# ISELIN DOCK
## FEASIBILITY STUDY

Woods Hole Oceanographic Institution

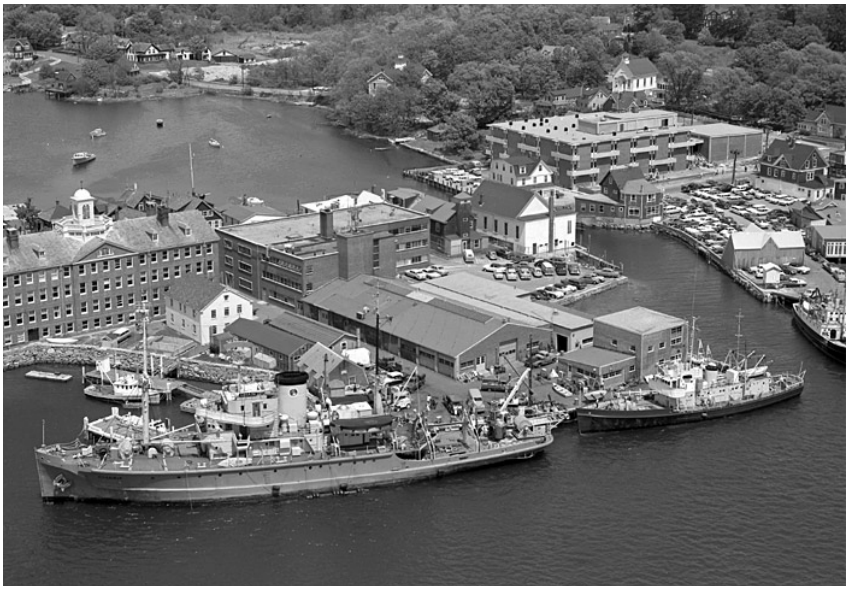
2017 Woods Hole Aerial

# Woods Hole Oceanographic Institution

## Historic Perspective

For nearly a century, Woods Hole Oceanographic Institution (WHOI or Institution) has been one of the best known and most trusted names in ocean science and exploration. WHOI's scientists and engineers have played a part in many of the discoveries that form the modern understanding of the ocean and how it interacts with other parts of the planet, including human society.

Since its founding in 1930, WHOI has had waterfront facilities in Woods Hole capable of berthing and supporting the activities of its ocean-going research vessels, as well as those of other institutions. Iselin Dock was constructed in its current configuration in 1969 to accommodate an expanding fleet.

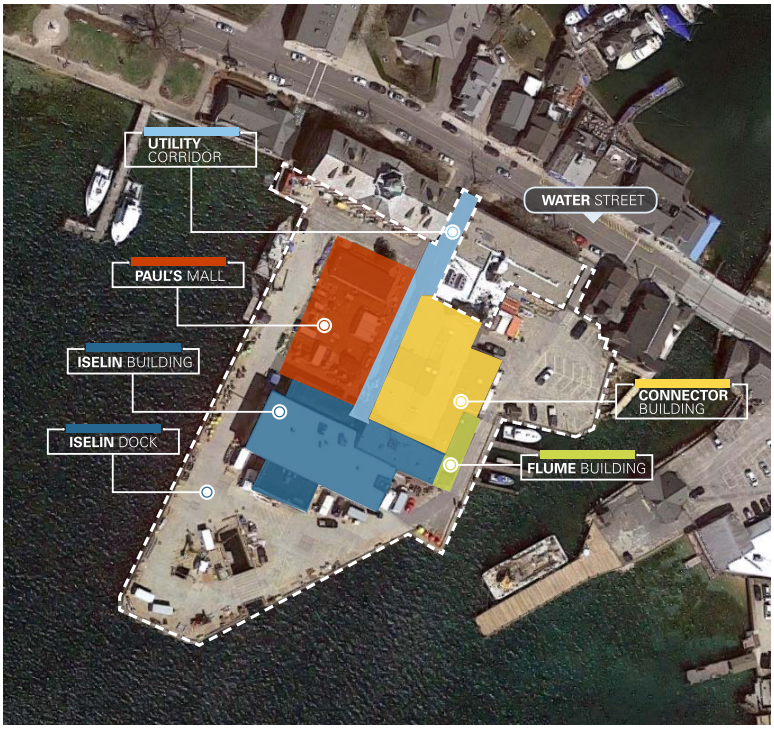


1965 Woods Hole Aerial

# Iselin Dock 2018

Iselin Dock is located at 98 Water Street in the village of Woods Hole in Falmouth. The facility consists of a triangular shaped dock and a complex of facilities to support activities that benefit from direct access to the waterfront. The dock has over 700 linear feet of deep-water berth, 430-ft on the west face that can accommodate two vessels end-to-end and 256-ft on the east face, which can accommodate a global class research vessel. The dock is a reinforced concrete deck built on two-hundred-and-thirty-two 14 to 18-in. diameter steel pilings with a steel sheet pile bulkhead holding back fill on its interior edges. On the dock and adjacent bulkhead apron are laboratory buildings totaling over 90,000 sf that house flexible "high bays," machine/mechanical shops, rigging shops, underwater vehicle labs and office space. The complex supports ship mobilization, vehicle, equipment and sensor testing and loading, as well as dive operations for training, testing and inspection.

