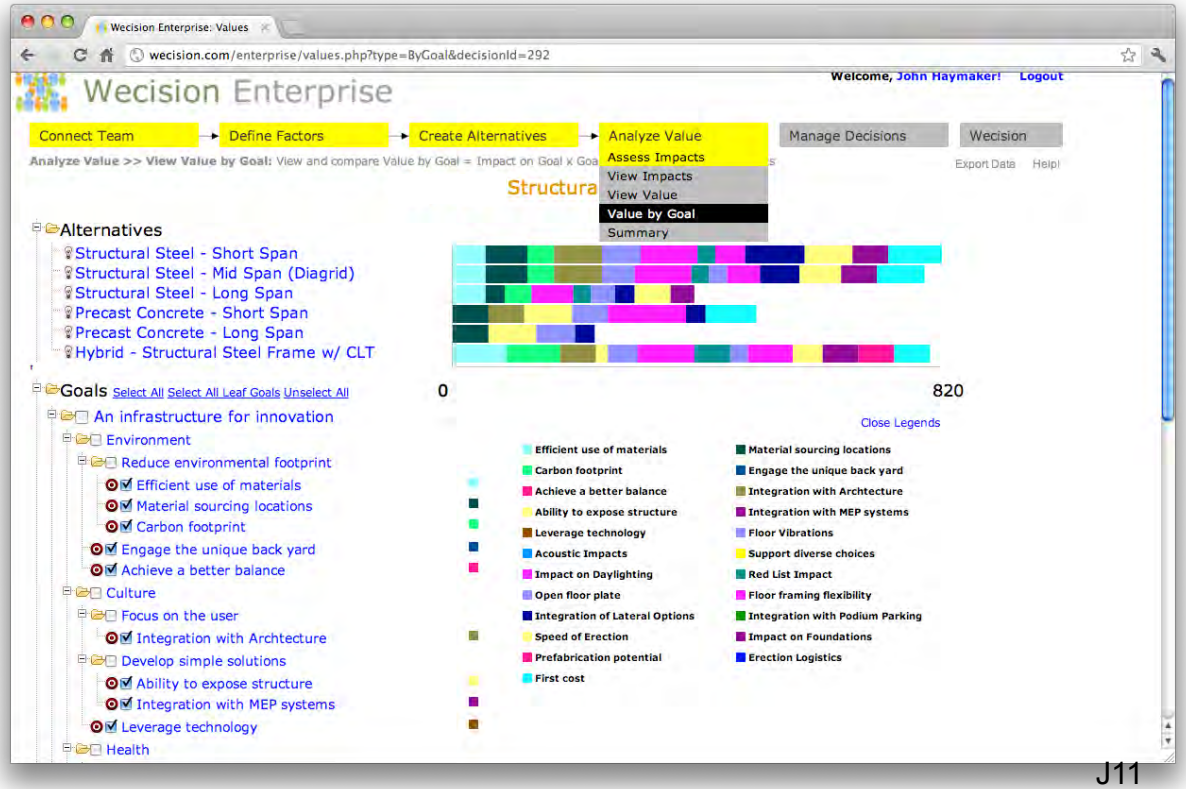
J9

Designers connect supporting data to impacts



J10

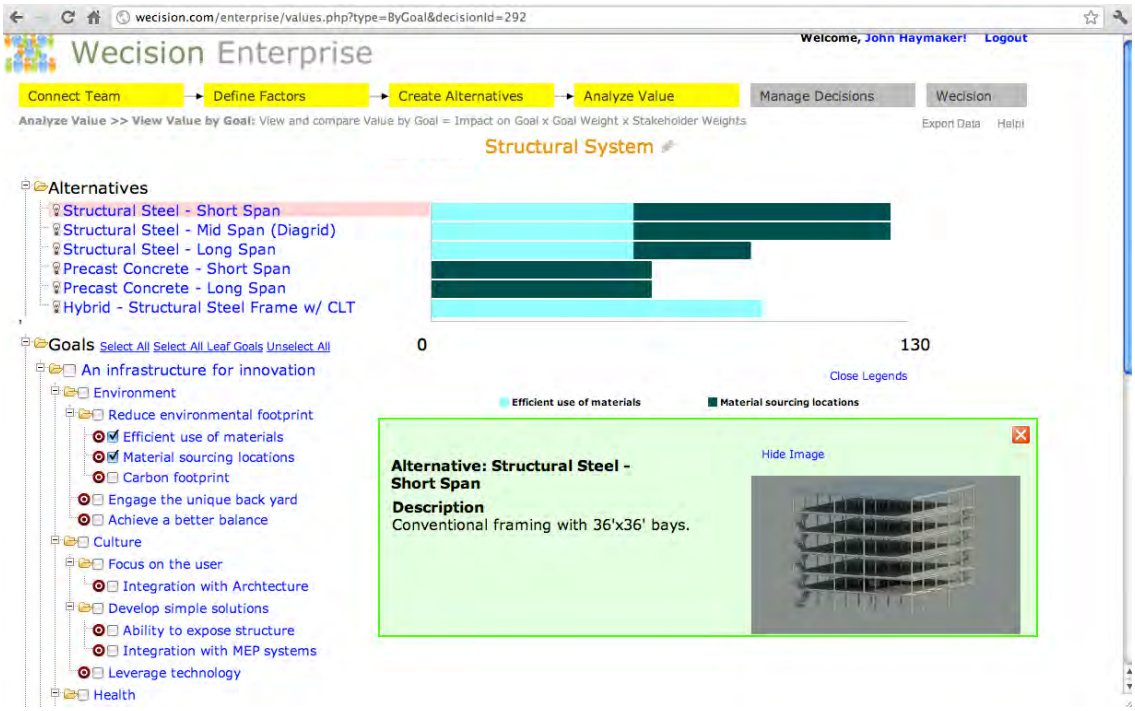
Wecision CBA – Analyze Advantage from Factors



J11

Wecision CBA Case Study: Bay View campus

Wecision helps stakeholders understand driving factors and tradeoffs in decisions.



J12

Wecision Weight Rate and Calculate Case Study: Theme Park

DPR was asked to study prefabrication potential for a large international theme park.

J13

Objectives

Stakeholders weigh Goals, Deciders weigh Stakeholders

J14

Impacts

Designers assess the impacts of each Option for each Objective…

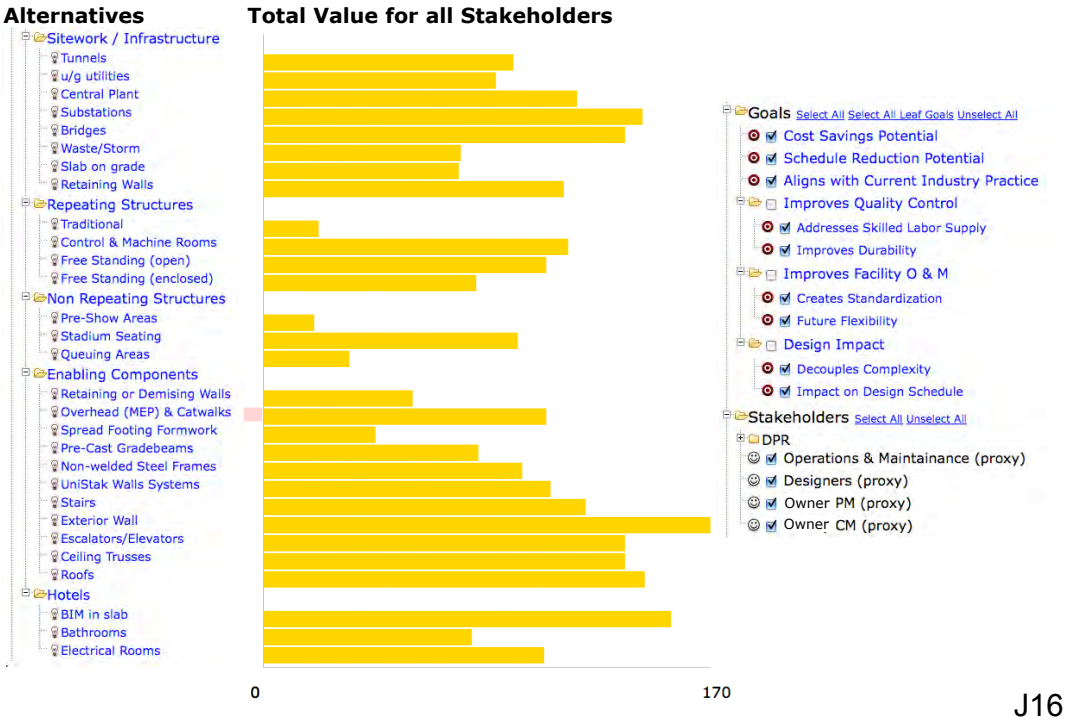
* When many Designers enter Impacts for the same Option, results are averaged

J15

Value

Wecision communicates the total Value of each Option*

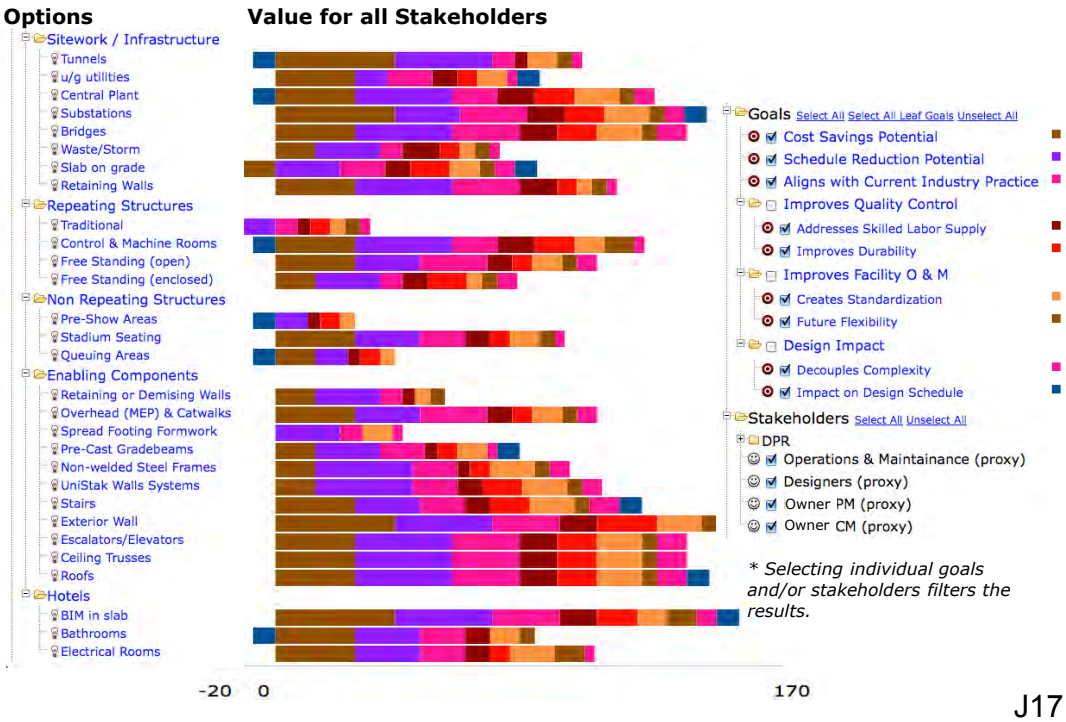
**** Value of Option = Goal Weight X Stakeholder Weight X Option Impact on Goal***



J16

Value

Wecision explains which Options perform best for all Goals and all Stakeholders

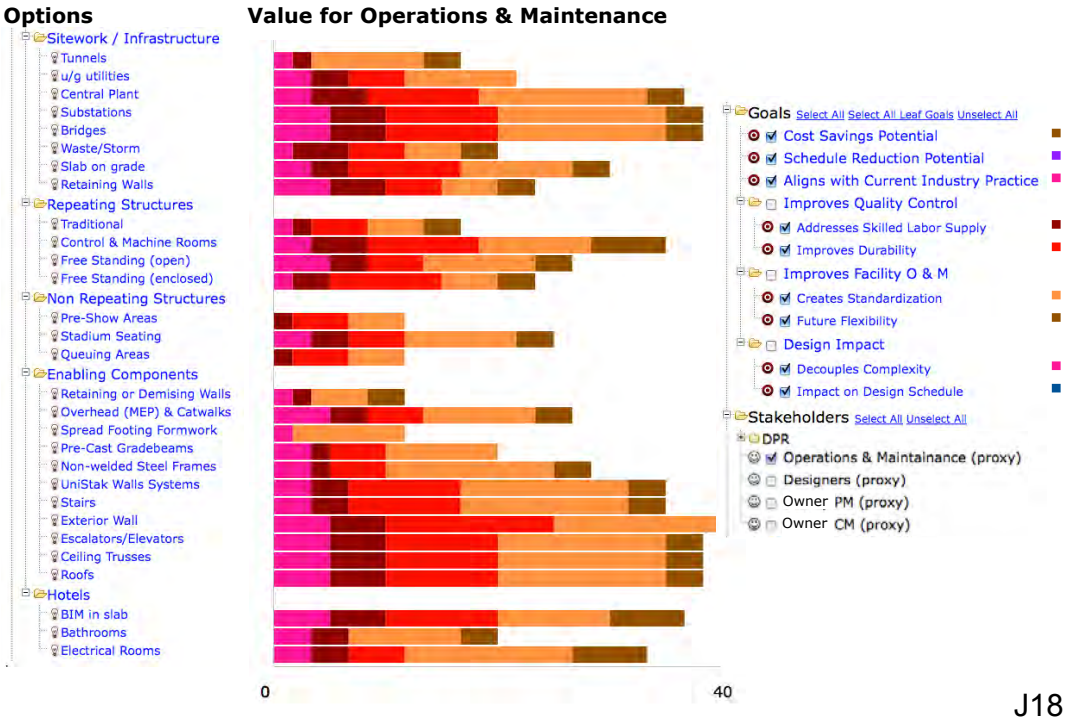


** Selecting individual goals and/or stakeholders filters the results.*

J17

Value

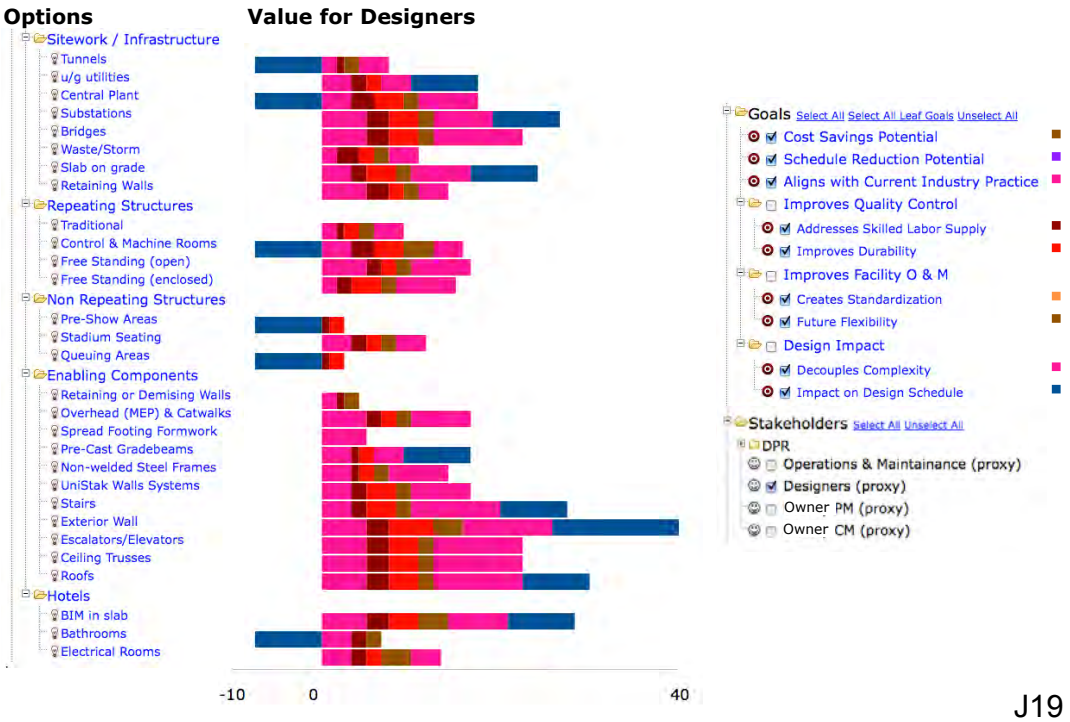
Wecision explains which Options perform best for individual Stakeholders (such as Operations & Maintenance)



J18

Value

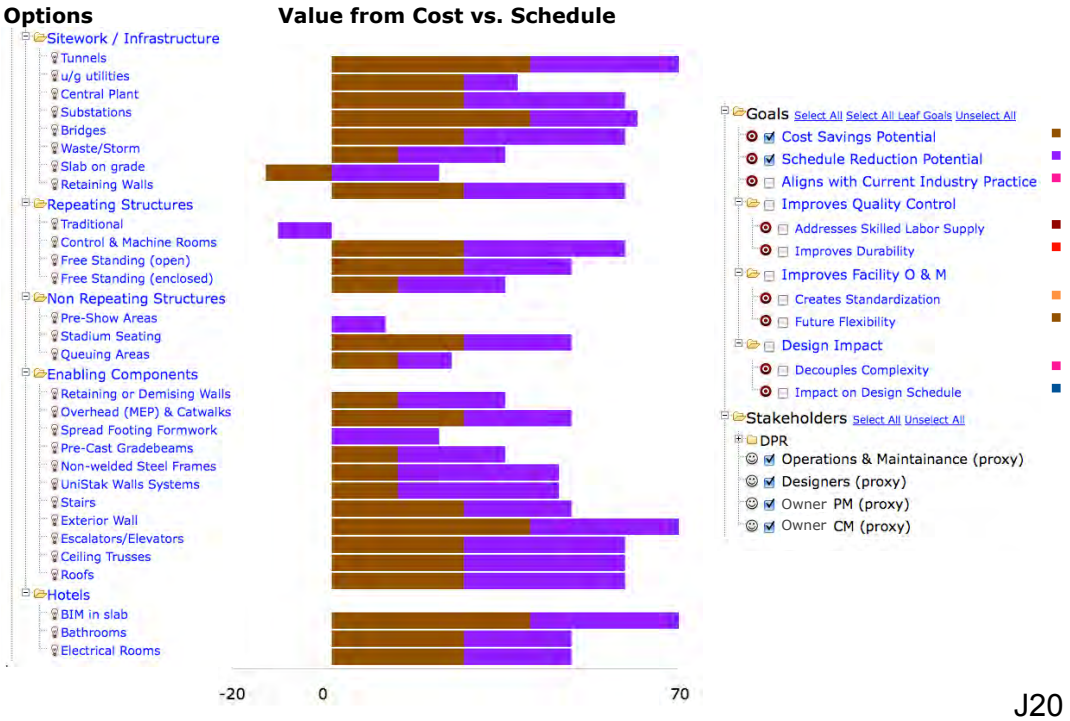
Wecision explains which Options perform best for individual Stakeholders (such as Designers)



J19

Value

Wecision explains which Options perform best for which Goals (such as Cost vs. Schedule)

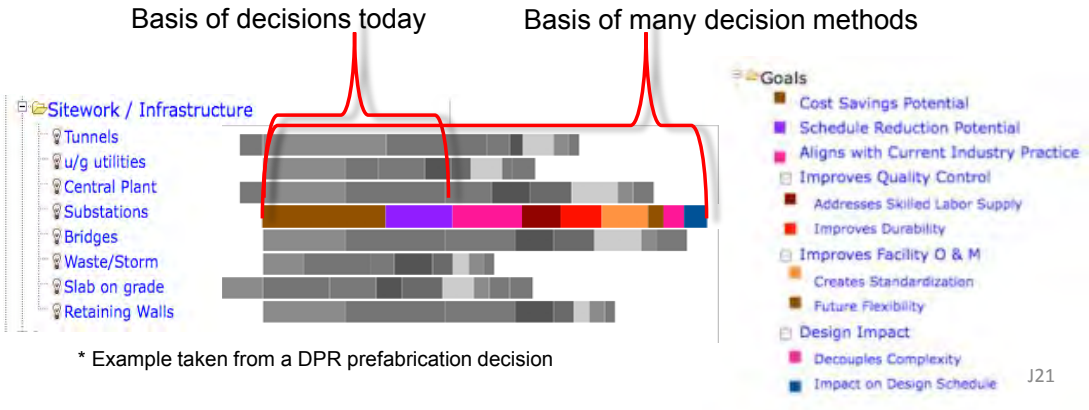


J20

The promise of formal design and decision methods

Include more people, generate more alternatives, consider more factors, make better decisions, faster. Document and reuse rationale.