The limits of work include the Iselin, Flume and Smith Connector building, the access roads at Water Street both east and west of the Smith building, Paul's Mall and the remaining dock structure. The image below delineates the study's project limits.




**Feasibility Study's Project Limits**

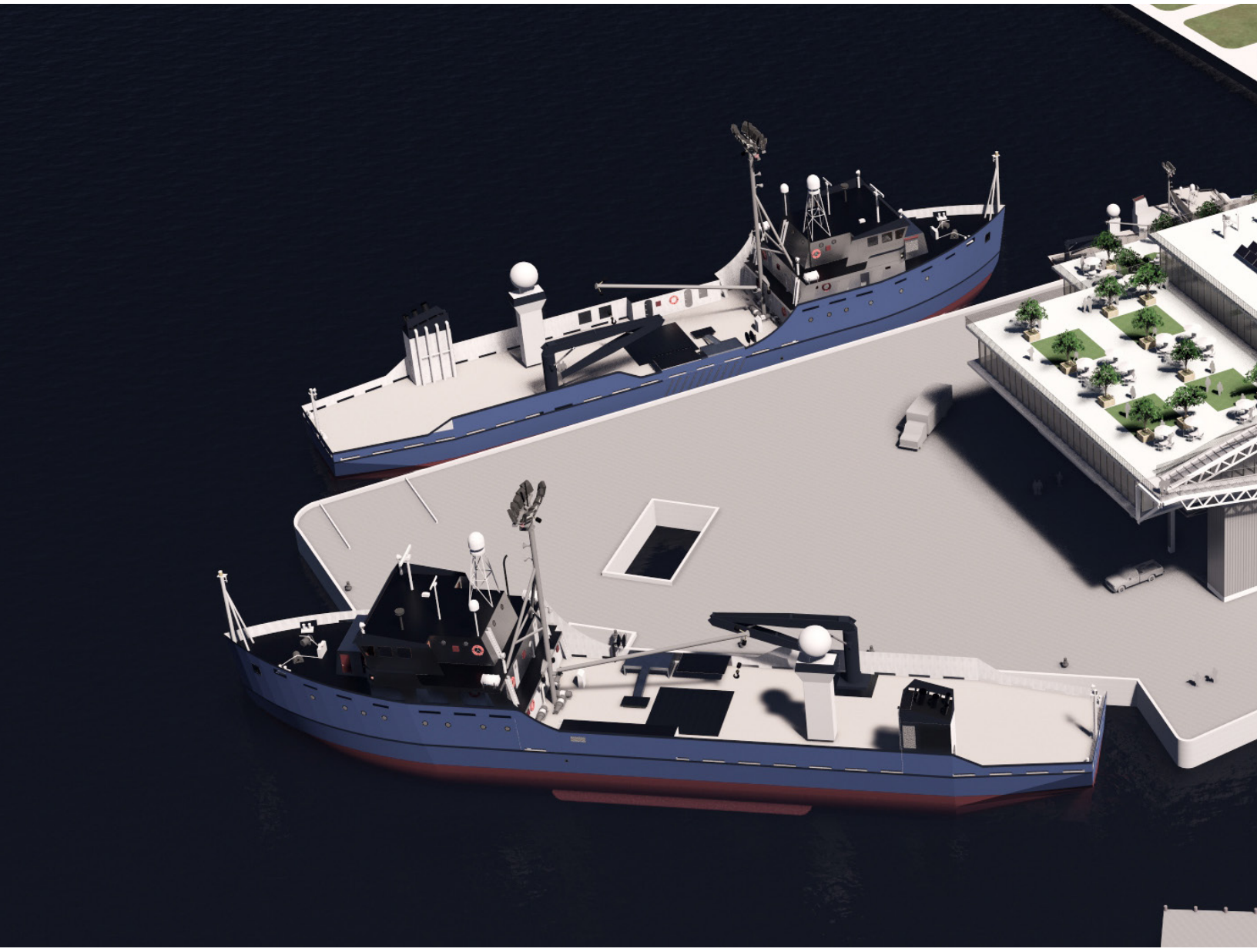
## Goals of the New Woods Hole Research Facility

- Dock target design life of 100 years, minimum 50 years.
- Dock elevation to accommodate sea level rise into the next century.
- State-of-the-art dock and research facilities.
- Resilient design of building and utilities for extreme weather events.
- Improve operational flexibility of the dock and laboratory facilities.
- Expansion potential of the dock and research facilities.
- Improved and secure site that still provides public access.
- Phased construction to maintain some dock and building operations.

# Dock Design for the Next Century

Iselin Dock is nearing the end of its 50-year design life and is approaching $1M in annual maintenance costs. With maintenance costs increasing and degrading infrastructure impacting dock operations, the Institution faces the risk of greater operational restrictions and lost research opportunities. Sections of the concrete deck have undergone full depth replacement, whereas the steel elements have required significant efforts to combat corrosion.

The replacement of the aging Iselin Dock provides an opportunity for the Institution to create a waterfront research facility that anticipates and enables the direction of ocean research for the next century. With open and deliberate planning, WHOI intends for this project to assess future needs in the context of the changing environment.



The recommended solution for the new dock structure is a steel pipe pile-supported platform with a concrete deck and replacing the steel sheet pile bulkhead. Although, identical in concept to the existing structure, even after 50 years, this type of construction is still one of the most commonly used waterfront solutions today. Since 1969, many advancements have been made in the design and use of materials to improve the durability of in water structures, which should yield improved durability and reduced maintenance costs over a 50- to 75-year timeframe. For example, marine specific concrete mixes, the use of epoxy coated steel reinforcing and cathodic protection are industry standard improvements compared to designs 50 years ago.

**Replace In-Kind Dock Concept - "Public Garden" Building Concept**

# Four Dock Trade Studies

## Four Primary Design Variables were Considered:

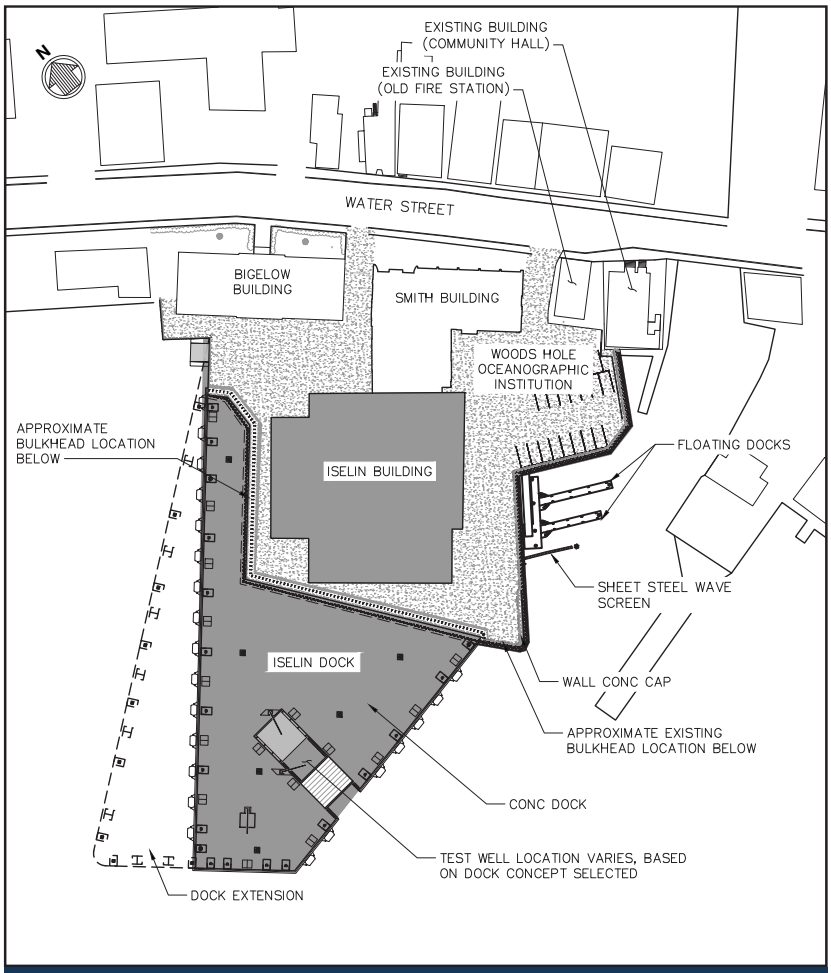
1. Dock Footprint
2. Dock Elevation
3. Location of Large Test Well
4. Design Life for the Dock and Bulkhead

Each of the four variables provides trade-offs not limited to dock function, cost, construction schedule and permitting.

## Two Concepts for the Dock Footprint

**(1) Replace In-Kind concept** replicates the 37,100-sf footprint of the existing dock.

**(2) Dock Extension concept** doubles the length of the south berth to 164 ft, which provides a new berth for the future Regional Class Research Vessels while increasing the dock footprint by more than 50% to 56,700 sf.




DOCK FOOTPRINT CONCEPTS

## Dock Elevation

With the rate of sea level rise (SLR) continuing to accelerate, planning for its impact is fundamental to the design of a waterfront research facility intended to last 100 years.