	Current practice	Formal decision methods
Process Schedule	🕐 🕐 🕐 🕐	🕐 🕐
Process Cost	$ $ $ $	$ $
Product Cost	$ $ $ $	$ $ $
Product Value	$ $	$ $ $ $



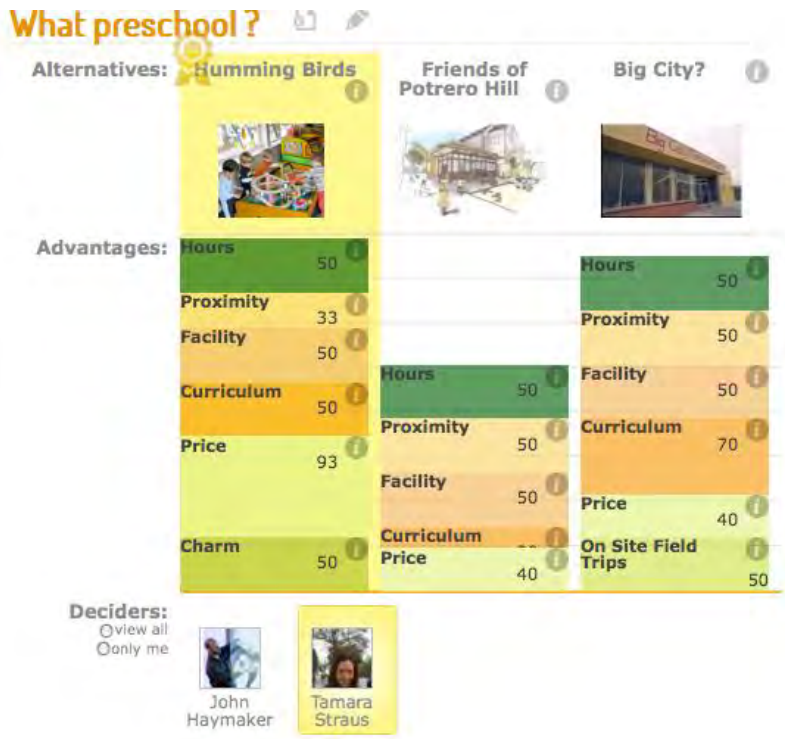
* Example taken from a DPR prefabrication decision

J21

Palo Alto High Speed Rail

J22

Haymaker-Straus Preschool selection



J23

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J24

Stakeholder vulnerability and resilience alternative assessment of maritime infrastructure: Method development and pilot project for RI

Re: Memo to team (Eric K. Emily H., Brian L., Duncan M.)
From: Austin and Rick
Date: Dec. 19, 2014

Team:
Welcome aboard! You've each been selected to play an important role in the research project that is being funded by the RI Dept. of Transportation. The work will take place over the course of this year, culminating in a series of workshops in late Spring.

This memo provides an overview of your roles and the various tasks/deliverables that you have signed on for. Note that this will evolve and be refined over time.

Motivating questions
- How do stakeholders perceive impacts of Hurricane Sandy type event on the Providence Maritime Freight System (PMFS)?
- How do a 5 potential resilience measures meet the needs/objectives of PMFS stakeholders?
- What are the essential elements of a replicable method to conduct this type of assessments?

Team roles:
- Eric K. (20 hours/week) – oversee creation of portfolios, assist with interviews, set up and maintain workspace on Sakai, oversee write up of final report, misc.
- Brian (up to 15 hours per week) – contribute to strategies portfolios, assist with production of portfolios (web, print, etc.)
- Emily H. (up to 15 hours per week) - contribute to strategies portfolios, assist with production of portfolios (web, print, etc.)
- Duncan – (RA hours + 5 hours/week) Create storm portfolio, work with team on visualizations.

Step one is assembling a PORTFOLIO of **storm scenario** and **strategies**, as follows:
1) Storm event -- that results in 21' storm surge
2) Alternative 1 - Relocate businesses to Quonset Pt "resilient maritime industry park"
3) Alternative 2 - Implement "minimum" independent resilience measures that cost 5% of net profits and phased in over 10 years
4) Alternative 3 - Implement "aggressive" independent resilience measures that cost 20% of net profits and phased in over 10 years
5) Alternative 4 - Elevate individual properties to 30' above MSL
6) Alternative 5 – Do nothing

L1

For the storm scenario, we will need:

1) A description of the storm (Category, duration, surge height, wave height, currents, etc.)
2) Visualizations that include:
    a. 8-10 local scale buildings using 3D visualizations
    b. Visual representation of debris
    c. Visual representation of current velocity and waves if possible

Storm impacts questions for stakeholder participants:

Will you have access to your business?
Does your hurricane plan address this level of storm?
Do you have Memorandums of Understanding with other businesses?

For each alternative, we need the following:

1) A 1-2 paragraph description of the alternative
2) A short summary of the costs
3) A short summary of the benefits
4) A short summary of the environmental implications
5) 2-3 visualizations
6) Consideration of the following metrics:

Objectives:

Constraints for stakeholders (e.g., do not spend >$1B)
Goals for stakeholders (e.g., minimize business downtime post storm, minimize business downtime in implementation phase)

Assess impacts (how well does each alternative meet each goal?)

	Storm barrier	Relocate Or elevate?	Min. Individual measures	Max. Individual Measures	Do nothing	
GOALS						
Feasibility						
Effectiveness for storm scenario						
Cost						
% Cost to Feds						
% Costs to State						
% Costs to Local						
% Private costs						
Aesthetics						
Jobs created						
Jobs retained						
Recreation impacts						
Navigation impacts						
Maximize short term profit						
Maximize long term profit						
Minimize business downtime						

Deadlines:

Eric:

1/9 – Sakai workspace up and running, webmeeting tested, folders created for storm scenario and strategies
1/12 – Metrics for each of the "goals" identified above (work with others)
    - What are the questions that can be answered through the exercise?
1/16 – Draft of "Background" chapter based on your paper with Emily P.

Emily:

1/12 - Initial (draft) 1-2 paragraph description of each alternative:
    Storm barrier
    Relocate businesses to Quonset Pt. "resilient maritime industry park"
    Elevate individual properties
    Minimum individual investments
    Maximum individual investments
    Do Nothing
1/15

Duncan

1/9 – Written description of the storm scenario event
1/16 – 8-10 Draft visualizations of local scale surge using 3D building footprints data

Brian

1/27 – Draft visualizations of debris (work with Duncan, read Malcolm Spaulding paper first)

L4

Stakeholder vulnerability and resilience alternative assessment of maritime infrastructure: Method development and pilot project for RI

Re: Memo to team (Eric K. Emily H., Brian L., Duncan M.)
From: Austin and Rick
Date: Jan 5, 2015

Team:
Welcome aboard! You've each been selected to play an important role in the research project that is being funded by the RI Dept. of Transportation. The work will take place over the course of this year, culminating in a series of workshops in late Spring.

This memo provides an overview of your roles and the various tasks/deliverables that you have signed on for. Note that this will evolve and be refined over time.

Motivating questions

- How do stakeholders perceive impacts of Hurricane Sandy type event on the Providence Maritime Freight System (PMFS)?
- How do a 5 potential resilience measures meet the needs/objectives of PMFS stakeholders?
- How do stakeholders perceive responsibility for investing and implementing resilience measures between public and private sectors?
- In what ways does a robust scenario exercise change the behavior of individual stakeholders?
- What are the essential elements of a replicable method to conduct this type of assessments?

Team roles:

- Eric K. (20 hours/week) – oversee creation of portfolios, assist with interviews, set up and maintain workspace on Sakai, oversee write up of final report, misc.
- Brian (up to 15 hours per week) – contribute to strategies portfolios, assist with production of portfolios (web, print, etc.)
- Emily H. (up to 15 hours per week) - contribute to strategies portfolios, assist with production of portfolios (web, print, etc.)
- Duncan – (some RA hours + up to 5 additional hours/week) Create storm portfolio, work with team on visualizations.

Step one is assembling a PORTFOLIO of **storm scenario** and **strategies**, as follows:

1) Storm event -- that results in 21' storm surge
2) Alternative 1 - Relocate businesses to Quonset Pt "resilient maritime industry park"
3) Alternative 2 - Implement "minimum" independent resilience measures that cost 5% of net profits and phased in over 10 years

N1

4) Alternative 3 - Implement "aggressive" independent resilience measures that cost 20% of net profits and phased in over 10 years
5) Alternative 4 - Elevate individual properties to 30' above MSL
6) Alternative 5 – Do nothing

For the storm scenario, we will need:

1) A description of the storm (Category, duration, surge height, wave height, currents, etc.)
2) Visualizations that include:
    a. 8-10 local scale buildings using 3D visualizations
    b. Visual representation of debris
    c. Visual representation of current velocity and waves if possible

For each alternative, we need the following:

1) A 1-2 paragraph description of the alternative
2) A short summary of the costs
3) A short summary of the benefits
4) A short summary of the environmental implications
5) 2-3 visualizations
6) Consideration of the following (DRAFT) metrics in a way that is MEASURABLE either quantitatively or qualitatively:

Table 1 -- DRAFT metrics -- please edit/comment/change as necessary

	Storm barrier	Relocate	Min. Individual measures	Max. Individual Measures	Do nothing	Elevate land
GOALS						
Cost Feasibility						
Political Feasibility						
Responsibility for implementing (% fed, state, local, private)						
Willingness to pay						
Effectiveness for storm scenario						
Cost						
% Cost to Feds						
% Costs to State						
% Costs to Local						
% Private costs						
Aesthetics						
Jobs created						
Jobs retained						
Recreation impacts						
Navigation impacts						
Maximize short term profit						
Maximize long term profit						
Minimize business downtime						

Deadlines:

Eric:

1/9 – Sakai workspace up and running, webmeeting tested, folders created for storm scenario and strategies

1/12 – Metrics for each of the "goals" identified above (work with Emily and others)

- What are the questions that can be answered through the exercise?

1/16 – Draft of "Background" chapter based on your paper with Emily P.

1/12 – Survey monkey for survey

Emily:

1/12 - Initial (draft) 1-2 paragraph description of each alternative (work with Eric):

Storm barrier
Relocate businesses to Quonset Pt. "resilient maritime industry park"
Elevate individual properties
Minimum individual investments
Maximum individual investments
Do Nothing

Duncan

1/9 – Written description of the storm scenario event

1/15 – 8-10 Draft visualizations of local scale surge using 3D building footprints data

Brian

1/27 – Draft visualizations of debris (work with Duncan, read Malcolm Spaulding paper first)

Stakeholder vulnerability & resilience strategy assessment of maritime infrastructure: Method development and pilot project for Rhode Island

Steering Committee Meeting
Date: 6-12-15 Time: 10:00 – 12:00
Location: Quonset Davisville Corporation Annex, 95 Cripe Street, N. Kingstown, RI

Conference call in number TBD
conference code TBD

Please direct questions to Austin Becker abecker@uri.edu

Meeting Objectives:
- Review workshop plans
- Overview of the "storm scenario" we will be using in the workshop
- Overview of the preliminary resilience strategies
- Update on surveys status
- Committee feedback on work to date and plans

I. Intros – 10 mins.
   a. Q. Who, if anyone, needs to be invited from DEM, RIEMA, and FM Global?

II. Update on stakeholder surveys (Eric and Rick) – 10 mins.
   a. Who has been interviewed, who is left (see handout)
   b. Preliminary findings

III. Review draft workshop agenda – 80 mins (Austin)
   a. Mark Amaral to assist with facilitation
   b. Participants to have PCs and use website
   c. Storm scenario presentation (Duncan McIntosh) – 20 mins.
      Q – What, if any, additional info should we provide?
   d. The plan for storm scenario activities with stakeholders – 10 mins.
   e. The plan for identifying stakeholder objectives/goals -- 10 mins.
   f. Strategies presentation (Eric Kretsch and Austin) – 20 mins.
      Q – Specific vs. generic strategies?
   g. Wecision tool (Eric and Austin) – 20 mins

IV. Workshop logistics (Austin)
   a. Timing - End of July – 4 hour block
   b. One or two committee reps to help with detailed agenda planning
   c. Invitees (see handout)
   d. Venue, computers, screens, invite, etc.

Steering Committee members

Name	Affiliation	Role	Email
Meredith Brady	RIDOT	Steering	
Julie Rosatti	USACE	Steering	
Kevin Blount	USCG	Steering	
Chris Witt	RI Statewide Planning	Steering	
Dan Goulet	CRMC	Steering	
Pam Rubinoff	CRC	Steering	
John Riendeau	CommerceRI	Steering	
David Everett	Providence Dept. of Planning	Steering	
Jeff Flumignan	MARAD	Steering	
Evan Matthews	Quonest/Davisville	Steering and Technical Chair	
Corey Bobba	RIDOT/FHWA	Steering/ Technical	
	DEM		
	RIEMA		
	FM Global		

Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Method development and pilot project for RI

Steering Committee Meeting
June 12th, 2015
Location: Quonset Davisville Corporation Annex

Meeting Notes

In Attendance: Evan Mathews (QDC), Corey Bobba (USDOT/FHWA), David Everett (Providence Dept. of Planning), Kevin Blount (USCG), Chris Witt (RI Statewide Planning), Dan Goulet (CRMC), Meredith Brady (RIDOT)
Call-in: Julie Rosatti (USACE), Katherine Touzinski (USACE), Bill McDonald (MARAD), Pam Rubinoff (URI GSO/RISG/CRC), John Riendeau (CommerceRI), Mark Amaral (Lighthouse Consulting Group)
Research team: Austin Becker (URI), Rick Burroughs (URI), Duncan McIntosh (Graduate Student), Eric Kretsch (URI Grad Student), Julia Miller (URI Coastal Fellow and note taker)
Regrets: Mike Sock (RIDOT)

Action items:

- Research team will incorporate the following elements into the storm scenario:
  - Map(s) showing water depths of storm surge
  - Discussion/analysis/characterization of wind and waves associated with scenario
  - Image(s) of typical waves associated with this scenario
  - Images from other historic storms at similar locations and previous events at Providence (e.g. Gulfport post Katrina, Sandy, Hurricane Carol)
  - The date of the scenario will be the date of the workshop
- In "Background Chapter" provide information on required building elevations per CRMC and City of Providence
- A suggestion was made that we bring someone in from the Port of NY/NJ to discuss lessons learned in Sandy. Evan will follow up on this and we will look at incorporating it into the workshop agenda.
- We will add "Basic human safety" and "Lifelines" to the goals list
- Results of workshops should be presented at USCG Safety Forum(s)
- We will brainstorm other ways to disseminate information resulting from the research
- A letter of invitation will be sent to stakeholders in the next week. We will follow up with a phone call to set the date of the workshop.

Discussion Notes:

General

AB: We plan to hold the workshop at the end of July. Our target is about 25-30 participants. We will start with the business community and invite/include others as space and schedule permit. If necessary, we can hold two workshops but we prefer to keep it to one only. We will provide refreshments and a $50 gift card as incentives. We have been working on the storm scenarios, strategies, and WeCision tool. These are developing well and we continue to fine tune.

Storm Scenario

1. AB: Do we want to provide details of climate?
    a. CB: keep key aspects in the presentation- pieces that validate why we chose the model at high tide, coming from south etc.
    b. RB: this type of an event is similar to hurricane carol; this type has happened.
2. DG: What quadrant will be in?
        i. DM: northeast/ top right.
3. DG: Do we have pictures from Gulfport with debris fields?
    a. Ab: Yes, in the website we will provide images from 38, 54 and also other hurricanes from other places.
4. PR: Will you share water depth for flood?
    a. DM: We can show water depth from our maps. We have 21 ft. storm surge and then can subtract ground level.
    b. PR: it would be helpful to include water depth in storm tools
5. Em: We have to build to +16, does providence already have to do that?
    a. +10 in providence.
6. JR: Do you anticipate the wave action will be significant?
    a. DM: I have looked at wave model and it predicts more 4 or 5 ft waves.
    b. AB: Julie do you know any other wave models?
    c. JR: storm models after sandy for the whole northeast.
7. CN: Can we have visualization of wave action?
    a. DM & AB: Yes, we can provide some visualizations of wave heights to provide context.
8. DE: On the wind issue is there any way to predict debris just from that?
    a. AB: We can include a Hazus run for wind damage.
9. KB: What time of year will storm occur?
    a. AB: This is up to the team. I propose that we set it for the day of the workshop.
10. JR: Is tourism more or less in a certain time of year?
    b. KB: We did ours around July 4th for most congested roads.

Workshop Plans 2:

1. EM: We have contacts with NYNJ port and they have a lot of experience with what they dealt with after sandy and recovery. Power and fuel went down.
    a. PR: Really helpful to put it into reality check.
2. DE: Are there examples that are comparable?

    a. EM: It's mainly about aftermath and resilience. Providence only has 3 to 5 days of extra fuel supply.
3. EM: How much fuel does the hurricane barrier have?
4. RB: Wouldn't the operator want their tank to be empty?
    a. EM: They only have resupply and they are constantly resupplying.

GOALS

5. CB: What about life-line services? Power to homes/health and safety
    a. We will let them decide which goals they want.
6. CB: What is the point of creating new jobs? (Why is that a goal?). Maybe, if the port is more resilient that can attract new businesses.
    a. EK: Our thought was to let these emerge from the group and brain storm.
7. UNK: We need to have basic public safety on the goals list.

Resilience Strategy Concepts

1. Generic vs. specific strategies?
2. CB: Will zoning ordinances be in accommodate?
3. DE: What are the circumstances in the examples that allowed them to accommodate?
    a. AB: We can try to provide storyline.
    b. UNK: Mention whether these were done as response or preparation.
    c. EM: We should add other realistic examples: if we could show coal and salt movement.
    d. KB: What will the debris in the water? Blocking the navigation sectors?
4. AB: Should we provide exact locations for relocate?
    a. EM: Relocate is very controversial, we shouldn't provide specific examples at 1st
5. EM: Should we include Fall River?
    a. AB: We were think because this was a RIDOT project we would only include RI ports
    b. KB: Port security we group ports of Narragansett Bay.
6. DG: Relocate should show types of areas but also show challenges to this.
    a. Should show constraints and challenges to relocation.
7. RB: What kinds of single businesses have relocated because of storm danger?
8. EM: Marine terminals have migrated away from the business centers except for new England because we have no where to go. We have constrained businesses not to move.
9. PR: Why are relocate and retreat put together?
    a. AB: Relocate is more of a proactive response, whereas retreat would simply not allow for new businesses to develop or old businesses to redevelop in the flood plain
10. Workshop Plans 3

1. CW: What will you be left with at the end of the workshop?
    a. What are options are realistic?

   b. What are the attitudes towards strategies?
2. CB: For flow: we should give move reasons why we are doing this? What would it mean for RI? We need to prepare.
   a. AB: What is the role for DOT in this workshop?
   b. CB: I could say a couple words on the US perspective
   c. MB: I don't think we need to do stage setting; having done small town planning you need to really jump in and not do too much background which could be on the website
3. EM: My concern is getting not mixed enough stakeholders. You have public sector, which this is apart of our job but the private sector is going to have a difficult time getting to something in the middle of the day.
   a. AB: Working Waterfront Alliance seemed to be okay with a half day but can not give a full day.
   b. AB: Could also provide two days for options.
4. DE: Later down the road, I would like to see this have an impact on policy.
   a. RB: We would ideally like impact on firm level.
5. DE: What is the best way of making the powers that be see this is a solid effort.
   a. RB: We would have some increasingly exciting graphics which newspapers are attracted to.
6. EM: I think that at a minimum that it would be important to have the security sector acknowledge us. Mayor should be invited; he is interested in port issues.
   a. DG: Invite climate change resilience legislative bodies.
7. AB: Challenge is making sure there is a balance and that it is focused on users of the port.
8. EM: I've seen in the past businesses that interact with the politicians will have a different answer and not be as a candid.
9. MB: If we have two workshops; we could invite them to one and give another without politicians.
10. DG: I think one meeting is fine because with two it might get lost.
11. AB: My main concern is getting these businesses to attend.
12. KB: If we took the businesses that have a regional effect and pull those out for 3 days what will be that aspects getting those back up?
13. DG: What if we have the same day as the Port Safety and Security Forum?
   a. EM: If you have it in the same room; have the opportunity to grab them.
   b. DG: I think that having that will raise attendance – pick them up at 1230 and give them lunch then go to 4:30.
14. JM: Can this businesses attend a full day? We talked earlier about them only being able to give a half day.

Q4

Agenda

Meeting Objectives:
- Review workshop plans
- Overview of the "storm scenario" we will be using in the workshop
- Overview of the preliminary resilience strategies
- Update on surveys status
- Committee feedback on work to date and plans

I. Intros – 10 mins.
   a. Q. Who, if anyone, needs to be invited from DEM, RIEMA, and FM Global?
II. Update on stakeholder surveys (Eric and Rick) – 10 mins.
   a. Who has been interviewed, who is left (see handout)
   b. Preliminary findings
   c.
III. Review draft workshop agenda – 80 mins (Austin)
   a. Mark Amaral to assist with facilitation
   b. Participants to have PCs and use website
   c. Storm scenario presentation (Duncan McIntosh) – 20 mins.
      Q – What, if any, additional info should we provide?
   d. The plan for storm scenario activities with stakeholders – 10 mins.
   e. The plan for identifying stakeholder objectives/goals -- 10 mins.
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      Q – Specific vs. generic strategies?
   g. Wecision tool (Eric and Austin) – 20 mins
IV. Workshop logistics (Austin)
   a. Timing - End of July – 4 hour block
   b. One or two committee reps to help with detailed agenda planning
   c. Invitees (see handout)
   d. Venue, computers, screens, invite, etc.

Q5

HURRICANE RESILIENCE:
PLANNING FOR THE PORT OF PROVIDENCE
Post workshop review and debrief
Project Steering Committee
10-19-2015
Coastal Institute (Bay Campus) Large Conference Room
9am – 12pm

RSVPs: Linsey Callaghan (RIDOA), Evan Matthews(QDC), John Rieandeau (CommerceRI), Kevin Blount (USCG), David Everett (Prov Planning), Pam Rubinoff (CRC/RISG), Meredith Brady (RIDOT)

Regrets: Corey Bobba, Julie Rosatti, Chris Witt, Colin Franco

Research team: Mark Amaral, Rick Burroughs, Austin Becker

Note takers: Eric Kretsch, Duncan McIntosh, Alanna Casey

Objectives

1. Review the August 3rd, 2015 workshop agenda and draft report
2. Evaluate the process, tools (visualizations & Wecision) and concepts used during the workshop
3. Make specific recommendations for how these elements can be adjusted to improve the future workshop's outcomes
4. Agree to concrete next steps for the organizations represented on steering committee to take to further this resilience work.

Agenda and flow

09:00 Introductions

09:15 Review of objectives and agenda (Austin)

09:25 At the macro scale, Walk through of the workshop's goals, agenda and outputs– what did we do, what did we accomplish.

QUESTIONS:

(1) Overall, how well did the process and flow achieve the workshop's agenda;
(2) In what ways did the workshop yield informed results that could shape long-term hurricane resiliency planning for the port of Providence;
(3) Big picture, what was missing?

09:45 Using the workshop objectives, assess key elements of the event: Present overview of session with examples/samples, get feedback from group. These objectives were:

1. Understand and comment on a possible storm scenario and consequence for the port area (30 minutes) (*Objective 1 in objective list of final report*)
   - Presentation from Port of New York New Jersey
   - Visualizations- what could happen in Providence
   - Participants identifying impacts

QUESTIONS:

(1) How useful was the Presentation from Port of New York New Jersey at informing the conversation;
(2) Was the chosen storm scenario (Cat 3 / worst cast) appropriate for the exercise?;
(3) In what ways were the visualizations helpful and how could they be improved;
(4) Was the group activity helpful in shaping the understanding of possible impact and if not, how could this time have been spent differently?

2. Long term resilience concepts alternatives (30 minutes)
   - Review different long-range resilience concept alternatives for protecting port community against storm damage (*Objective 3 in objective list*) (show example of slides)
   - Review possible long-range resilience goals for the port (*Objective 2 in objective list*) (show example of slides)
   - Application of Wecison tool
     - Weigh importance of each goal to different long-range resilience concept alternatives (*Objective 4 in text of final report*)
   - Presenting results to Understand the value of each alternative to each stakeholder (*Objective 6 in objective list*)

   QUESTIONS:

   (1) In what ways did the three concepts support or hinder the conversation;
   (2) How could the long term resilience goals have been explained more clearly;
   (3) What are the strengths and weaknesses of voting on goals as a measurement of alternatives; Did the Wecision tool facilitate or slow this process;
   (4) What three things would you change about the use of the Wecision tool;
   (5) How can the Wecision results be more clearly presented;
   (6) What results did the process lead to?

3. Conclusion (15 minutes)
   - Groups answered two questions:
     - Assess this workshop methodology and tool as a way to measure port vulnerability and initiate discussion on long-range resilience concept alternatives (*Objective 7 from objective list*)
     - Identify collective action that needs to be discussed now and recommendations for RI DOT; capture next steps. (*Objective 8 from objective list)*

   QUESTIONS:

   (1) What other approaches could be used to define future actions by the participants;
   (2) What were the plusses and minuses to this method for collection of information

11:00 Development of process and application

1. Are there other factors that were missed but are critical to honest resilience planning (e.g., political will, costs, efficacy of options, time)?
2. Role of the steering committee played in the project: (1) was it too much time; (2) was it valuable; and, (3) would you do it again?

3. What are the next steps for the organizations represented on steering committee to further this resilience work?
4. Discuss where we should target for next workshop (another one in PVD? Other places?)
5. Present planned next steps and how the process will be revised

12:00 Adjourn

Materials:

- Hard copies of summary report
- Marked up maps on easels
- Hard copies of workshop PPTs
- Refreshments (coffee, fruit, bagels?)

HURRICANE RESILIENCE:
PLANNING FOR THE PORT OF PROVIDENCE
Post workshop review and debrief
Project Steering Committee
10-19-2015
Coastal Institute (Bay Campus) Large Conference Room
9am – 12pm

RSVPs: Linsey Callaghan (RIDOA), Evan Matthews(QDC), John Rieandeau (CommerceRI), Kevin Blount (USCG), David Everett (Prov Planning), Pam Rubinoff (CRC/RISG), Meredith Brady (RIDOT), Mike Sock (RIDOT), Dan Goulet (CRMC), Deb Rosen (URITC), Bill McDonald? (MARAD)

Regrets: Corey Bobba, Julie Rosatti, Chris Witt, Colin Franco, John Haymaker, Jeff Flumignan

Research team: Mark Amaral, Rick Burroughs, Austin Becker

Note takers: Eric Kretsch, Duncan McIntosh, Alanna Casey

Objectives

1. Review the August 3rd, 2015 workshop agenda and draft report
2. Evaluate the process, tools (visualizations & Wecision) and concepts used during the workshop
3. Make specific recommendations for how these elements can be adjusted to improve the future workshop's outcomes
4. Agree to concrete next steps for the organizations represented on steering committee to take to further this resilience work.

Agenda and flow

09:00 Introductions

09:15 Review of objectives and agenda (Austin)

09:25 Walk through of the workshop's goals, agenda and outputs– what did we do, what did we accomplish.

09:45 Using the workshop objectives, assess key elements of the event:

- Understand and comment on a possible storm scenario and consequence for the port area
- long-range resilience concept alternatives for protecting port community against storm damage
- long-range resilience goals for the port
- Application of Wecison tool
- Conclusion

11:00 Development of process and application

12:00 Adjourn

Recommendations for RIDOT include:

- A database of stakeholder and designer/expert types to include in these types of discussions.
- A database of standard resilience goals to consider.
- A database of alternatives to address port resiliency, indexed by performance with respect to these goals.
- A network of experts able to propose and analyze these alternatives.
- A process and tool for collecting, accessing, analyzing this information.

The next steps in this project are to improve and refine the workshop methodology and implement hurricane resilience workshops in port communities around the state of Rhode Island. Specifics include:

- Refine workshop tools, Wecision interface, and workshop methodology.
- Develop more robust disaster visualizations and models.
- Conduct additional workshops in Providence and other RI ports.
- Conduct follow-up survey with stakeholders to identify workshop impacts on business planning.

Many thanks to our graduate research assistants Eric Kretsch and Duncan McIntosh, seniors in Landscape Architecture Brian Leverriere and Emily Humphrey, and student volunteers at the workshop Julia Miller (Coastal Fellow), Nicole Andrescavage, Zaire Garrett, Peter Stempel, and Emily Tradd.

For further information on this project please contact Dr. Austin Becker at 401-636-0430.

Appendix 1: August 3rd, 2015 Workshop Agenda

HURRICANE RESILIENCE:
LONG-RANGE PLANNING FOR THE PORT OF PROVIDENCE
August 3rd, 2015, 1-5PM
Save the Bay Center, 100 Save The Bay Drive, Providence, RI 02905

Workshop Objectives:

1. Understand and comment on a possible storm scenario and its consequences for the port.
2. Review proposed long-term resilience goals for the port and weigh importance of each goal to different long term resiliency concept alternatives.
3. Review proposed long-term resilience concept alternatives for developing a resilient port community.
4. Assess this workshop methodology as a way to measure port vulnerability and initiate discussion on long term resilience concept alternatives
5. Identify collective action that needs to be discussed now and recommendations for RI DOT; capture next steps.

Detailed Session plan

1:00 Welcome and flow, *Dr. Austin Becker, Project Team co-leader*

1:25 Major Storm Scenario – what has and what could happen

- Super Storm Sandy and the Port of New York New Jersey -- What really happened *Mary Lee Clanton, Manager, Facility Construction Support*
- Cat 3 Scenario and the science of New England hurricanes, *Duncan McIntosh, PhD student*
- Identifying impacts and consequences for the short and long terms, *Participant activity*

2:50 Break

3:00 Long term resilience concept alternatives for the Port of Providence

- Using the Wecision decision making tool *Dr. John Haymaker, Director, AREA Research*
- Present three long term resilience concept alternatives
- Measure and discuss how proposed concept alternatives would achieve proposed long-term resilience goals.

4:20 Conclusion

- Discussion on long term resilience concept alternatives and workshop methodology
- Next steps

5:00 Adjourn to reception

Event followed immediately by an informal cocktail reception at Save the Bay
Reception sponsored by the Providence Working Waterfront Alliance

Workshop Debrief Steering Committee Meeting Binder Materials
for October 19, 2015

1. Oct. 19th Agenda
2. Handout Questions (from mark)
3. Workshop report (draft)
4. Workshop materials (color printouts of PPTs)
    a. Original Detailed Agenda
    b. Table of attendees
    c. Mary Lee PPT
    d. Deck 1 (storm sceneario) 3 slides plus notes if printing new
    e. Deck 2 (goals)
    f. Deck 3 (strategies)
    g. Deck 4 (Wecision)

Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot Project for the Port of Providence

Appendix 2 – Workshop Materials

This appendix contains slides and handouts from the Aug 3, 2015 workshop.

Contents:

HURRICANE RESILIENCE: LONG-RANGE PLANNING FOR THE PORT OF PROVIDENCE

August 3rd, 2015, 1-5PM
Save the Bay Center, 100 Save The Bay Drive,
Providence, RI

THE UNIVERSITY OF RHODE ISLAND DEPARTMENT OF MARINE AFFAIRS

urit uri transportation center

U.S. Department of Transportation Federal Highway Administration

RI dot

Project Team

RI dot

U.S. Department of Transportation Federal Highway Administration

urit uri transportation center

THE UNIVERSITY OF RHODE ISLAND DEPARTMENT OF MARINE AFFAIRS

Leads
- Evan Matthews, Port of Davisville, Chair of Steering Committee
- Austin Becker, URI, Project co-lead
- Rick Burroughs, URI, Project co-lead
- John Haymaker, Area Research, Wecision lead
- Mark Amaral, Lighthouse Consulting, Workshop Facilitator

Steering Committee
- Dan Goulet, CRMC
- Corey Bobba, FHWA
- Julie Rosatti, USACE
- Katherine Touzinsky, USACE
- Pam Rubinoff, CRC/RI Sea Grant
- Kevin Blount, USCG
- Bill McDonald, MARAD
- Meredith Brady, RIDOT
- John Riendeau, CommerceRI
- David Everett, City of Providence Dept. of Planning
- Chris Witt, RI Statewide Planning

Students
- Eric Kretsch, Julia Miller, Duncan McIntosh, Emily Humphries, Peter Stempel, Emily Tradd, Nicole Andrescavage, Zaire Garrett, Brian Laverriere, LAR 444

WEBSITES

www.screenleap.com/abecker

www.wecision.com

www.portofprovidenceresilience.org

STUDY AREA FACTS

Perimeter = 7 Miles
Area = 1500 Acres

# of businesses: ~30
employed:
- Direct: ~1,000
- Indirect: ~2,000

Total foreign trade (MT):
- 4.8M (2013)
- Rank: 46 (in US)

Main petroleum supply for RI

Channel depth: 40' (2004 - $65M)

USACE, 2013, 2012
FXM Associates, 2008; 4Ward Planning, 2015

Workshop Objectives

- Understand and comment on storm scenario & consequences
- Review four long-range resilience concept alternatives
- Review possible long-range "resilience goals" for the port and weigh importance of each
- Provide feedback on workshop methodology as a way to measure port vulnerability and initiate
- Identify collective action that needs to be discussed now and recommendations for RIDOT

http://www.portofprovidenceresilience.org/

Agenda

1:00 **Welcome and Flow**

1:25 **Scenarios**

a. **Super Storm Sandy and the PNYNJ**
b. **What the science says could happen in Providence**
c. **What do you think could happen**

2:50 **Break**

3:00 **Long term resilience concept alternatives**

a. **Present Wecision tool**
b. **Three long term resilience concept alternatives**
c. **Compare proposed long term resilience goals to concept alternatives**

4:20 **Conclusion**

5:00 **Adjourn for cocktails**

(Intro Mary Lee Clanton)

Conclusion and next steps

- Final analysis and question
- Next steps

Final Analysis

A. In tables, answer each question, write on flips and be prepared to present to group:
   A. What was useful, what would you change about this workshop's methodology as way to discuss long term resilience concept alternatives?
   B. Are there any specific activities that you agency/ company could be taking now to create long term resiliency?

Next steps

a. How information is going to be used
b. What we expect from them, if anything?
c. What do they need?
d. Thanks sponsors/funding agents and project team

Project Team

Facilitators

John Haymaker, Area Research, Wecision lead
Mark Amaral, Lighthouse Consulting, Workshop Facilitator

Steering Committee

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Hurricane Science and the "Hurricane Scenario"

R. Duncan McIntosh, MPS

University of Rhode Island
Department of Marine Affairs

THE UNIVERSITY OF RHODE ISLAND

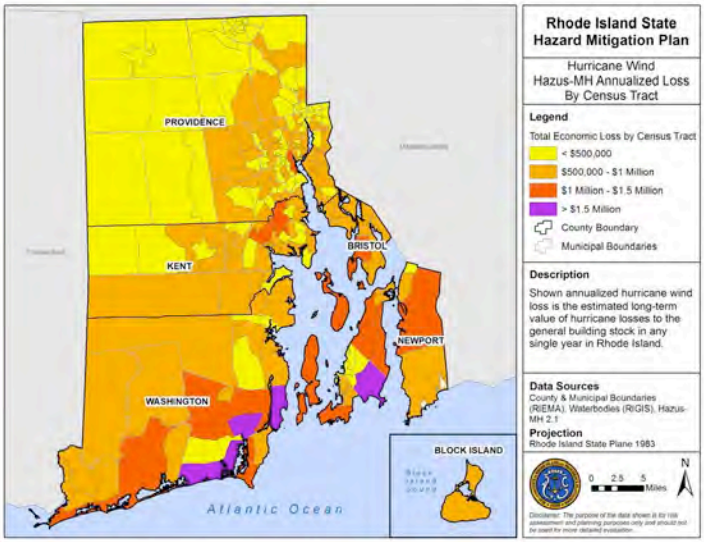
THINK BIG WE DO

Rhode Island Hurricanes: Historical Record

- 37 hurricanes within 50 mi of RI since 1851
- ≈ 4 year return period
- ≈ 22.8% chance of hurricane per year

Rhode Island Hurricanes: Historical Record

- Annualized losses over $134 million* statewide [1].
- Hurricane of 1938 alone:
  - $2.3 billion* damage
  - 564 deaths
  - storm tide of 15.8 feet (@ high tide) at the Prov tide gauge [1].



HAZUS MH
EARTHQUAKE • WIND • FLOOD

1. Rhode_Island_Emergency_Management_Agency, *Rhode Island Hazard Mitigation Plan*. 2014.

*(in 2012 dollars)

1938 Hurricane Flood Model (StormTools)

Hurricane Impacts 101

Wind, Rain, Waves, Surge

Extra-tropical Transition (ET)

As hurricanes move into the mid-latitudes, they transition from:

Tropical

(feeding off latent ocean heat)

Extra-tropical

(feeding off a temperature contrast, or a front)

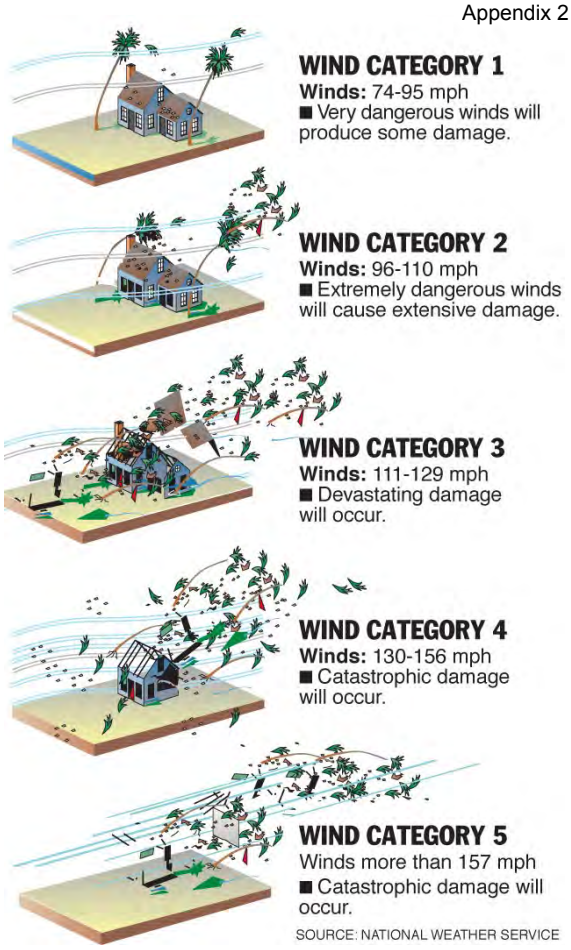
Can lead to:

- Larger diameter wind and rain fields
  - As with Hurricane Sandy
- Accelerated forward velocity
  - As with the 1938 Hurricane

Hurricane Impacts: **WIND**

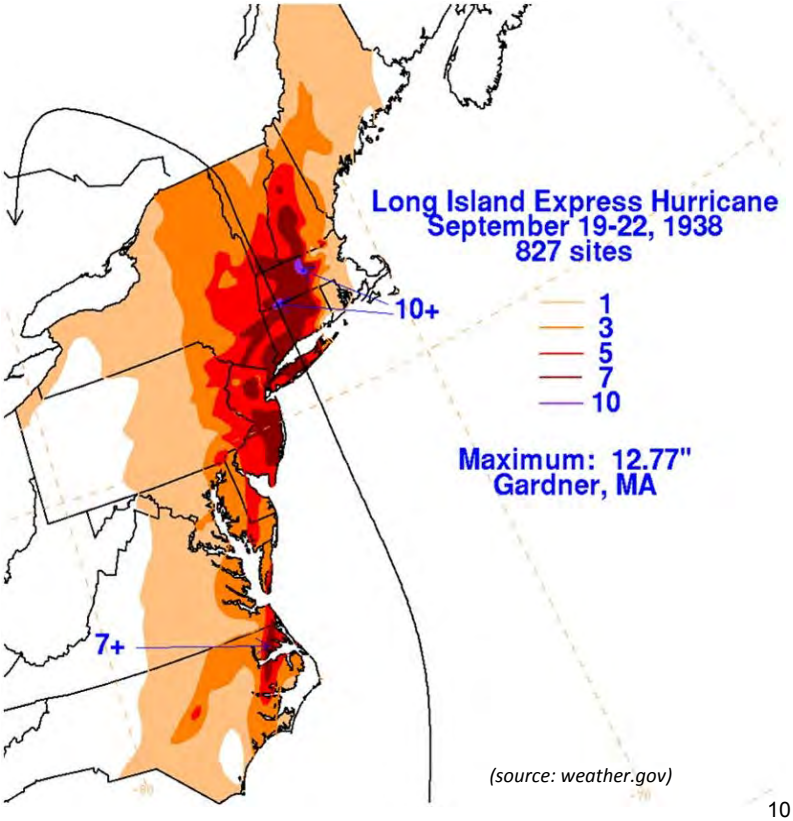
Saffir-Simpson Scale

Category	Winds (mph)	Destruction
1	74-95	Very dangerous winds will produce some damage
2	96-110	Extremely dangerous winds will cause extensive damage
3	111-129	Devastating damage will occur
4	130-156	Catastrophic damage will occur
5	>157	Catastrophic damage will occur



Hurricane Impacts: **RAIN**

- 1938 hurricane produced **10 to 17 inches** of rainfall across Connecticut River Valley.
- Worst flooding ever recorded in this area

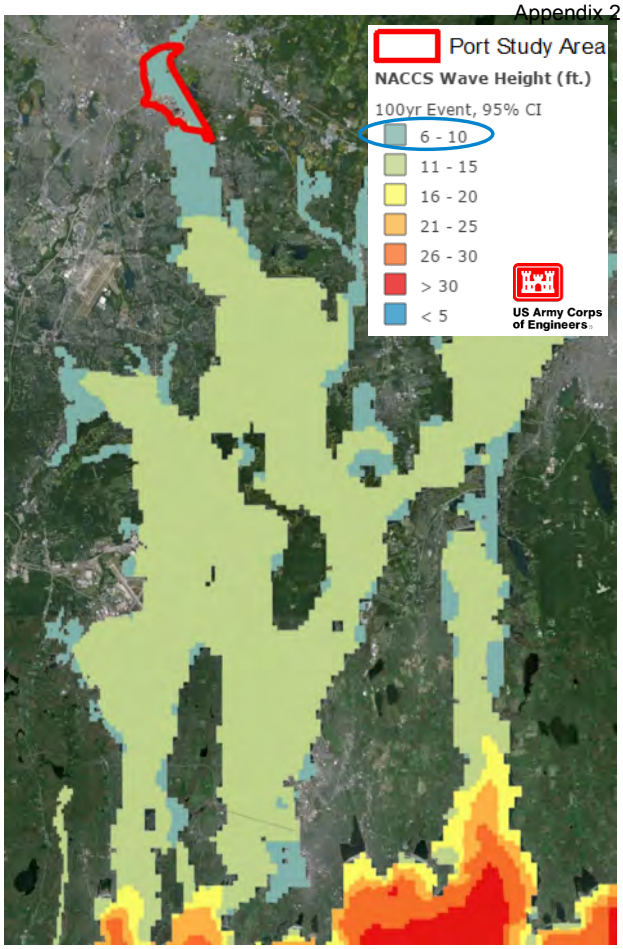


(source: weather.gov)

Hurricane Impacts: **WAVES**

- USACE N. Atlantic Coast Comprehensive Study (NACCS) used coupled wave and current models (ADCIRC and STWAVE) to produce simulated wave heights for a 100 year event

- Models indicate that Port of Providence could expect **<u>6 – 10 foot waves</u>** from such an event.