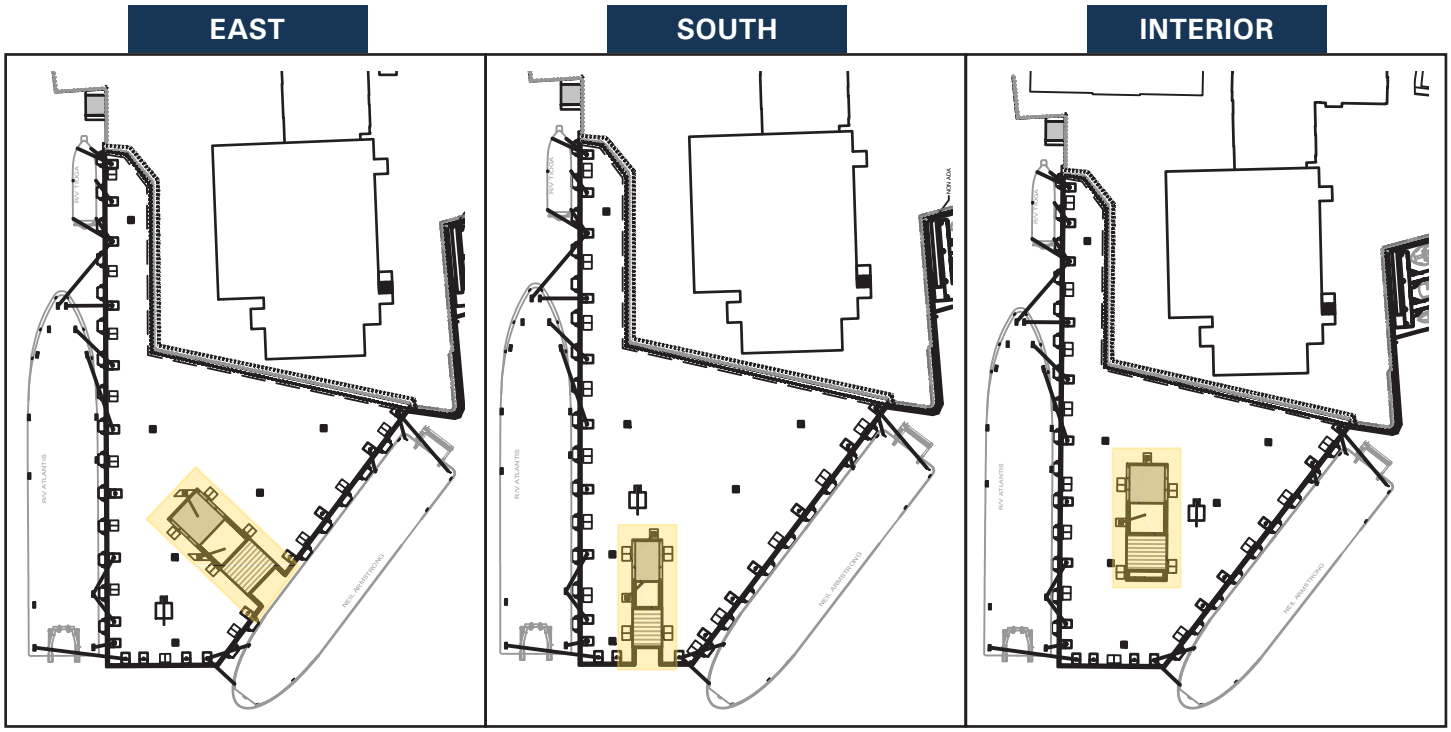
The recommended dock elevation for Iselin Dock for the year 2100 is 10-ft NAVD88 (North American Vertical Datum of 1988). This represents an increase of 4ft from current dock elevation, which is approximately 5.5 ft above the current mean high water mark). This would position the dock at an elevation safe from nuisance flooding through this century to provide for normal dock operability during typical environmental conditions.

**Recommended Iselin Dock Elevation for the Year 2100 10-ft NAVD88**

While increasing the deck elevation 4 ft will keep the dock operational 80 years out, it will complicate vessel and dock operations in the near term. In order to minimize operational impacts, this Study also considers raising the dock 2.5 ft (consistent with nearly 70 years of SLR), and a third option that will accommodate both. The latter modular solution is an adaptive strategy that will design the dock foundation piles to accommodate increasing the deck surface an additional 1.5-ft by adding fill and paving.

## Location of Large Test Well

Unique to Iselin Dock is that the facility is used for testing and research. Much of this work occurs at the existing large test well, which is a 90-ft long by 20-ft wide cutout in the middle of the east berth. The test well provides protected access to the sea as well as services such as power, communications, cranes, floating platforms and testing vans. The preference is to increase the size of the test well by 50% in width and move it to the south berth to take advantage of the deeper water depths. Scenarios for three test well locations: 1) east berth, 2) south berth and 3) interior berth were developed for the two dock footprint concepts: Replace In-Kind and Dock Extension.




## Design Life for the Dock and Bulkhead

The industry standard design life for structures in the marine environment is typically between 50 to 75 years. Designing for 100 years requires higher quality materials and specifications that require additional upfront capital costs.

### Achieving a 100-year Design Life

#### Bulkhead Requirements/Necessities

Encapsulate the new steel sheet pile bulkhead in concrete. Additional riprap stone will need to be excavated to allow for the placement of concrete.

#### Dock Requirements/Necessities

- High-density polyethylene (HDPE) sleeves to protect the above water surfaces of the steel pipe piles.
- 20-year sacrificial anodes replaced five times.
- Steel reinforcing bars for the concrete upgraded from epoxy-coated to stainless steel.
- Additional concrete testing to ensure a 100-year concrete mix.

# Sea Level Rise

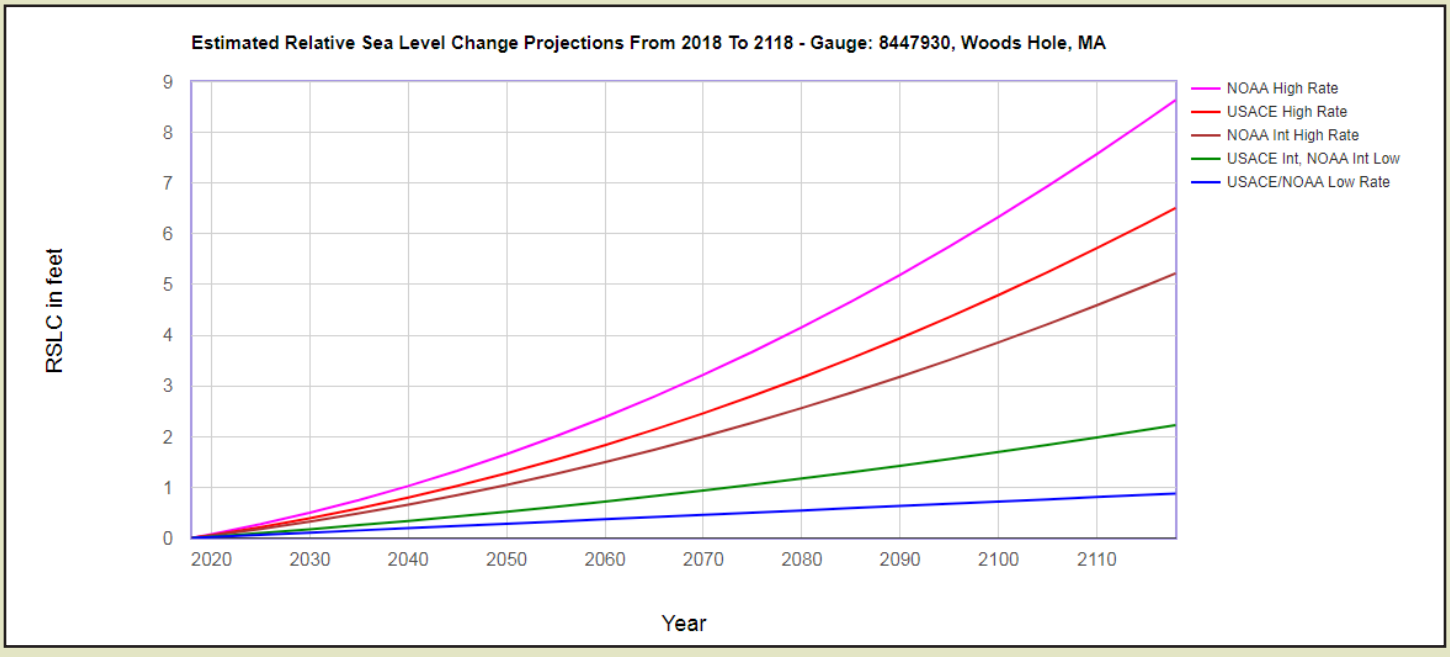
Warming oceans combined with the effects of melting ice sheets and glaciers have been causing sea levels to rise globally since the last glacial period. Although the phenomenon is not new, recent studies indicate that the rate of global SLR may be higher over the past two decades as compared to the past century, and a considerable amount of research is being conducted on this subject. Projections of mean global SLR vary based on underlying projections of greenhouse gas (GHG) emissions and its modelled effect on SLR. Ice-sheet melt in Greenland and Antarctica constitute a growing share of the variance in these projections.

## Federal Policies

Although there is consensus that design should incorporate global warming and SLR, the development of codified methods is still in its infancy. For example, federal agencies (i.e. the USACE, NOAA and Department of Defense (DOD) have developed projections that differ in approach. Where the USACE uses three projections correlating to 0.2m, 0.5m and 1.5m global SLR scenarios, NOAA and the DOD use four and five scenarios respectively that account for up to 2.0m of global SLR.