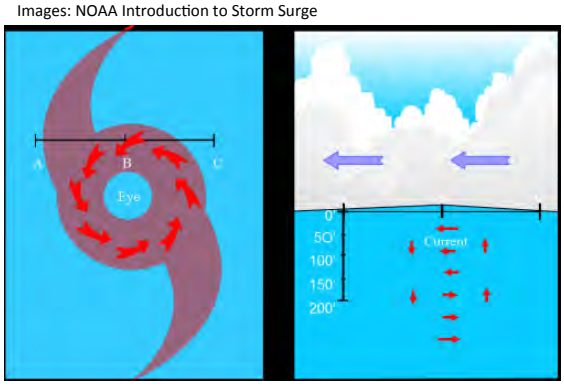


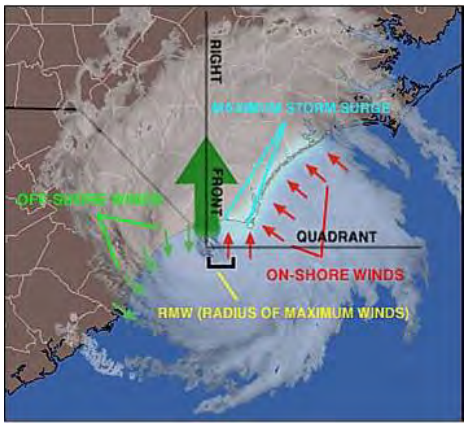
Hurricane Impacts: **STORM SURGE**

- Most powerful and destructive of coastal hurricane impacts
- An abnormal rise in sea level caused by two factors:
  1. **Inverted-barometer effect***:* low pressure allows a "dome" of water to rise
  2. **Winds:** drive deep currents which are forced 'upwards' by coast bathymetry

Winds → Ocean Currents → Coastal Bathymetry → Rise in Water Level

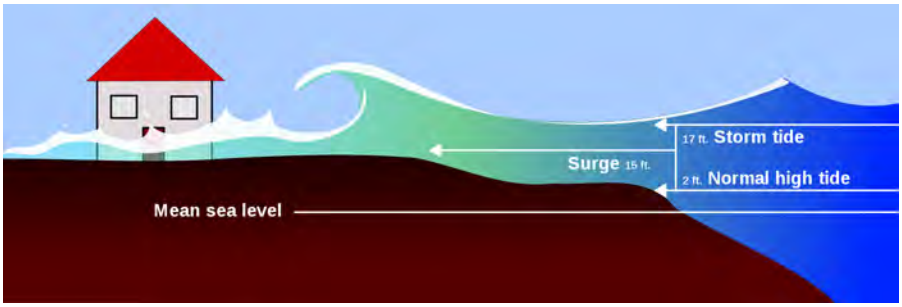
Images: NOAA Introduction to Storm Surge



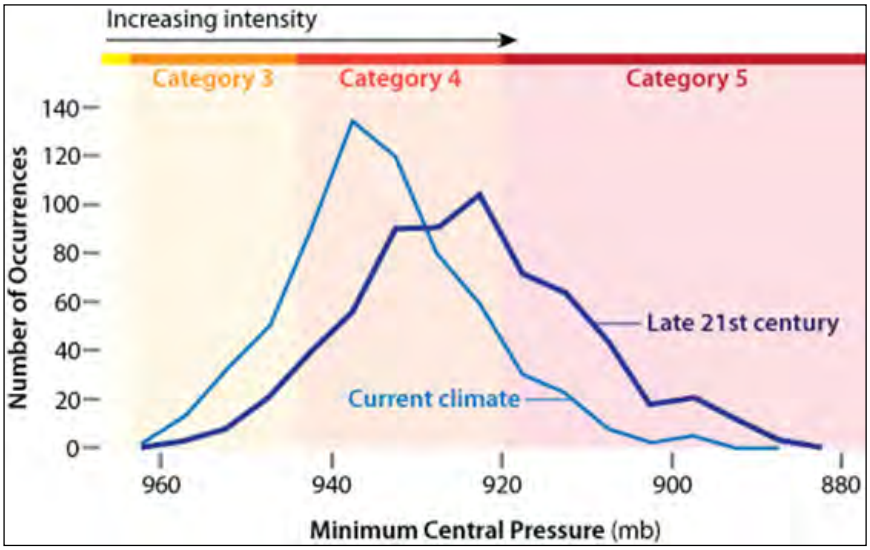


Hurricane Impacts: **STORM SURGE**

- Also driven by the forward speed of the storm
- May arrive ahead of the storm itself
- Can last 6 - 12 hours
- Storm surge + local tide cycle = **storm tide**
- Storm tide + wave action = actual water level



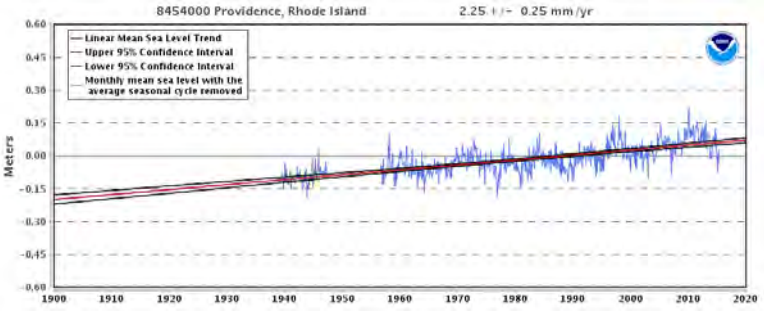
Hurricanes in a Changing Climate



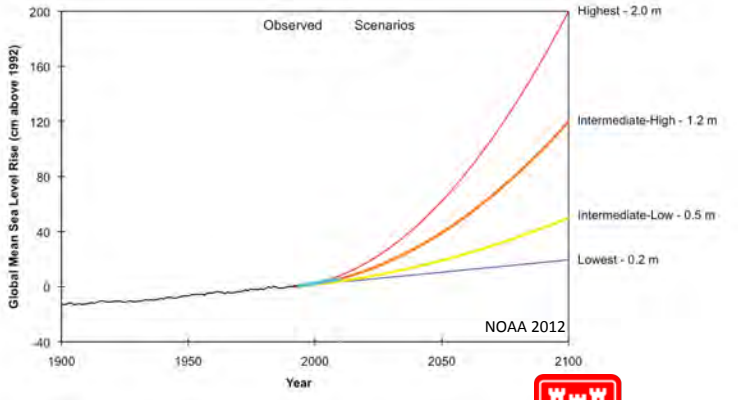
- Change in Frequency: Uncertain
- Change in Intensity: **expect stronger & wetter storms**
  - Atlantic basin models:
    - Wind speeds ~ **4% stronger for every 1° C increase** in sea-surface temperature
    - **Rainfall increase near 20% by 2100** [1].

(Graph, Tom Knudson, NOAA GFDL)

Sea Level Rise (SLR)

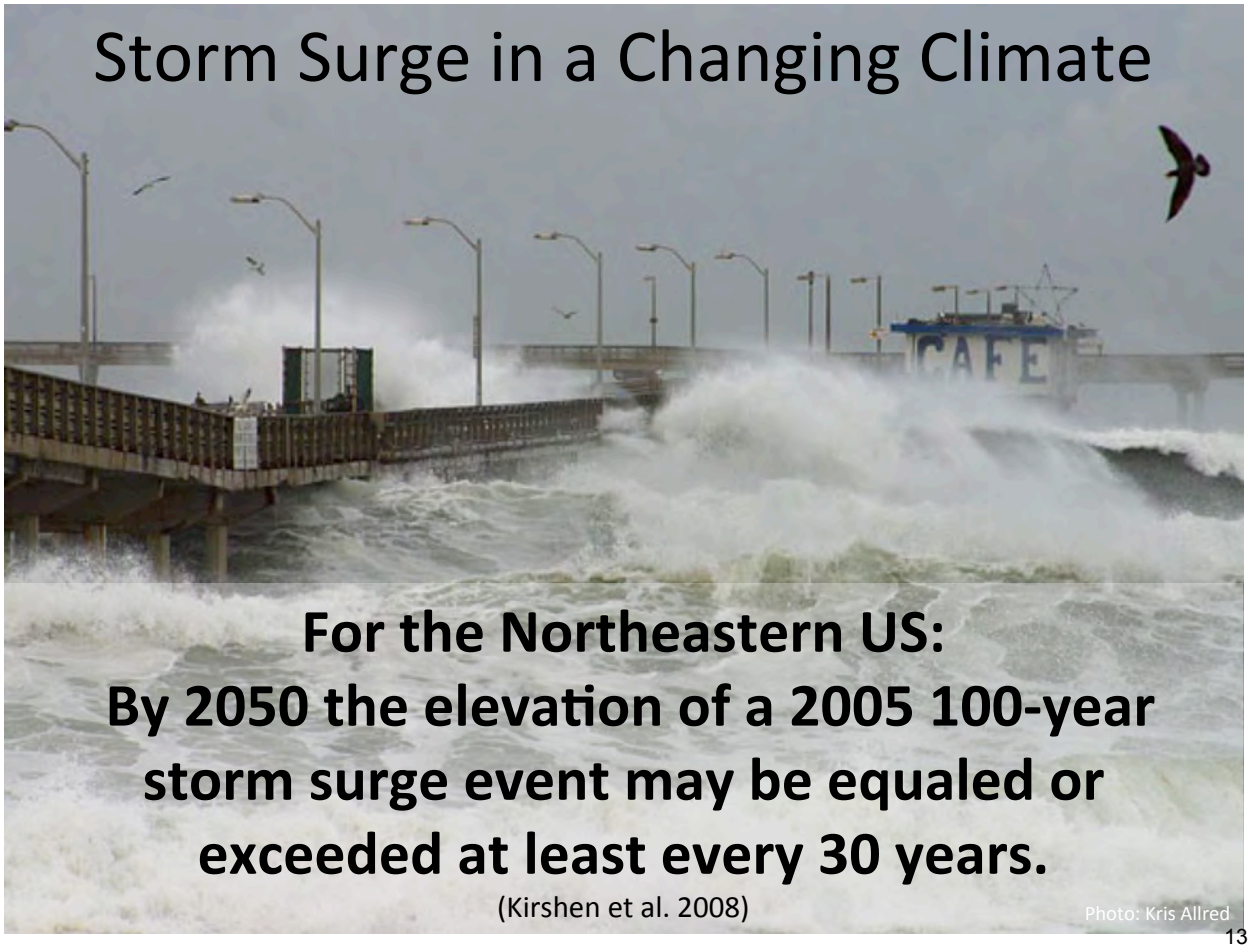


Observed rate of SLR
Providence tide gauge:
~ 0.1 inches per year



Projected SLR:
US National Climate Assessment (2012)
0.7 – 6.6 feet by 2100

NOAA
USGS science for a changing world
SERDP DOD • EPA • DOE
US Army Corps of Engineers



A Hurricane Storm Scenario
to consider in the workshop exercise that follows…

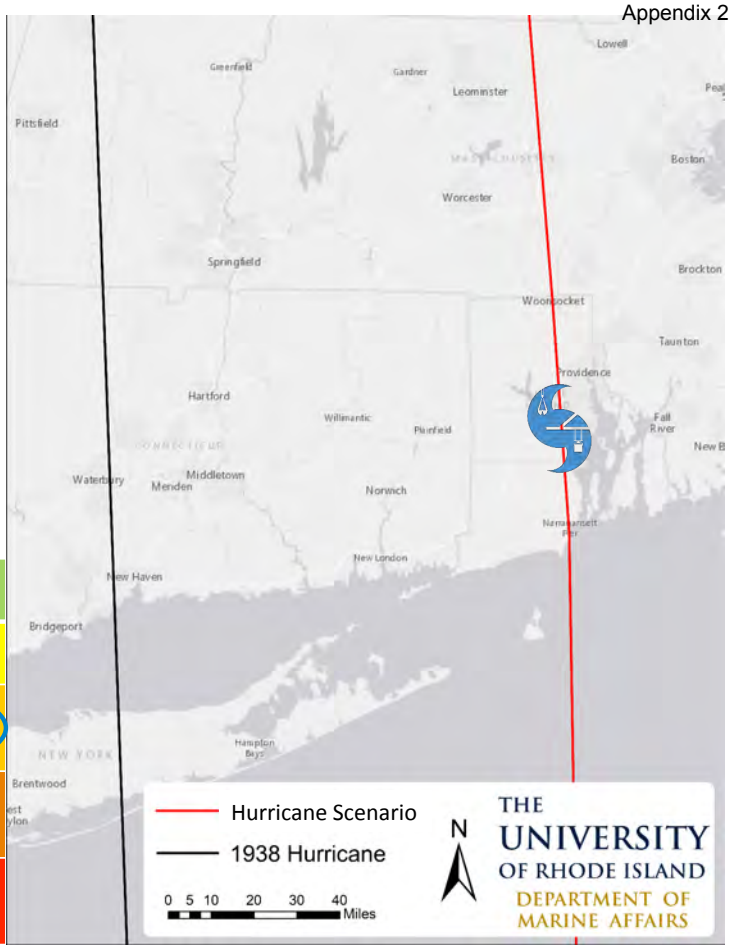
Hurricane Storm Scenario

- Based on historical evidence
- Extreme, yet plausible storm scenario
- Category 3 Hurricane
- Landfall on August 3 at 11:00AM high tide
  - Tracking north at 40 mph and approaching Rhode Island from the south
    - For NE US, a Cat 3 Hurricane has a return period of ~ 60 years [1], or a 1.7% chance of impacting the region in a given year.

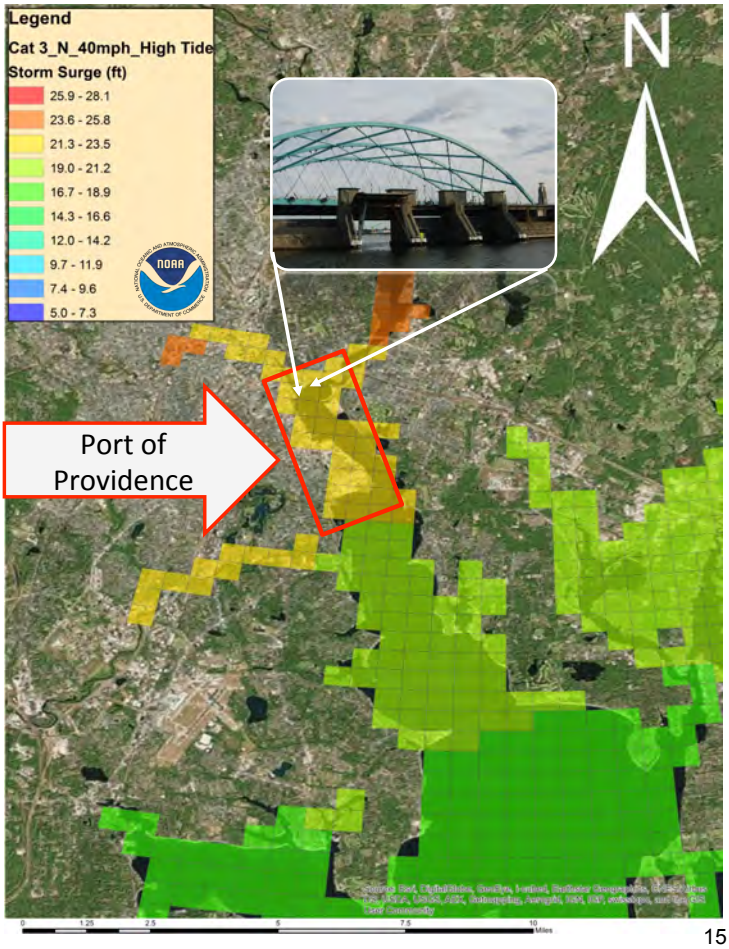
1. Ginis, I. *Predicting a Hurricane's Path of Destruction in Rhode Island*. 2006. Rhode Island Emergency Management Agency.

- ‘Direct hit’ for Providence
- Comparable to 1938 hurricane, but shifted ~ 80 mi East
- Comparable to Sandy without the ‘left hook’

1	74-95	some damage
2	96-110	extensive damage
3	111-129	Devastating damage
4	130-156	Catastrophic damage
5	>157	Catastrophic damage

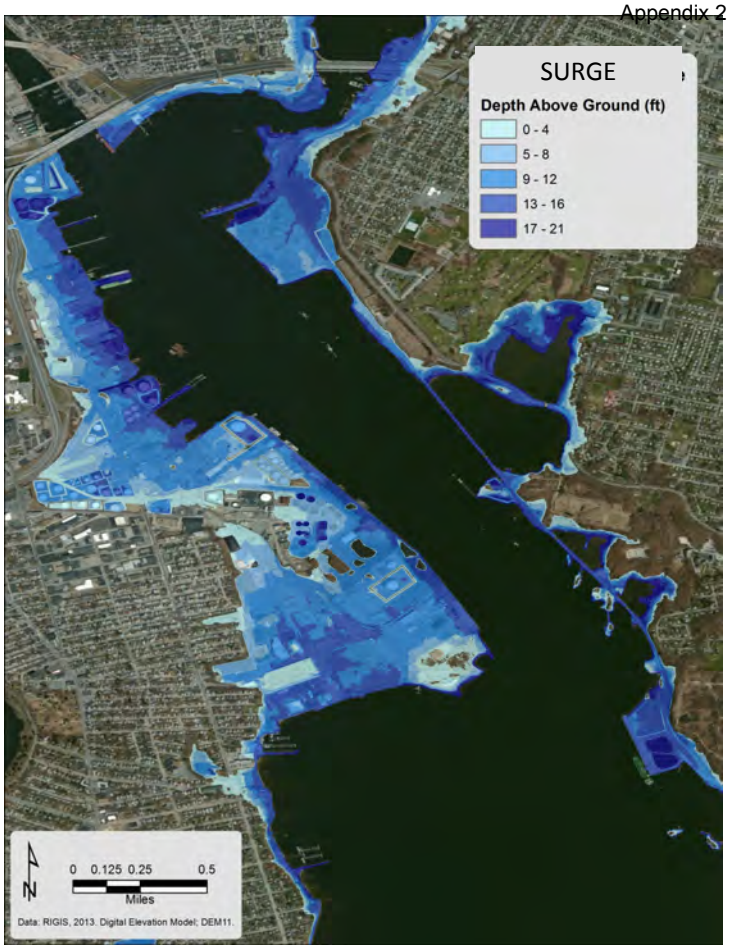


- Winds: ~ **111-129 mph**
- Waves: ~ **6-10’**
- Storm Tide: ~ **21’**
  - SLOSH model
  - Does not overtop Fox Point Hurricane Barrier

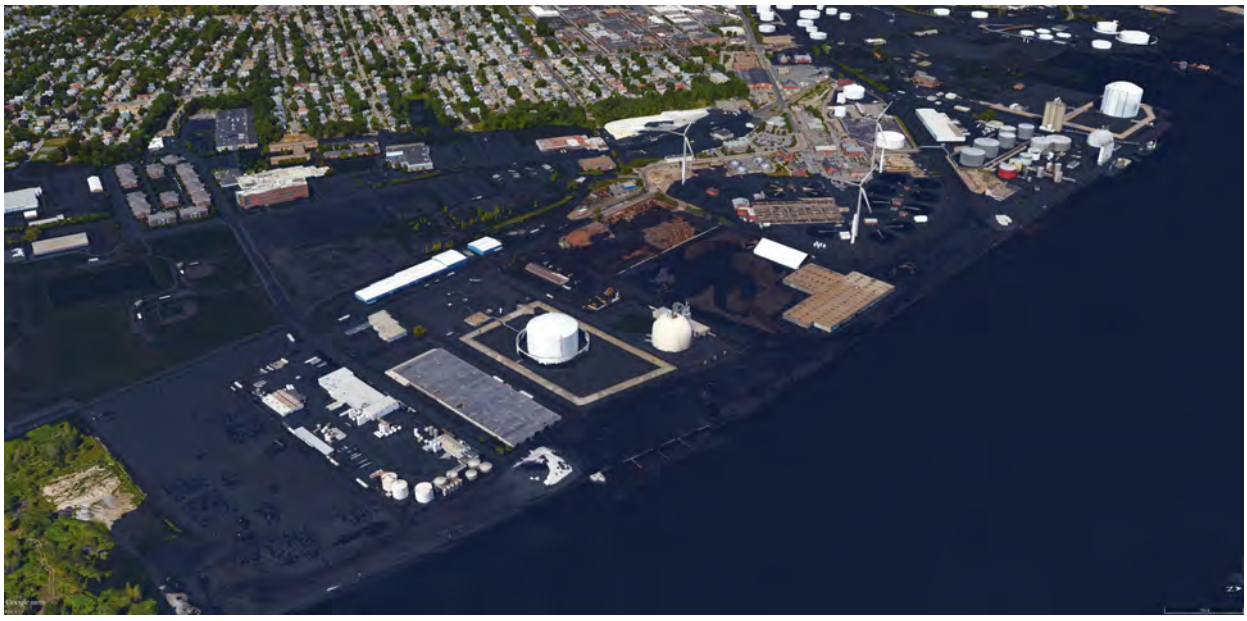


- GIS Visualization of 21 ft "bathtub" inundation
- Assumes Fox Point Barrier not overtopped
- Only shows passive level of sea
- Does not show expected 6-10' wave action
- You have hard copies of this map at your tables

- Based on RIGIS, 2013 DEM derived from a 1-meter resolution digital elevation model originally produced as part of the Northeast LiDAR Project in 2011.