The table below provides the anticipated SLR projections for the agencies referenced above based on the tide gauge on Iselin Dock, whereas the graph shows the same projections for USACE and NOAA.

| Global SLR Scenario | USACE | NOAA | DOD | Woods Hole Relative SLR in 2118 |
|---|---|---|---|---|
| 0.2m (0.7 ft) in year 2100 | Low | Lowest | Lowest | 0.88 ft |
| 0.5 m (1.6 ft) in year 2100 | Intermediate | Intermediate-Low | Low | 2.23 ft |
| 1.0 m (3.3 ft) in year 2100 | | | Medium | 4.36 ft |
| 1.2 m (3.9 ft) in year 2100 | | Intermediate-High | | 5.22 ft |
| 1.5 m (4.9 ft) in year 2100 | High | | High | 6.51 ft |
| 2.0 m (6.6 ft) in year 2100 | | Highest | Highest | 8.64 ft |



## Emission Impacts

Each of the different future global SLR scenarios can be correlated to one of the four GHG concentration trajectories adopted by the International Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5). These trajectories are called Representative Concentration Pathways (RCPs). The scenarios (i.e. RCP2.6, RCP4.5, RCP6.0 and RCP8.5) correspond to the possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0 and +8.5 W/m2 respectively). The RCPs are consistent with atmospheric conditions corresponding to a wide range of possible changes in future anthropogenic GHG emissions. RCP2.6 assumes the global annual GHG emissions peak between 2010 and 2020 with emissions declining significantly thereafter. RCP4.5 assumes peak emissions around 2040, RCP6.0 around 2080, and RCP8.5 assumes continued rise of emissions throughout the 21st century.

## Local SLR Estimates

In addition to the global mean SLR, the total relative sea level change at any given location includes a local component given the varying non-climatic background vertical land movement, oceanographic effects, and spatially variable responses of the geoid to shrinking land ice. At Woods Hole, the local SLR projections under RCP8.5, which are being used in the update to the state of Massachusetts's Hazard Mitigation and Climate Adaptation Plan, were adopted. These elevations have a 99.5% probability of not being exceeded within the respective timeframes, assuming contribution of ice mass loss in these projections based on IPCC AR5 and expert elicitation. However, when accounting for possible ice sheet instabilities, the probability of exceedance drops to 83%.

| Tidal Benchmark | Elevation (ft-NAVD88) Epoch (1983-2001) | Elevation (ft-NAVD88) Epoch (1999-2017) | 2070 (ft-NAVD88) | 2100 (ft-NAVD88) |
|---|---|---|---|---|
| Highest Annual Tide | 1.86 | 2.07 | 6.4 | 9.9 |
| Mean Higher High Water | 0.84 | 1.05 | 5.4 | 8.9 |
| Mean High Water | 0.56 | 0.79 | 5.2 | 8.7 |
| Mean Sea Level | -0.38 | -0.17 | 4.2 | 7.7 |

## Woods Hole SLR Projections

Understanding that the proposed project is being planned for a 100-year service life, it is reasonable to consider SLR projections up to 100 years in the future (2120). However, given the uncertainties associated with climate science and SLR projections, it is recommended that design elevations be based on projections for year 2100. Uncertainties beyond 2100 become increasing large and may not warrant present day actions due to changing infrastructure uses, technology, neighboring landscape changes, etc.

These considerations suggest the deck elevation for Iselin Dock should be 10 ft NAVD88 (an increase of 4 ft from current deck elevation, which is approximately 5.5 ft above the current mean high water mark). This would position the deck at an elevation safe from nuisance flooding through this century to preserve normal dock operability during typical environmental conditions. However, a 4.0 ft increase may be impractical, at least initially. More extreme water levels due to storm surge will be combatted through the resilient design of the building and utility infrastructure. As other project constraints dictate, an adaptable approach to increasing the deck elevation can be executed. It may be favorable to increase the deck elevation incrementally as the rise in sea level becomes more predictable.

**At Woods Hole, higher end projections anticipate over 4 ft of SLR in 50 years and nearly 8 ft in 80 years.**

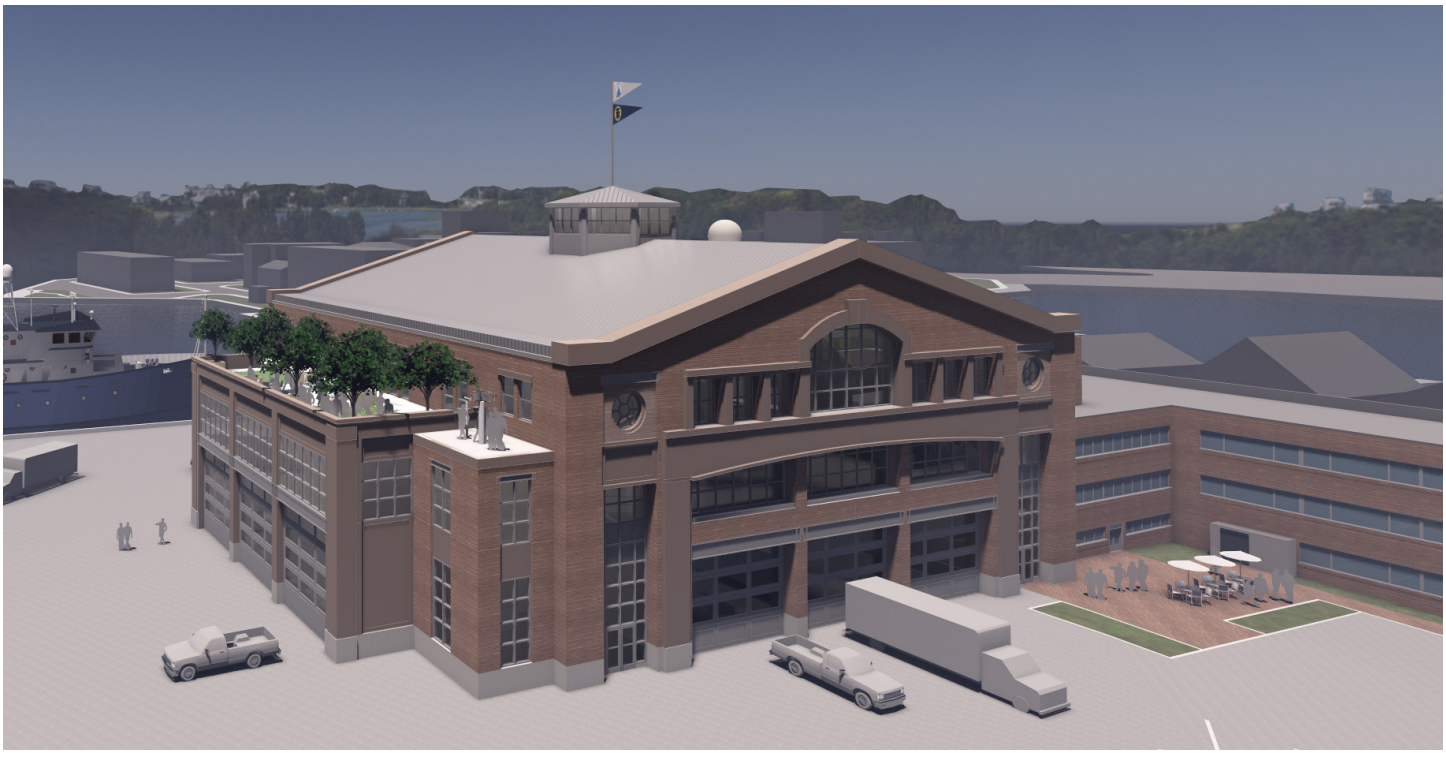
# State-of-the-Art Research Building

While the dock is deteriorating, the condition of the upland infrastructure is also affecting the Institution's level of service. The primary site utilities are deteriorating and require regular maintenance to remain serviceable. Most critically, the mechanical room servicing Iselin and the Smith Connector Buildings is vulnerable to flooding during storm events. Redevelopment of the site will not only reset the operational timeline for the facility, but also provide WHOI the opportunity to promote and expand its role as a leading oceanographic research institution.

The new state-of-the-art facility will be outfitted with world-class laboratories, workshops and high bays, a real-time ocean observing system and public event spaces, and will adopt resilient design strategies to mitigate impacts due to extreme weather events. To accomplish this vision, the site will need to be rebuilt, including the demolition of the current Iselin, Smith Connector, and Flume buildings, reconstruction of the site utilities, grading and paving and the new research building itself. The design of the primary activities are dependent on the physical constraints of the site and the required size of the building. The site constraints and building size are characterized by the footprint and height of the building and the height of the surrounding site that bridges the new higher dock elevation to Water Street.


**Iselin Laboratory**

## Three-Level Building - "Civic Neo-Classical" Design Concept



The total net assignable square footage (nasf) requirements by program is 35,840 nasf, which is nearly 40% larger than Iselin and the Smith Connector Buildings currently.

In order to accommodate the expanded building, the footprint of the structure was sized to the greatest extent possible, limited primarily by the existing steel sheet pile bulkhead and the vehicle circulation pattern required for truck access around the site. Working within this footprint, 3-Level and 4-Level building concepts were developed, which were based on the same program designed around 35,840 nasf and 57,500 gsf. The building concepts incorporate resilient design strategies such as elevated power and mechanical systems, watertight utility shafts, a flood-resistant ground floor, and one that can be retrofitted to be raised an additional 1.5-ft if the modular dock design is implemented.