ProvPort

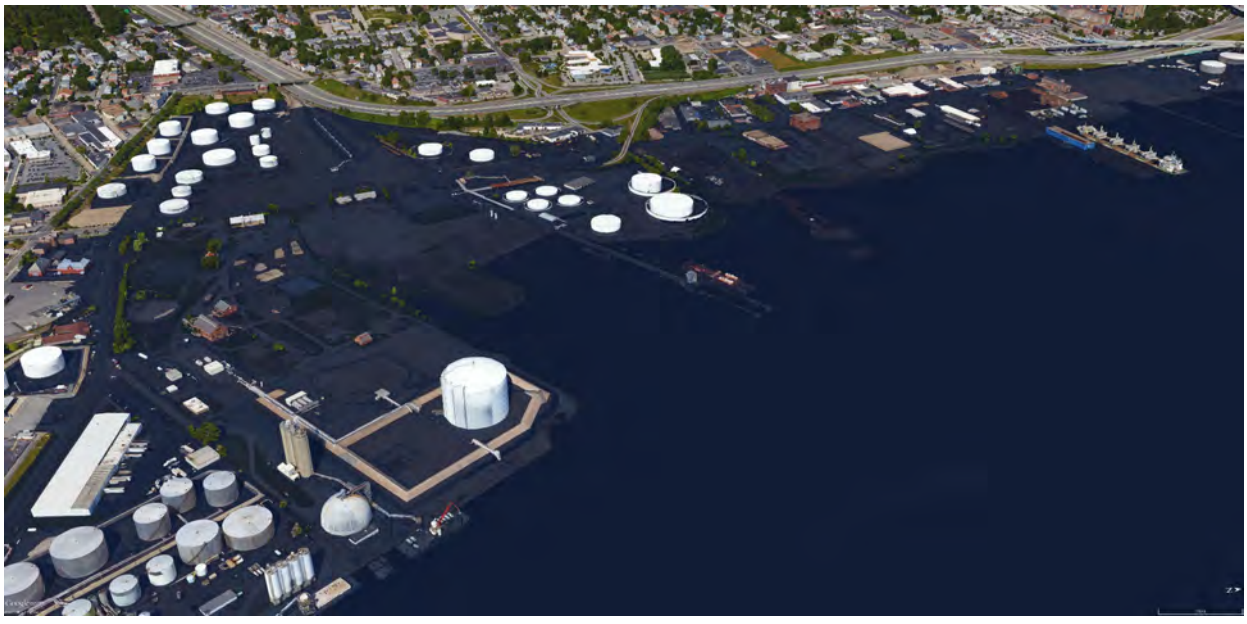


See: http://www.portofprovidenceresilience.org/storm-scenario.html

Metals Recycling, Inc.

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Motiva



See: http://www.portofprovidenceresilience.org/storm-scenario.html

Sprague

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Exxon Mobile (E. Providence)

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Wilkes-Barre Pier (Capital Terminals, E. Providence)

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Workshop Exercise
What are the consequences of this Hurricane Scenario?

Participants divide into groups to describe the consequences on maps

Group activity

- Each Group on map provided will:
  - With sticky cards, identify vulnerable areas & key consequences (i.e., what are storm's impacts) by time on maps:
    - Weeks after event (yellowsticky notes)
    - Months after event (orange sticky notes)
    - Years after event (pinksticky notes)
  - Report out top three vulnerabilities and consequences. Top three for each time frame (weeks, months and years after the storm.)

By time…

Weeks after event

Months after event

Years after event

Resilience Strategies:

4 long-term resilience design concepts

http://www.portofprovidenceresilience.org/

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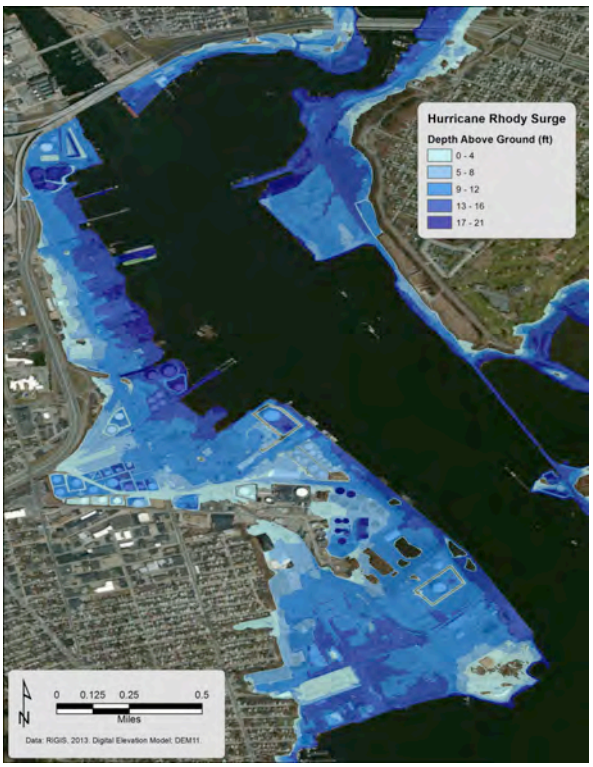
Assumptions

- Resilience: *Ability to rapidly bounce back to normal operations after extreme (e.g., Cat 3) event*
- Long-term: Out to ~2040 (focus here is not on emergency response)
- Common objective to strengthen the port community
- Actual solutions would likely combine concepts
- High costs; funding mechanisms unknown at this time

1. Do Nothing –
No change to port resilience



1. Do Nothing –
No change to port resilience

Advantages

- Low/no upfront costs
- No disruption until storm event(s) occur
- Easy
- Allows for investments in other priorities

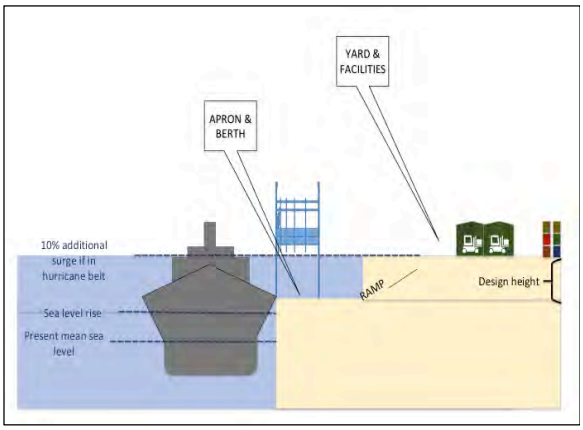
Disadvantages

- Risk of major catastrophe after each storm event
- Risk of businesses leaving the State
- Risk of major environmental damage to Narragansett Bay
- Risk of channel closing for weeks/months
- Impacts to state's energy supplies

2. Accommodate –
Site-specific improvements to increase resilience

Elevate

Elevated Utilities and Generator
(Pt. Judith, RI)



Land underneath infrastructure
(Gulfport, MS)

Accommodate Examples

Protect/Reduce

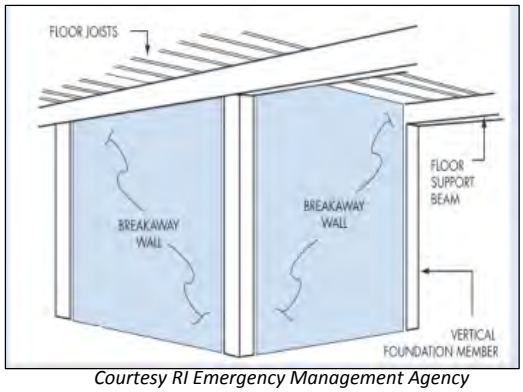
- Construct barriers and berms.
- Reinforce windows and doors.
  - Door barriers.
- Debris traps
- Storm water detention
- Cover and move stock piles of materials

https://www.walthers.com/prodimage/0933/09330000003168.gif

Accommodate Examples

Wet Flood Proofing

- Floodable first floors/ foundations
- Break-away/removable walls (reduces structure damage)
- Flood/salt tolerant constructions/materials



Courtesy RI Emergency Management Agency

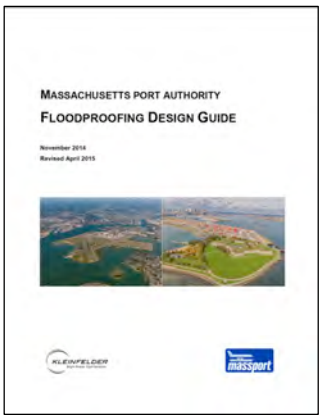
Dry Flood Proofing

- Seal around utility entry points
- Install waterproof bulkheads
- Install pumps with back up generators

Example: Port Authority of NY/NJ

Courtesy Port Authority of NY/NJ

Example: Massport (Boston)



- New design elevation: 20.5’ (Category 3 surge)
- Building Retrofit elevation: 17.5’ (Category 2 surge + wave)
- Identifies all critical infrastructure and risk to flood damage
- Establishes flood-proofing standards for existing and new construction
- Defines permitable uses for accommodation strategies
  - ex. Dry floodproofing can not be use in VE-Zones

2. Accommodate –

Site-specific improvements to increase resilience

Advantages

- Costs can be incremental
- Site-specificity
- Low-cost options
- Single business could improve its own resilience
- Could address SLR
- Does not disrupt port system as a whole

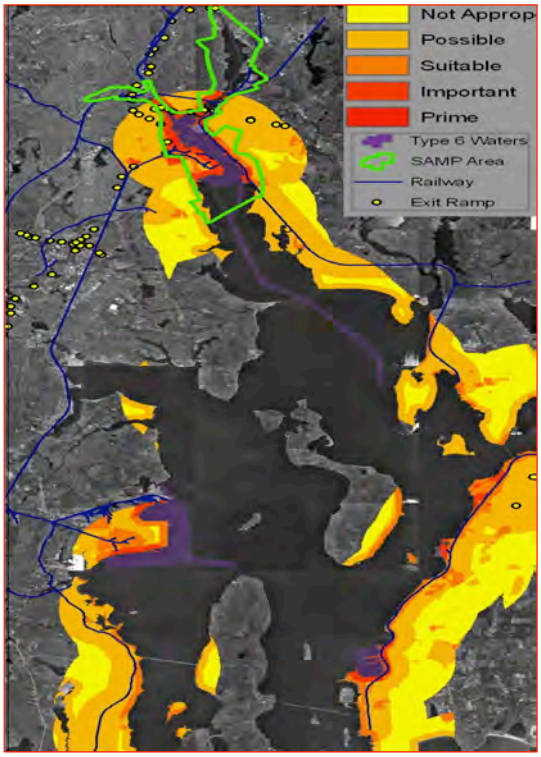
Disadvantages

- Limited in ability to protect against major storm
- Does not address interdependent uses
- Storm could result in high levels of environmental damages
- Few tested examples for industrial waterfronts
- Less likely to protect navigation channel from debris

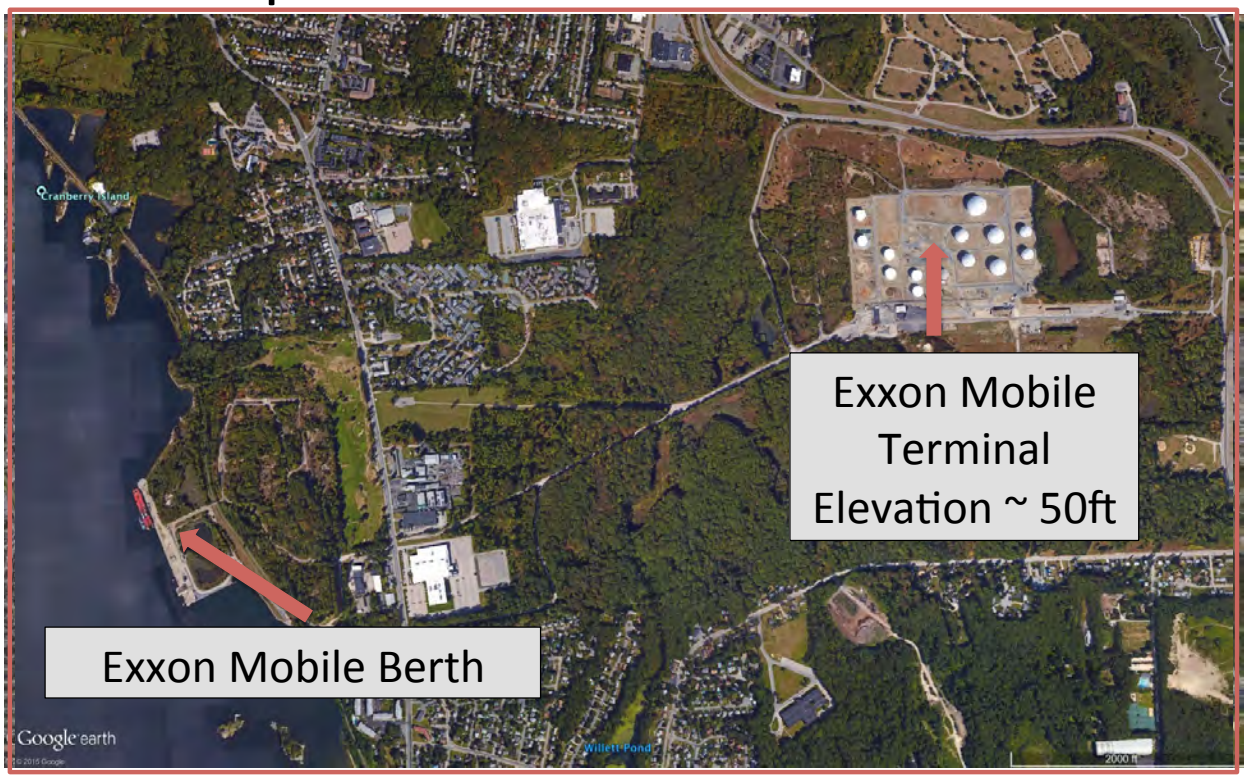
3. Relocate

Move port uses to less vulnerable location.

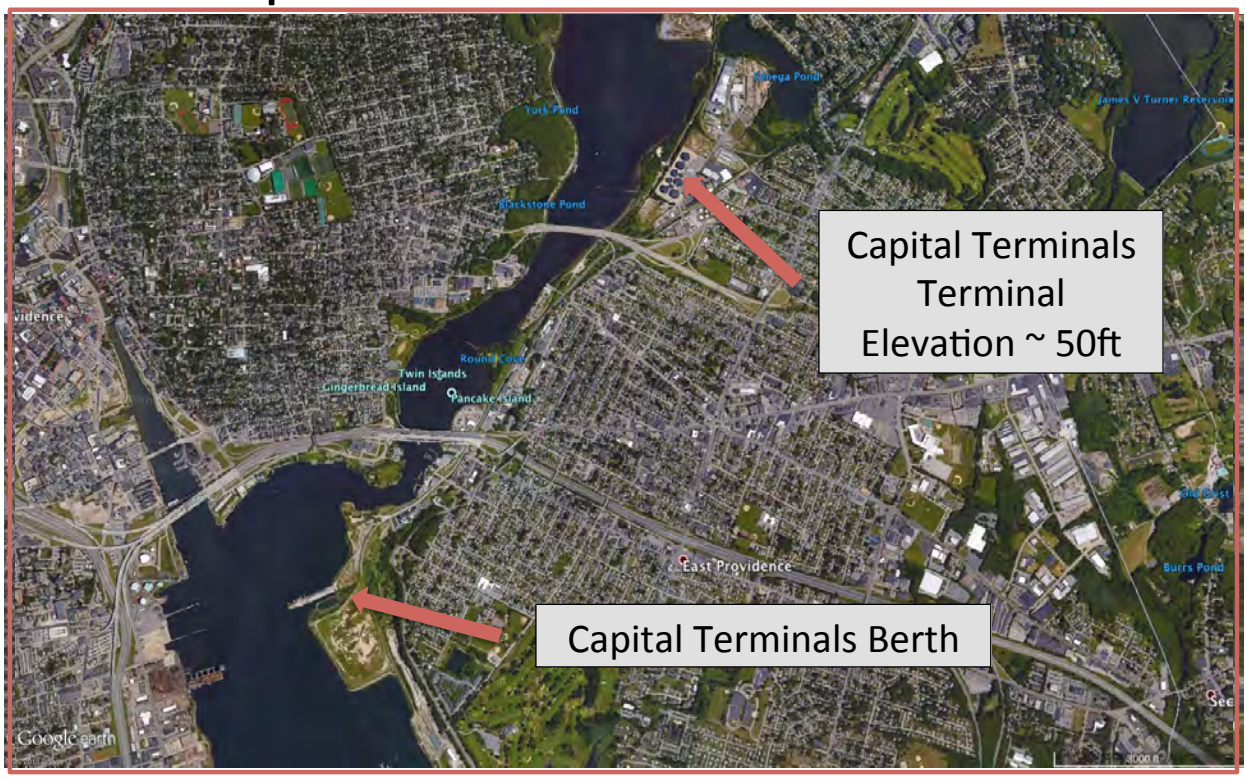
Characteristic	Points
1000’ from >40’ water	3
1000’ from 30-40’ water	2
1000’ from 10-20’ water	1
1000’ from Type 6 waters	2
Current land use industrial	2
Current land use vacant	2
Industrial zoning in place	1
>1 mile from highway exit	1
<1000’ from rail line	1



Example: East Providence Terminals



Example: East Providence Terminals



3. Relocate – Moving port uses to less vulnerable location.

Advantages

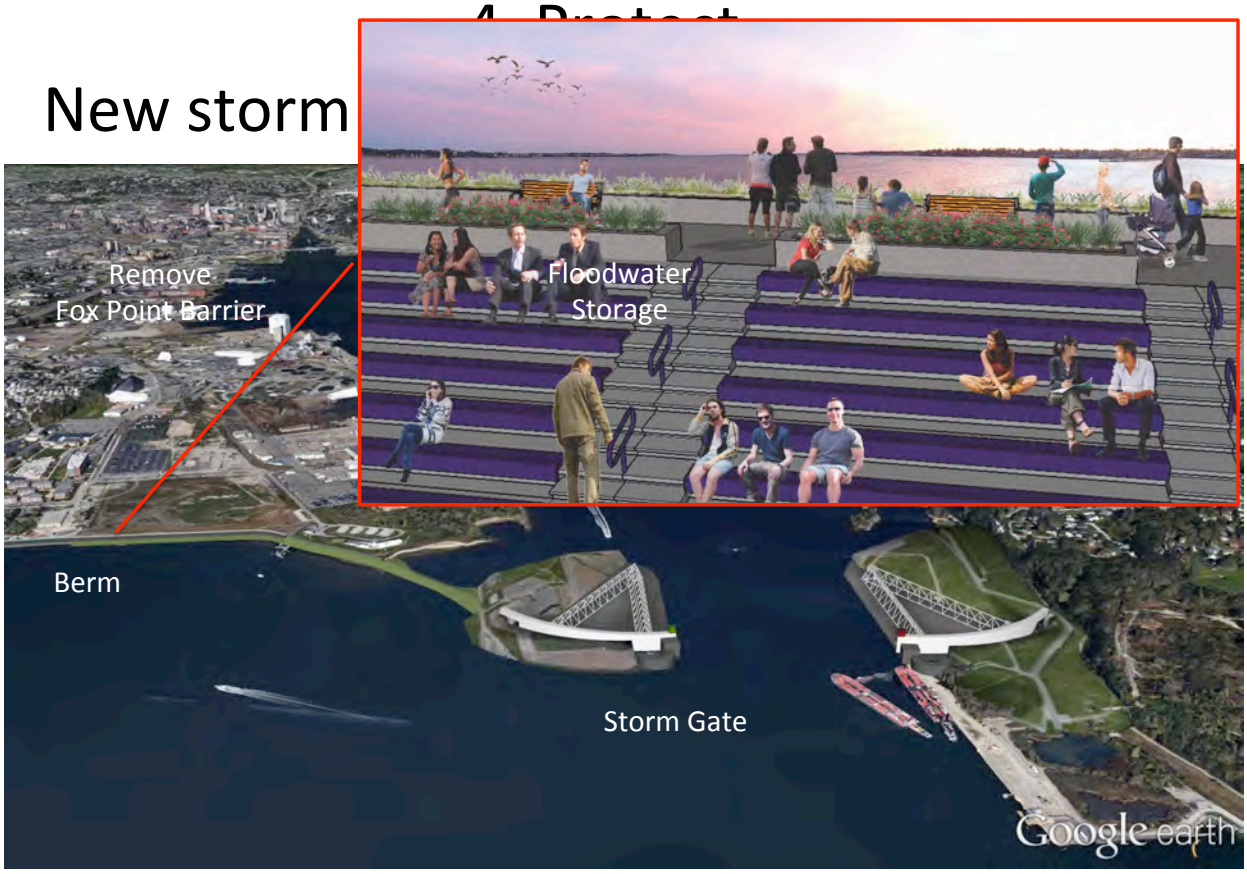
- Removes hazardous materials from floodplain
- Tested strategy has been implemented elsewhere
- Opens floodplain as public waterfront space and/or environmental remediation
- Can account for SLR
- Reduces debris in navigation channel after storm
- Improves water quality to Providence Harbor

Disadvantages

- Disrupts port network
- Limited land availability
- High costs
- May impact communities around relocation sites
- Complexities from dependence on utilities (e.g., pipelines, rail, highway)
- May displace environmental damages to other places

4. Protect

New storm



4. Protect – Storm barrier for Providence Harbor.

Advantages

- Protects during all major events
- New public uses can be integrated (e.g., on berm)
- Does not disrupt shipping
- Creates safe harbor for new business
- Tested solution
- Very long term solution
- Frees up land in City through removal of current barrier system

Disadvantages

- Impacts of sea level rise are not addressed
- May impact tidal flows (water quality)
- Impacts sediment flow, water quality, discharge from watershed (sedimentation of navigation channel)
- High upfront costs
- May impact view of Bay
- May require pumping due to increased freshwater flows

1. **Do Nothing** – No change to port resilience.
2. **Accommodate** –Improvements to current port infrastructure to increase resilience.
3. **Relocate** – Moving port uses to less vulnerable location.
4. **Protect** – New storm barrier for Providence Harbor.

Discussion -> goals and preferences

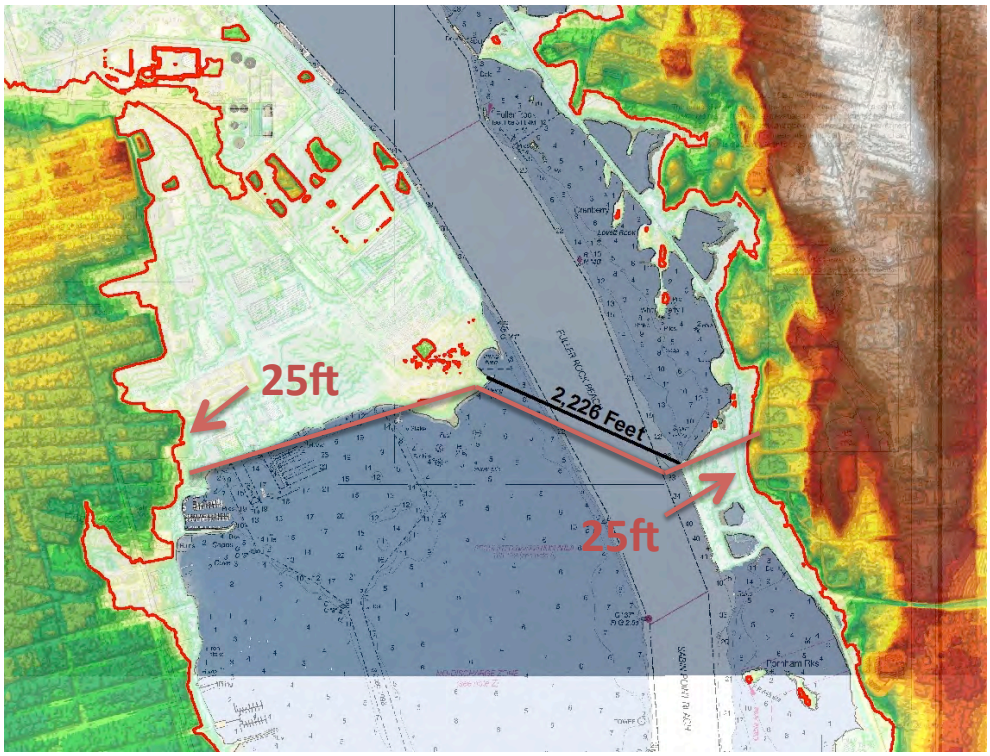
References

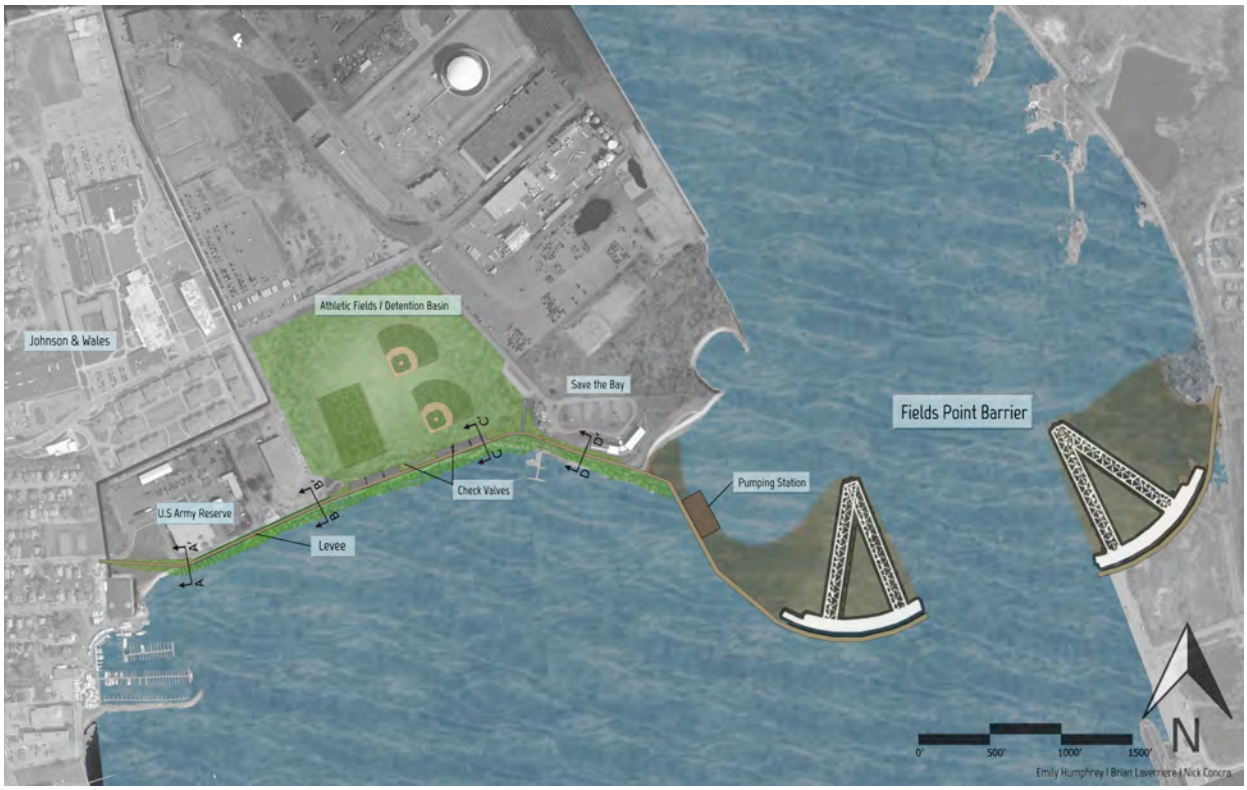
- Becker, A. & Caldwell, M. (2015) Stakeholder perceptions of seaport resilience strategies: A case study of Gulfport (Mississippi, USA) and Providence (Rhode Island, USA). Journal of Coastal Management.
- Klienfelder. (2014, October 20). Massport Disaster Infrastructure Resilience Planning Study: Final Draft Report. Massport.
- Klienfelder. (2014, October 20). Floodproofing Design Guide . Massport.
- URI Coastal Resources Center (2014) *Catalogue of Adaptation Techniques for Coastal and Waterfront Businesses.* retrieved from http://www.beachsamp.org/wp-content/uploads/2015/05/adaptation_catalogue.pdf
- URI LAR444 (2014) Port Providence Design Concept. University of Rhode Island, Kingston, RI.

Extra Slides Below

Relocate Example: $235M -- Port of Nassau, Bahamas

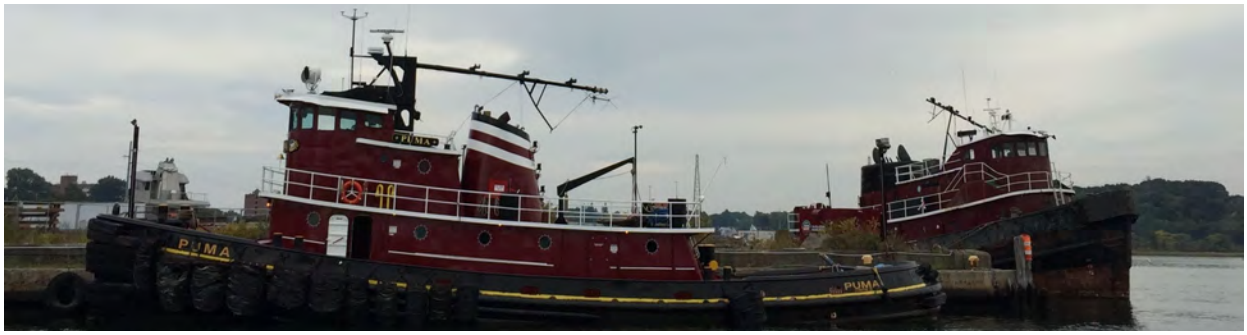
Credit: Coastal Systems International





Example: Capital Terminals

Proposed Long-term Goals for a Resilient Waterfront Business



- Discuss seven goals and its definition
- Each goal has a 1-5 metric, defined in detail in your handout
- 5 mins. per goal for discussion and changes to effectiveness rating
- Weigh the importance of the goal in Wecision
- Provide feedback on your handouts

1. Ensure post-hurricane(s) business continuity for waterfront business

Protect
4

- Storm barrier would be closed for storm event
- Post-event business would return to normal operations
- Other parts of supply chain may be impacted

Relocate
4

- Business would be located in less vulnerable locations
- More limited damages allowing for a quicker return to normal
- Other parts of supply chain may be impacts

Accommodate
3

- Some business would be more protected, would likely be impossible to fully protect all
- Clean up and repairs would restrict quick return to normal

Do Nothing
2

- Many business would be destroyed completely
- Require an extended rebuilding period

3

2. Minimize hurricane damages to infrastructure and waterfront business

Protect
4

- Storm barrier would be closed for event all buildings and infrastructure would be protected.

Relocate
4

- Depending on relocation locations, there would be less damage, because structures and infrastructure are located out of vulnerable areas, as much as possible.

Accommodate
3

- Some structures would be more protected due to accommodation measures, likely there would be damages to some infrastructure and buildings.

Do Nothing
2

- Many structures would be destroyed in the event.

4

3. Minimize hurricane-related environmental damage from port uses

Protect
4

- Barrier prevents major spill during event as well as limit WQ impacts caused by surge running over port land
- May limit tidal flow causing periodic water quality issues

Relocate
4

- Major infrastructure (tank, storage areas) located out of flood plain, preventing major spills
- Remediation would occur at port property
- Minor water quality issues (currently seen at port), would be relocated with port business
- Overall impact should be positive with proper planning

Accommodate
2

- Spills from tanks and waste water treatment facility minimized.
- Runoff caused by surge would carry contaminants back into natural environment

Do Nothing
1

- Damage to storage facilities means spills likely
- Waste treatment facility would be flooded
- Debris and contaminants washed off port property
- Major contamination of water way would result in long-term damage

5

4. Build public support for hurricane resilience measures & port operations

Protect
4

- Construction of barrier would allow for integration of public space on the fringes of port area
- Public access by sea, may be restricted due to constriction of channel by barrier

Relocate
5

- Relocating port would allow for current port land to be remediated and returned to park space allowing access to port land
- Restricts the redevelopment of the current port

Accommodate
3

- Minor alterations to port structures would enhance public access to current green space in port area; however, no new green space would be created.

Do Nothing
3

- Current green space and public access would be maintained

6

5. Minimize hazard insurance rates

Protect
5

- Risk to port business would be dramatically decreased reducing hazard insurance rates.

Relocate
4

- Some port infrastructure would be relocated out of flood plain, which would reduce rates.

Accommodate
4

- Improvements to port structure would stimulate discounts on insurance premiums.

Do Nothing
2

- Rates would increase overtime, with sharp increase post event.

7

6. Foster port growth

Protect
4

- Creation of "safe port" would motivate new business in port
- Current businesses could expand, marketing "safe port"
- More jobs created in the long term.

Relocate
3

- Post-storm, some business would be able to maintain close to normal operation

Accommodate
3

- No "safe port" effect
- Post storm, business would maintain 50% of normal operations
- May maintain business in State in long term.

Do Nothing
2

- No "safe port" effect
- Post-storm, businesses would not be able to maintain normal function; may lose business to other ports
- Rebuilding may stimulate short-term economic development (e.g., construction jobs)
- Funding can be focused on other priorities

8

7. Protect human safety & critical lifelines

Protect
5

- All critical life lines are located behind protective barrier
- RI Hospital & generator pumps' fuel supplies protected
- No damage to waste treatment facility allowing normal operation throughout and after storm
- Port areas available as staging areas for relief supplies and services

Relocate
4

- RI Hospital oil supply still located at port of Prov and in harms way.
- Possible damage to waste treatment facility, impacting normal operations

Accommodate
3

- Critical lifelines can be protected
- Fuel supplies located at port of Prov and in harms way.
- Waste treatment facility can be protected allowing for close to normal operations.

Do Nothing
1

- All critical lifelines are maintained at current locations.
- Fuel supplies in flood zone.
- Possible damage to waste treatment facility, impacting normal operations.

9

WECISION SUMMARY

(switch to browser)

10

RESEACH TEAM ASSESSMENT SUMMARY

1. Ensure post-hurricane business continuity for waterfront business
2. Minimize hurricane damage for infrastructure and waterfront business
3. Minimize hurricane-related environmental damage from port uses.
4. Build public support for hurricane resilience measures & port operations
5. Minimize hazard insurance rates
6. Foster port growth
7. Protect human safety & critical lifelines

CONCEPTS	*G1*	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*
Protect							
Relocate							
Accommodate							
Do Nothing							

LESS EFFECTIVE 1 2 3 4 5 **MORE EFFECTIVE**

Wecision
Collaborative Decision Process

Introduction to the tool and process for the
HURRICANE RESILIENCE:
PLANNING FOR THE PORT OF PROVIDENCE

Stakeholder Workshop
August 3rd, 2015, 1-5PM

John Haymaker, PhD, AIA, LEED AP
Director of Research
Perkins+Will
AREA Research

PERKINS +WILL

ADVANCE. RESEARCH. EXPAND. APPLY.
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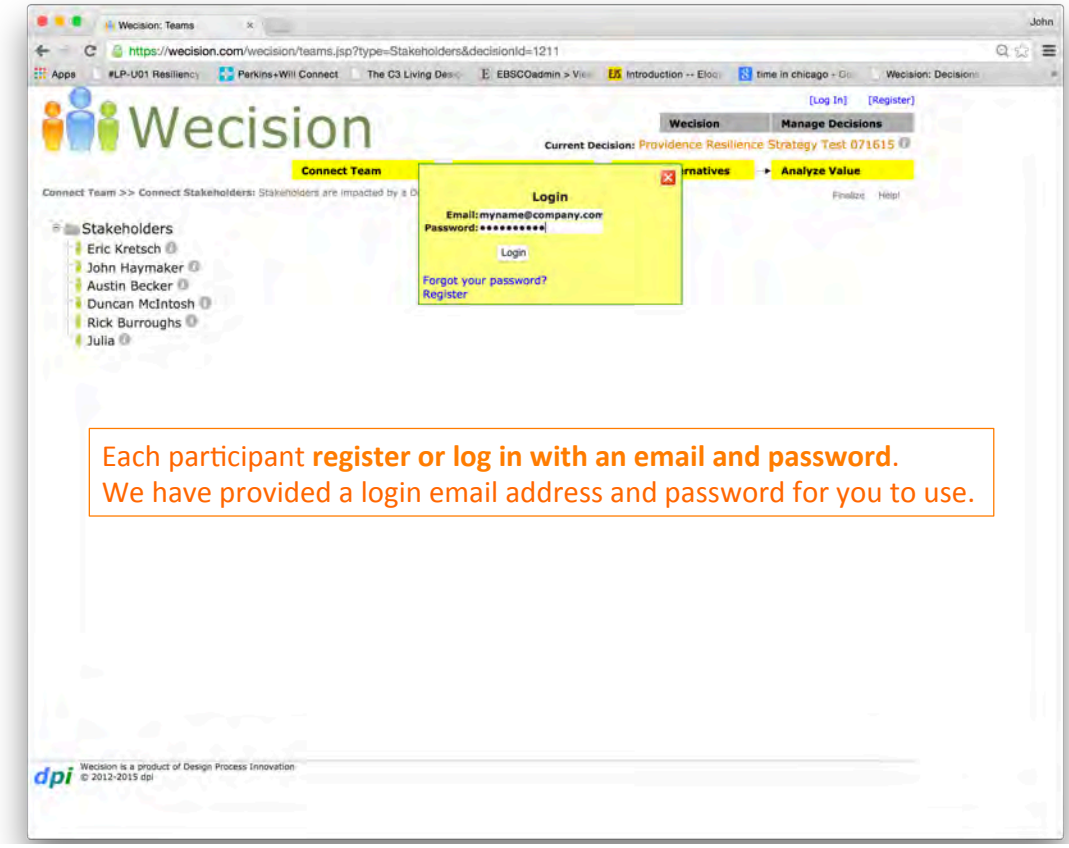
Wecision: Teams
https://wecision.com/wecision/teams.jsp?type=Stakeholders&decisionId=1211
Wecision
[Log In] [Register]
Wecision
Manage Decisions
Current Decision: Providence Resilience Strategy Test 071615
Connect Team
Analyze Value
Login
Email: myname@company.com
Password:
Login
Forgot your password?
Register
Stakeholders
Eric Kretsch
John Haymaker
Austin Becker
Duncan McIntosh
Rick Burroughs
Julia
Each participant register or log in with an email and password.
We have provided a login email address and password for you to use.
dpi
Wecision is a product of Design Process Innovation
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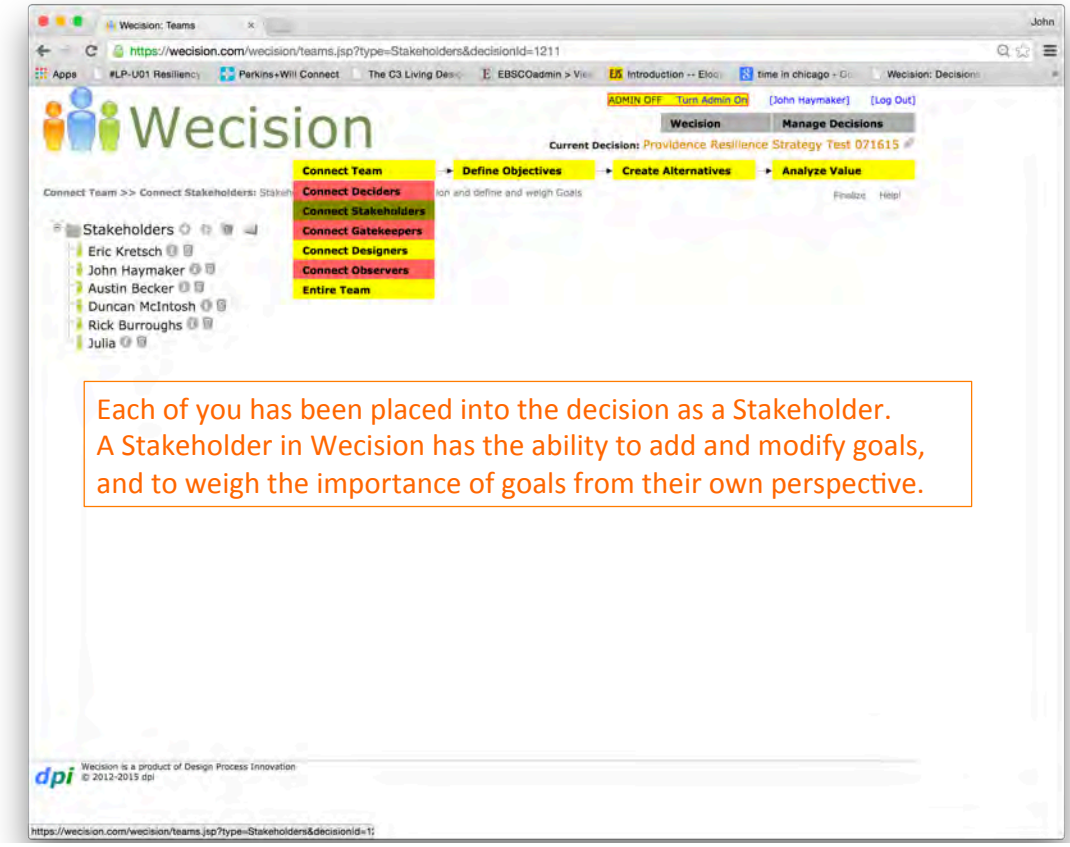
Wecision: Teams
https://wecision.com/wecision/teams.jsp?type=Stakeholders&decisionId=1211
ADMIN OFF Turn Admin On
[John Haymaker] [Log Out]
Wecision
Manage Decisions
Current Decision: Providence Resilience Strategy Test 071615
Connect Team
Define Objectives
Create Alternatives
Analyze Value
Connect Deciders
Connect Stakeholders
Connect Gatekeepers
Connect Designers
Connect Observers
Entire Team
Stakeholders
Eric Kretsch
John Haymaker
Austin Becker
Duncan McIntosh
Rick Burroughs
Julia
Each of you has been placed into the decision as a Stakeholder.
A Stakeholder in Wecision has the ability to add and modify goals,
and to weigh the importance of goals from their own perspective.
dpi
Wecision is a product of Design Process Innovation
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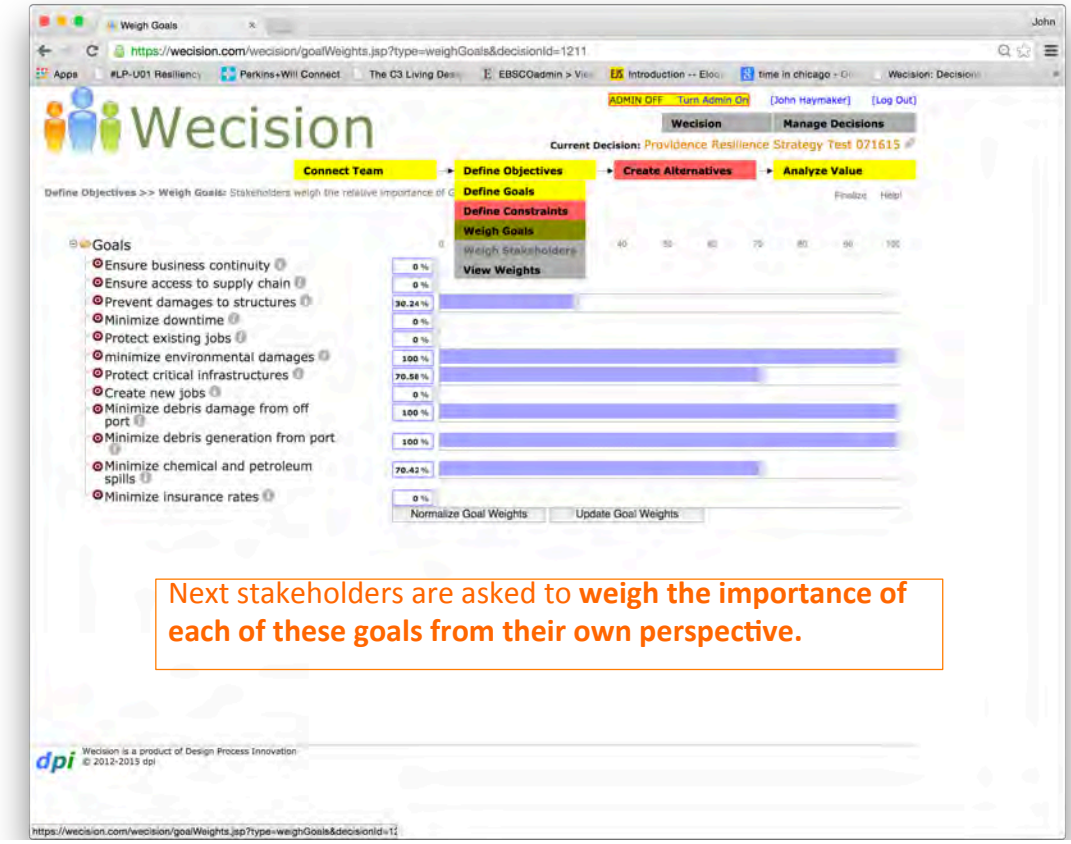
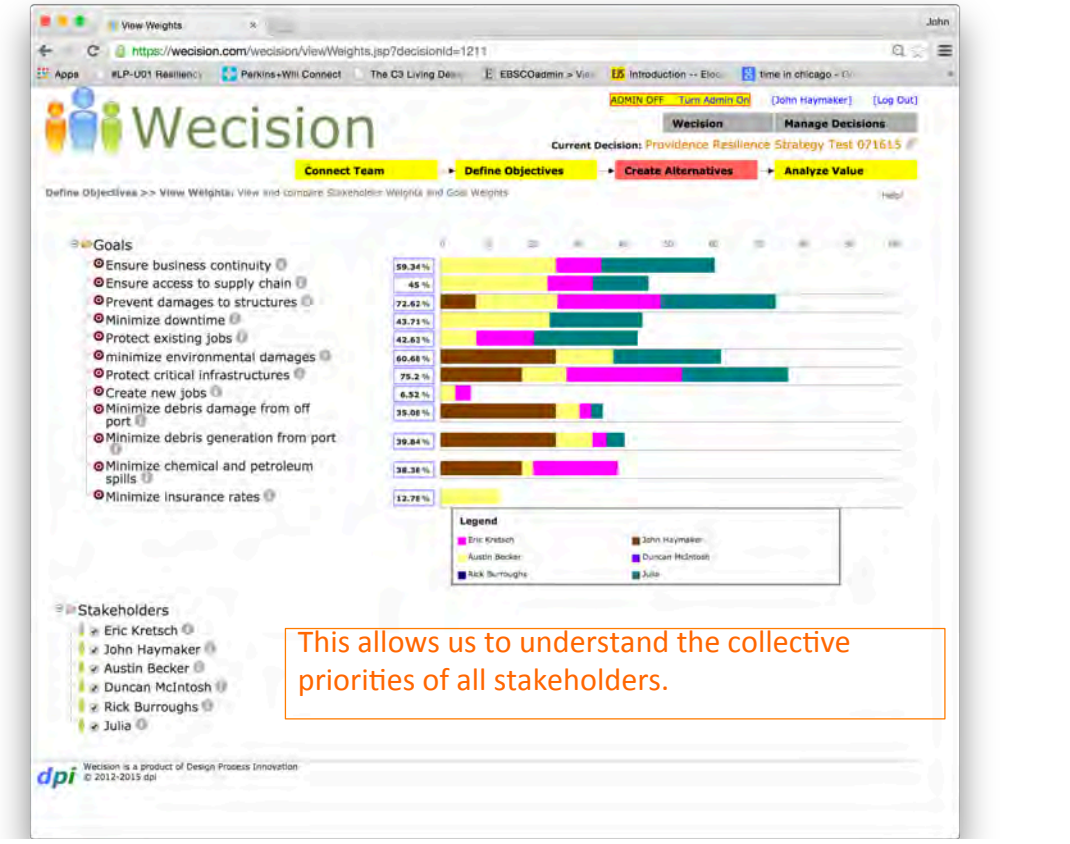
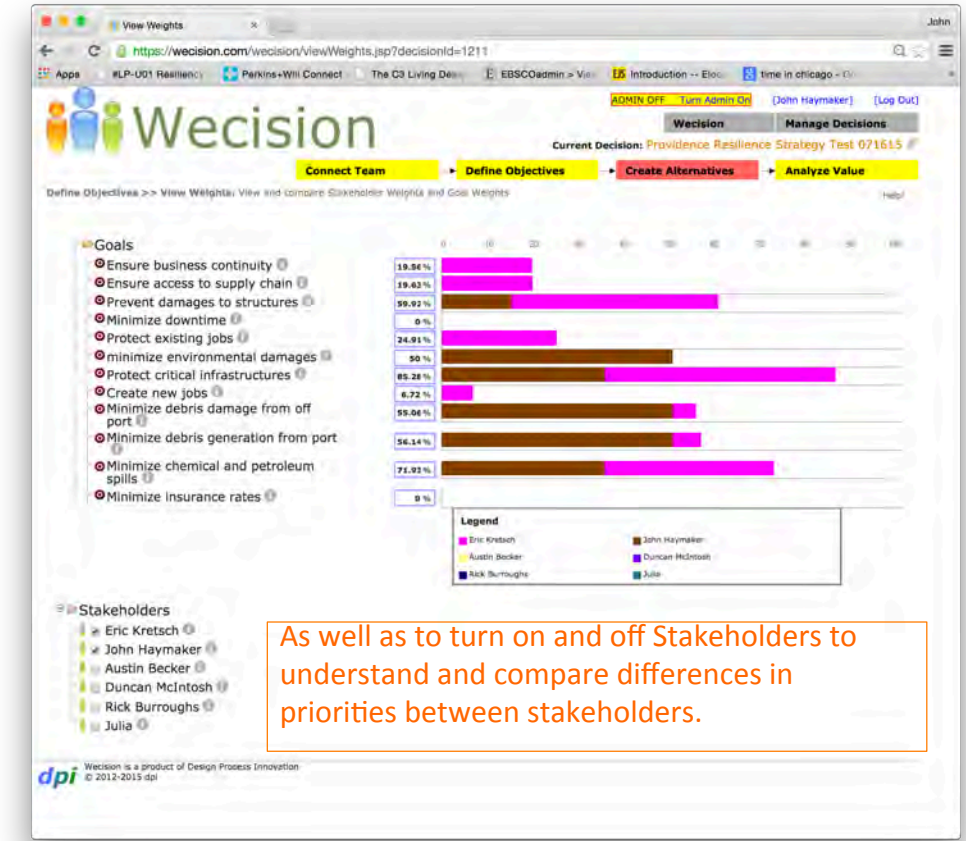
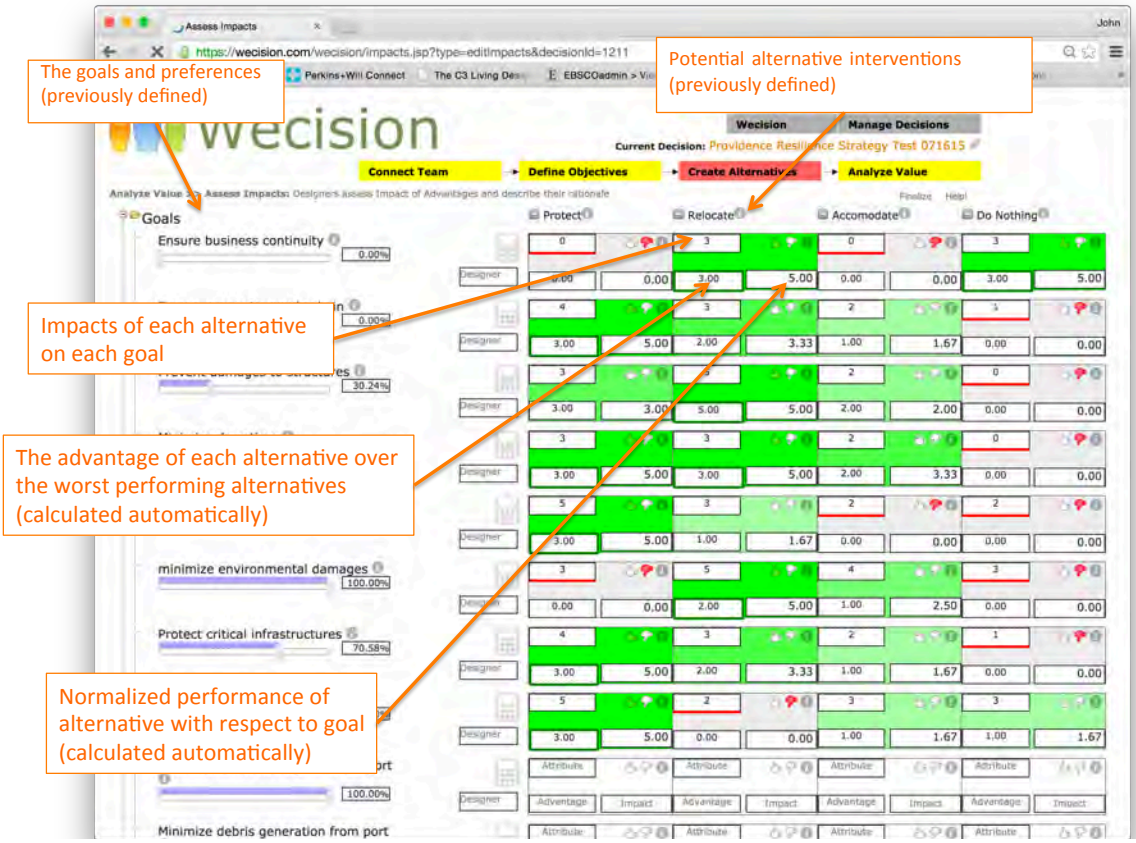


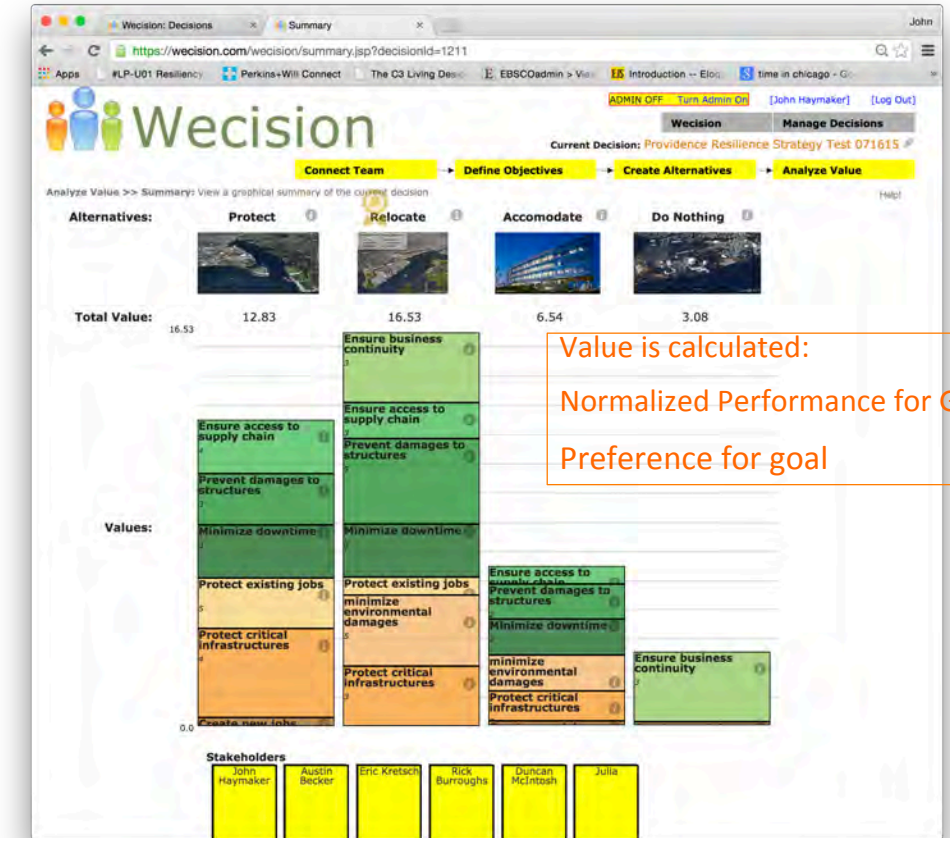
Next stakeholders are asked to **weigh the importance of each of these goals from their own perspective.**



This allows us to understand the collective priorities of all stakeholders.


Wecision
Connect Team
Define Objectives
Create Alternatives
Analyze Value
Goals
Ensure business continuity
Ensure access to supply chain
Prevent damages to structures
Minimize downtime
Protect existing jobs
minimize environmental damages
Protect critical infrastructures
Create new jobs
Minimize debris damage from off port
Minimize debris generation from port
Minimize chemical and petroleum spills
Minimize insurance rates
Stakeholders
Eric Kretsch
John Haymaker
Austin Becker
Duncan McIntosh
Rick Burroughs
Julia
As well as to turn on and off Stakeholders to understand and compare differences in priorities between stakeholders.

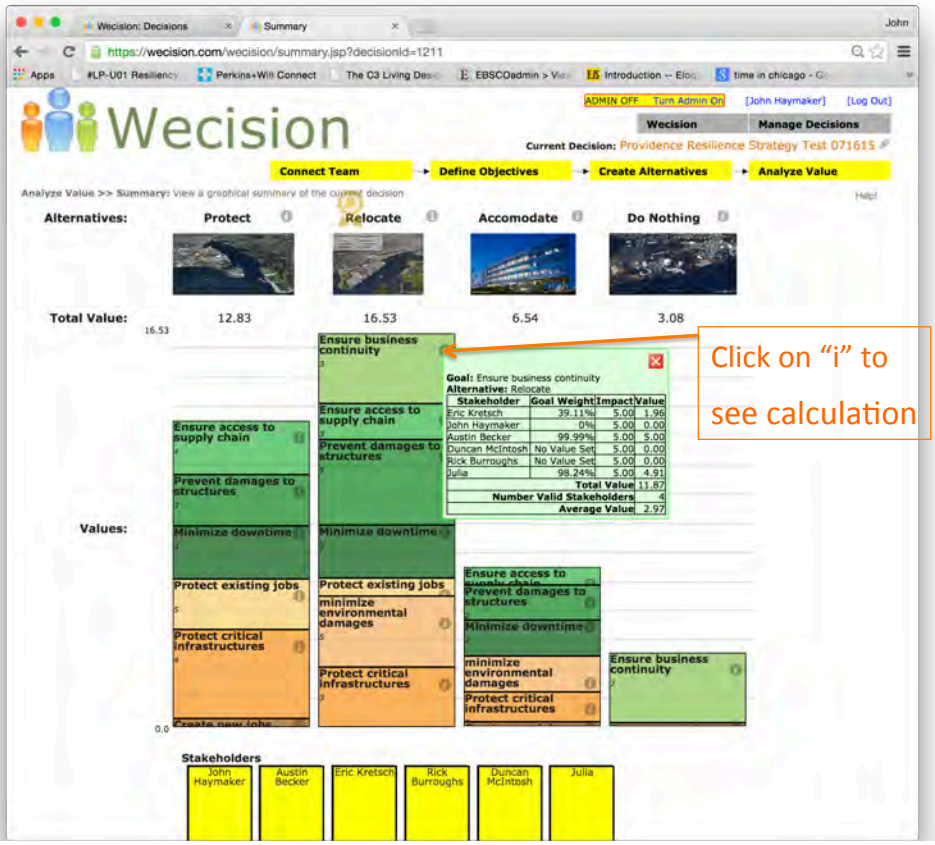

The goals and preferences (previously defined)
Potential alternative interventions (previously defined)
Impacts of each alternative on each goal
The advantage of each alternative over the worst performing alternatives (calculated automatically)
Normalized performance of alternative with respect to goal (calculated automatically)
Wecision
Connect Team
Define Objectives
Create Alternatives
Analyze Value
Goals
Protect
Relocate
Accomodate
Do Nothing
Ensure business continuity
minimize environmental damages
Protect critical infrastructures
Minimize debris generation from port



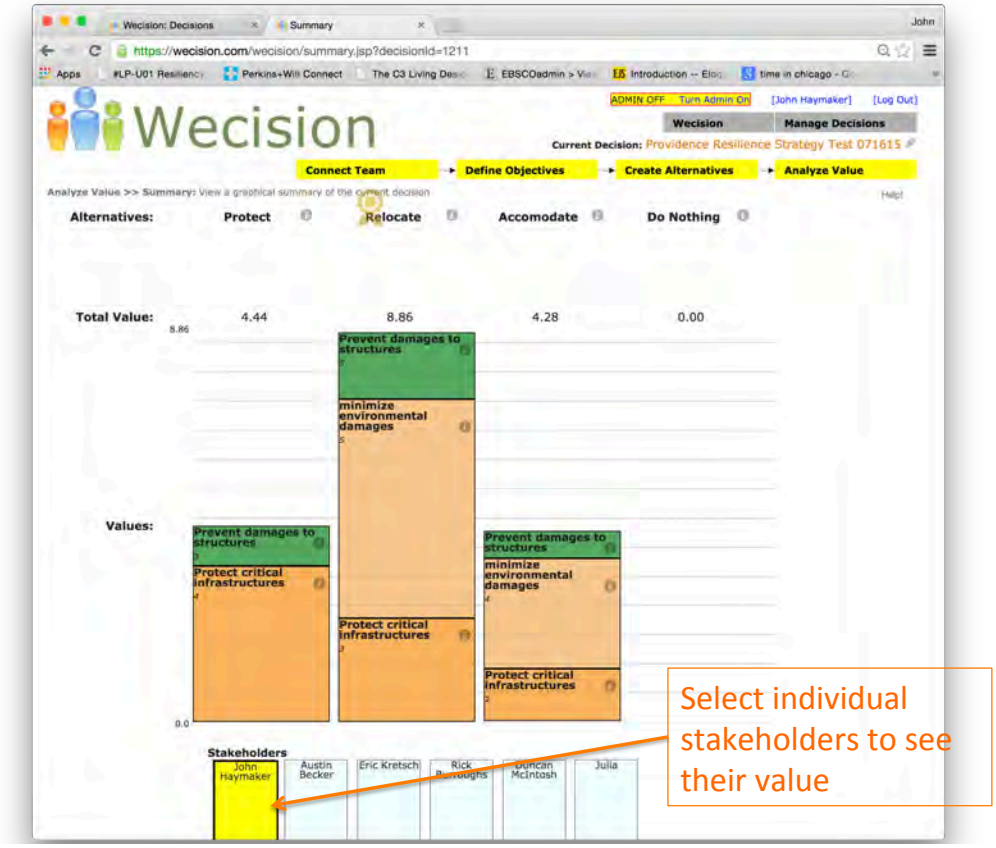
Value is calculated:

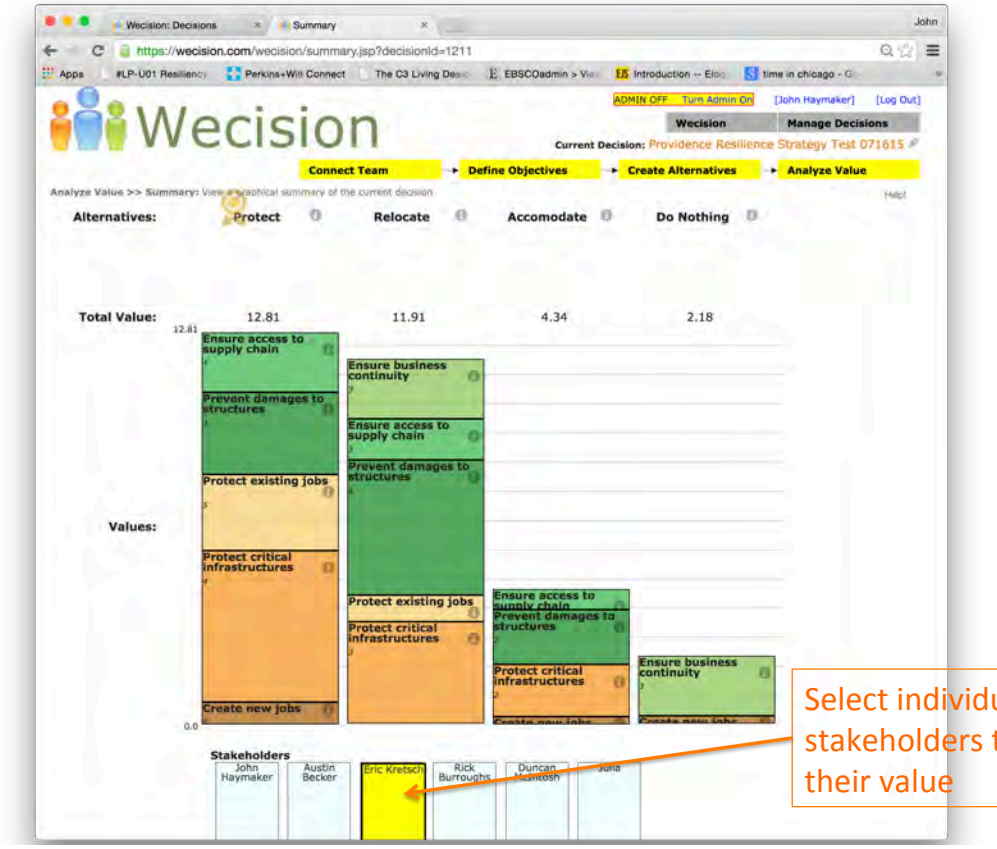
Normalized Performance for Goal X

Preference for goal



Click on “i” to see calculation


Wecision
Connect Team
Define Objectives
Create Alternatives
Analyze Value
Alternatives:
Protect
Relocate
Accomodate
Do Nothing
Total Value:
4.44
8.86
4.28
0.00
Values:
Prevent damages to structures
minimize environmental damages
Protect critical infrastructures
Stakeholders
John Haymaker
Austin Becker
Eric Kretsch
Rick Burroughs
Duncan McIntosh
Julia
Select individual stakeholders to see their value


Wecision
Connect Team
Define Objectives
Create Alternatives
Analyze Value
Alternatives:
Protect
Relocate
Accomodate
Do Nothing
Total Value:
12.81
11.91
4.34
2.18
Values:
Ensure access to supply chain
Prevent damages to structures
Protect existing jobs
Protect critical infrastructures
Create new jobs
Ensure business continuity
Stakeholders
John Haymaker
Austin Becker
Eric Kretsch
Rick Burroughs
Duncan McIntosh
Julia
Select individual stakeholders to see their value

http://wecision.com

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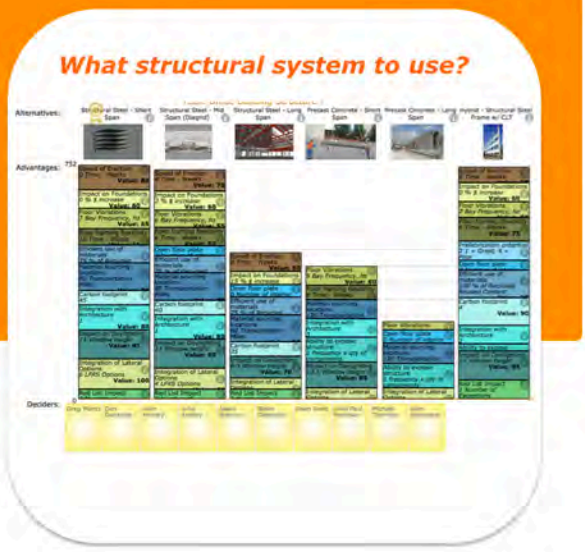

Stakeholder vulnerability and resilience strategy assessment of maritime infrastructure: Pilot project for Providence, RI

Outputs Related to Project

PROJECT WEBSITE
http://portofprovidenceresilience.org

LEVERAGED GRANTS
- *United States Department of Homeland Security* Coastal Resilience 2016-2017 ($16k of $1M)
- *Rhode Island Foundation* for Landscape Architecture Sustainability Studio 2015-16 ($10k)
- *URI Coastal Institute Leveraging Grant* - Development of disaster visualizations 2015 ($20k)
- *URI Coastal Institute Catalyst Grant* - Capacity building toward GeoDesign technologies 2015 ($6k)
- *URI Transportation Center Grant* for Sustainable Design Studio: A planning, policy, and design studio for seniors and graduate students on storm planning for the Port of Providence, 2014 ($10k)
- *URI Division of Research and Economic Development Proposal Development Grant* for "Building Leadership for Climate Adaptation: A Review of Approaches and Assessment of Applicability to the Maritime Infrastructure Sector" 2014-15 ($15k).

PUBLICATIONS (*graduate advisee, **undergraduate advisee)

Refereed Journal Papers Related to Project

7. Becker, A., (2016*)*, "Using Boundary Objects to Stimulate Transformational Thinking: Hazard Resilience for the Port of Providence." *Sustainability Science*.
6. Touzinsky, K, Rosati, J., Fox-Lent, C., Becker, A., Luscher, A. (2016), Advancing Coastal Systems Resilience Research: Improving Quantification Tools through Community Feedback. *Shore and Beach*. Vol. 84, No. 4, pp. 30-38.
5. Zhang, H., Ng, A., Becker, A. (*In Press*), "Institutional Barriers in Adaptation to Climate Change at Ports, Regions, and Supply Chains." North American Symposium on Climate Adaptation, New York, New York. Aug. 16-18.
4. Ng, A., Becker, A., Cahoon, S., Chen, S, Yang, Z., Earl, P. Time to Act: The Criticality of Ports in Adaptation to the Impacts Posed by Climate Change. (2016*)*, In Ng, A. et al (eds). *Climate Change and Adaptation Planning for Ports in Transportation and Supply Chains* (Edited book). Routledge, NY, NY.
3. Becker, A. and Ng, A. (2016), The state of climate adaptation for ports and the way forward, In Ng, A. et al (eds). *Climate Change and Adaptation Planning for Ports in Transportation and Supply Chains* (Edited book). Routledge, NY, NY.
2. Cahoon, S. Chen, P. Ng, A., Yang, Becker, A. (2016*),* Analyzing risks posed by climate change on transportation and supply chains: a fuzzy approach. In Ng, A. et al (eds). *Climate Change and Adaptation Planning for Ports in Transportation and Supply Chains* (Edited book). Routledge, NY, NY.
1. Messner, S., Becker, A., Ng, A. (2016*).* Seaport Adaptation for Climate Change: The Roles of Stakeholders and the Planning Process. In Ng, A. et al (eds). *Climate Change and Adaptation Planning for Ports in Transportation and Supply Chains* (Edited book). Routledge, NY, NY.

Non-Refereed Publications Related to Project

5. Becker, A. Burroughs, R., Kretsch, E.*, Haymaker, J., McIntosh R.*, (*In Prep*), "Vulnerability/Resilience Assessment for Maritime Infrastructure: Pilot Method Development for the Port of Providence." Workshop/project report for Rhode Island Dept. of Transportation.
4. Kane, M.**, Almeda, A.**, Green W., Becker, A., (2016), "Galilee: A Vision for a Resilient Port" Report from a 2016 Interdisciplinary Studio in Landscape Architecture at the University of Rhode Island. Funding support from the Rhode Island Foundation's Spartina Fund. Online at:

http://web.uri.edu/lar/files/Pages-from-FINAL-Galilee-Report-image.jpg.

3. Becker, A. (2016), "Hurricane Resilience: Long-range planning for the port of Providence." Case study report for PIANC Working Group 178.
2. Becker, A. (2015), "Rhode Island Embarks on Collaborative Planning Process for Building More Resilient Ports." FHWA Fostering Liveable Communities Newsletter, Issue 4, Number 3, October.
1. Ng, A., Becker, A. (2015), "Port adaptation to the impacts posed by climate change: How can scholars, policymakers, and industrial professionals contribute?" *The Maritime Economist*, *1(1).*

RELEVANT PRESENTATIONS ***(I=Invited, E = Expenses paid)***

31. Opaluch, J., Becker, A., Rubinoff, P., Kotowicz D., Robadue, D. (2017). "Motivating Actions to Reduce Storm Vulnerability," Department of Homeland Security Coastal Resilience Center, 2nd Annual Meeting, University of North Carolina, Chapel Hill, NC, Feb. 1–3.
30. Becker, A, (2016). "Toward a more resilient coast: Tools to Engage Decision Makers," US Naval War College, Newport, RI, Jan. 9. (I)
29. Becker, A, (2016). "Toward a more resilient coast: Research program overview," CELS Advisory Council Annual Meeting, Kingston, RI, Oct 21. (I)
28. Becker, A, (2016). "Adapting ports to climate change: Providence (RI) Case Study," AIVP Ports and Cities Conference, Netherlands, Oct 4-7.(I)
27. Thompson, R., A. Becker, D. Bidwell, and T. Smythe. Expanding opportunities and vulnerabilities in the Blue Economy. Presented at The 17th APEC Roundtable Meeting on the Involvement of the Business/Private Sector in the Sustainability of the Marine Environment. Taipei, Taiwan. August 31, 2016.
26. Becker, A., (2016). "Initiating Multi-Stakeholder Dialogue to Address the Wicked Challenge of Port-System Adaptation," North American Symposium on Climate Adaptation, New York, New York. Aug. 16-18. (I)
25. Becker, A. (2016). "The challenges of communicating climate change for coastal communities." Keynote speaker for Metcalf Institute fundraising event. Narragansett, RI, July 14th (I)
24. Becker, A., (2016). "Transformational Thinking for Port Adaptation," UNCTAD Technical Expert Meeting on Climate change impacts and adaptation for coastal transport infrastructure in Caribbean Small Island Developing States, 29 June- 1 July 2016.
23. Becker, A., (2016). "Inspiring resilience thinking for seaport systems." Transportation Research Board Conference for Committee on Maritime Transportation System (CMTS), National Academy of Sciences, Washington, DC, June 21-22
22. Becker, A, (2016). "Adapting ports to climate change: Providence (RI) Case Study," Adaptation Futures 2016, Rotterdam, Netherlands May 11-13.
21. Becker, A., (2016). "Inspiring resilience thinking for seaport systems." Green Ports for Blue Waters Conference, University of Rhode Island April 4-5, (I)
20. Green, W., Becker, A., (2016). "Built environments and rising seas: Service learning recommendations for the future of the Port of Galilee." A presentation of student work resulting from a course on resilient planning, policy, and design. Keeping History Above Water Conference, Newport, Rhode Island, April 10-13 .
19. Becker, A. (2016). "Hurricane Resilience and Impacts to Seaport Supply Chains." Invited Speaker for *the 2016 Stu Clark Speaker Series* at the University of Manitoba. March 4 (I,E)
18. Becker, A., Burroughs, R. (2016). "More holistic planning for long-term coastal resilience? Port of Providence Demonstration Project." Social Coast Conference. Charleston, SC, Feb. 10.
17. Becker, A. (2015). "Hurricane Resilience and Impacts to Rhode Island Ports." Testimony before RI House Commission on Economic Risk Due to Flooding and Sea Level Rise. Dec. 15. (I)
16. Becker, A. (2015). "Hurricane Resilience: Long Range Planning for the Port of Providence." URI Coastal Resources Center Seminar Series. Narragansett, RI, Nov. 10. (I)

15. Becker, A. (2015). “Hurricane Resilience: Long Range Planning for the Port of Providence.” Narragansett Bay Propeller Club Annual Meeting, Middletown, RI, Nov. 9. (I)
14. Becker, A., Burroughs, R., Kretsch, E.*, Haymaker, J., McIntosh, R.*, Miller, J.** (2015). “A methodology toward holistic long-term resilience planning: Rhode Island Pilot Study.” URI Leadership Summit. Kingston, RI, Sept. 19-20.
13. Becker, A. (2015). “Port Resilience: From knowledge to action.” United States Coast Guard Resilience Review Team, Washington, DC, (via webinar), June 4, 2015. (I)
12. Becker, A. (2015). “Climate change adaptation for the maritime freight sector: Moving from knowledge to action.” Economic Commission for Europe, Inland Transport Committee Working Party on Transport Trends and Economics Group of Experts on Climate Change impacts and adaptation for transport networks and nodes, Seventh session, Geneva, Switzerland (via webinar), June 3. (I)
11. Becker, A., Fischer, M., Schwegler, B., Chase, N. (2014). “Assessing Storm Vulnerabilities and Resilience Strategies: A Scenario-Method for Engaging Stakeholders of Public/Private Maritime Infrastructure.” Poster presentation at American Geophysical Union Conference, San Francisco, CA, Dec. 12-19.
10. Becker, A. (2014). “Climate Change Impacts in Rhode Island: The State of the Science,” *Staying Afloat: Adapting Waterfront Business to Rising Seas and Extreme Storms*, The 13th Annual Ronald C. Baird Sea Grant Science Symposium, Newport, RI, Dec. 10. (I)
9. Becker, A., Cox, K.*, Peterman, A. (2014), “Stakeholder drivers for building natural-disaster resilient seaport systems.” The Coastal Society and Restore America’s Estuaries Conference, Washington, DC, Nov. 11-14.
8. Becker, A. (2014), “Assessing vulnerability of maritime infrastructure: A case study of Rhode Island.” 2014 NSBPA Conference on New England Coastal Issues, Taunton, MA, Sept. 17-18. (I)
7. Toilliez, J., Mitchell, T., Becker, A. (2014), “Best Practices for Sustainable and Resilient Coastal Development through Consideration of Local Sea Level Dynamics.” 91st Coastal Engineering Research Board Meeting, San Francisco, CA, 9-11 September.
6. Becker, A. (2014), “Stakeholder vulnerability assessment of Maritime Infrastructure: A case study of Rhode Island.” Transportation Research Board Conference on *Innovative Technologies for a Resilient Marine Transportation System*, National Academy of Sciences, Washington, DC, June 24-26.
5. Becker, A. Weiss, L*., O’Brien, T. (2014), “Building leadership for climate adaptation: A review of approaches and assessment of applicability to the maritime infrastructure sector.” Transportation Research Board Conference on *Innovative Technologies for a Resilient Marine Transportation System*, National Academy of Sciences, Washington, DC, June 24-26.
4. Toilliez, J., Mitchell, T., Becker, A. (*2014)*, “Sea level change guidance.” ASCE International Conference on Sustainable Infrastructure Los Angeles/Long Beach, CA Nov. 2014.
3. Becker, A. (2014), “Moving toward resilience: A research agenda for sustainable seaports.” Green Boats and Ports for Blue Waters Conference, URI Graduate School of Oceanography, April 14. (I)
2. Becker, A. (2014) (Keynote speaker for research), “Climate resilience for ports and port cities: Setting a research agenda.” Consortium for Ocean Leadership 2014 Public Forum: The Urban Ocean, Washington, D.C., March 14. (I, E)
1. Becker, A. (2014), “Building seaport resilience to climate change: A research agenda.” Environmental Protection Agency Seminar Series, Narragansett, RI, March 5. (I)

RELEVANT STUDENT PRESENTATIONS

6. Kretsch, E.*, Becker, A. (2016). “Leadership and Responsibility for Long-Term Hurricane Resilience: Port of Providence, RI.” Transportation Research Board Conference for Committee on Maritime Transportation System (CMTS), National Academy of Sciences, Washington, DC, June 21-22.

5. Stempel, P.* (2016). “Data Driven Visualization.” Estuarine and Coastal Modeling Conference 2016, Narragansett, RI, June 14-15.
4. Kretsch, E.*, Becker, A. (2016). “Leadership and Responsibility for Long-term Hurricane Resilience: Stakeholder Perceptions in the Port of Providence, RI.” Social Coast Conference. Charleston, SC, Feb. 11.
3. Miller, J., Becker, A., Burroughs, R., Kretsch, E. (2015). “Perceptions of Hurricane Risk Amongst Port of Providence Stakeholders.” URI Coastal and Engineering Fellows Poster Session, URI, Dec. 15.
2.. Kretsch, E.*, Becker, A., Burroughs, R., Haymaker, J., McIntosh, R.*, Miller, J.* (2015). “Impacts of Storm Events and Resilience Options for Port Communities: Rhode Island Pilot Study.” Coastal Structures and Solutions to Coastal Disasters Joint Conference. Boston, MA, Sept. 9-11.
1. Kretsch, E.*, Becker, A. (2015)“Stakeholder Involvement in Understanding the Economic Impacts of Climate Change and Storm Events on Maritime Infrastructure: Rhode Island Pilot Study.” 7th Annual International Climate Change Conference. April 10-11. Vancouver, CA.

IN THE NEWS

Disaster visualization work of graduate advisee Peter Stempel featured on front page of *Providence Journal*, (Nov. 27, 2016), “Rising seas, rising stakes, R.I. researchers project future flooding.” Online at http://www.providencejournal.com/news/20161127/rising-seas-rising-stakes-ri-researchers-project-future-flooding.

Graduate advisee Peter Stempel featured in URI *Big Thinkers* (2016), “CELS grad student innovates ways to visualize climate change.” Online at http://web.uri.edu/cels/cels-grad-student-innovates-ways-to-visualize-climate-change/.

LAR 444 Studio Course featured at URI News (2015), “URI landscape architecture, environmental science and management, marine affairs students propose projects for Port of Galilee“ http://news.uri.edu/releases/.

Profile featured in URI *Big Thinkers* (2015), “CELS Professor aims to strengthen our nation’s ports.” Online at: http://web.uri.edu/cels/big-thinkers/.

Research featured in *41 Degrees North* (Winter 2015), “Preparing Ports to Ride out the Storm.” Online at: http://issuu.com/41n_rhodeislandseagrant/docs/41degreesnorth-winter15/4.

RELEVANT COURSES AND STUDENT INVOLVEMENT

Undergraduate/graduate course*: Landscape Architecture Sustainability Studio: Working Waterfront Storm Resilience (LAR 444)*

Terms: Fall 2014, Fall 2015 (co-taught with Prof. Will Green)

Graduate Course*: Port Planning and Policy (MAF 564)*

Terms: Spring 2014, Spring 2015, Spring 2016, Spring 2017

URI graduate students involved in project:

PHD - *Robert (Duncan) McIntosh, 2017; Peter Stempel, 2018*
MAMA – *Robert (Bobby) Witkop, 2018; Eric Kretsch, 2016*
MMA –*Kaitlyn Cox, 2014*
MESM – *Rita Lavoire, 2017; Mary Kate Kane, 2017*
UNDERGRAD – *Julia Miller, LAR 444 class (two semesters, 36 students total)*

Dr. Austin Becker Appointments/Service Related to Project

ICNet – Infrastructure and Climate Network, *Steering Committee Member for* 2016-present

NSF funded expert group	
IMAREST Conference on Storms, Tides, and Rising Seas: Impacts for Ports (2016), *Steering Committee*	2015 - present
AIVP – The Worldwide Network of Port Cities, *Associated Expert*	2015 - present
AAAS 2017 Annual Meeting, Boston, MA, Feb. 20, *Discussant for Science for the Land-Sea Interface: Informing Coastal and Nearshore Marine Policy*	2017
15th Worldwide Conference on Cities and Ports, Rotterdam, *Planning Committee and Rapporteur*	2016
2016 North American Symposium on Climate Adaptation, *Session Moderator*	2016
Transportation Research Board (TRB) and the U.S. Committee on the Marine Transportation System (CMTS) conference, *From Sail to Satellite: Delivering Solutions for Tomorrow's MTS*. 4th biennial research and development conference at the National Academy of Sciences Building, Washington, D.C., June 21-23, 2016, *Planning Committee and Session Moderator*	2015 - 2016
Joint Agency Coastal Infrastructure Resilience Workshop: Mobile Bay, AL. Sea Grant National Oceanic and Atmospheric Administration (NOAA), Committee on the Marine Transportation System (CMTS), U.S. Army Corps of Engineers, Engineer Research and Development Center (USACE-ERDC), *Invited expert*	2015