The only difference between the two building concepts is that the usage of the top floor of the 3-Level concept is being spread out over two stories in the 4-Level concept.

The hallmark feature of the 4-Level concept is that the top floor is dedicated to the public. The 3-Level and 4-Level buildings are anticipated to take 20 mos and 24 mos to construct, respectively. Note the ground floor of each building concept includes an additional 1.5-ft of clearance in case the modular dock design concept is selected.

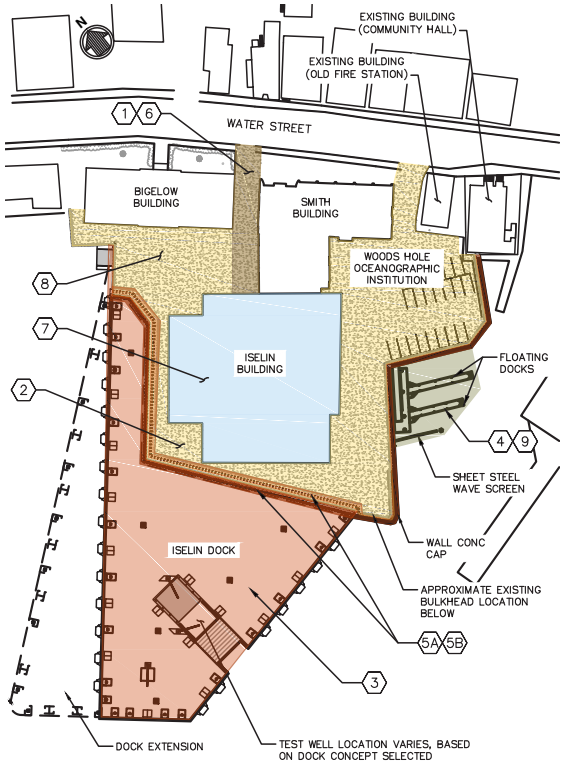
| Program Description | Net Assignable Square Footage | Percentage of Total |
|---|---|---|
| Research Labs | 13,720 | 38% |
| Multi-Use Workshops | 3,000 | 8% |
| Dive Operations | 2,250 | 6% |
| Shipboard Scientific Services Group | 2,545 | 7% |
| Marine Operations | 3,375 | 10% |
| High Bay | 6,350 | 18% |
| Public/Observatory | 4,600 | 13% |
| **NASF Total** | **35,840** | |
| **GSF Total (62% efficiency factor)** | **57,500** | |

## Four-Level Building - "Marine Terminal" Design Concept

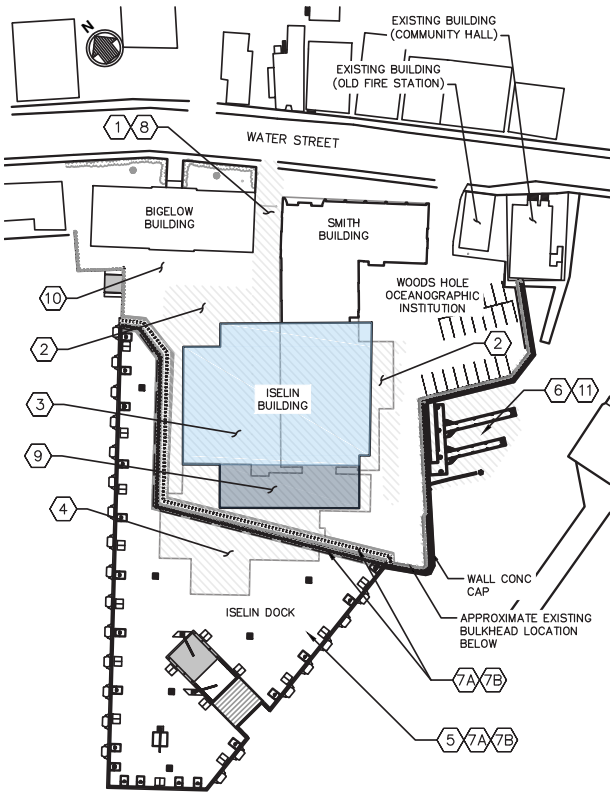
# Construction Plan Scenarios

## Continuous Construction | Building and dock non-operational for full duration.

| Phase No. | Description |
|---|---|
| 1 | Construct permanent utilities for Bigelow and Smith Buildings and disconnect and demolish utilities to remaining buildings |
| 2 | Demolish Iselin and Connector Buildings, Paul's Mall and pavement |
| 3 | Demolish existing dock up to the existing bulkhead |
| 4 | Demolish existing fixed timber piers and steel sheet wave screen |
| 5A | Construct new secant pile wall bulkhead and new dock |
| 5B | Construct new steel sheet pile bulkhead and new dock |
| 6 | Complete construction of new utility corridor |
| 7 | Construct new Iselin Building |
| 8 | Regrade existing site |
| 9 | Construct new floating docks |



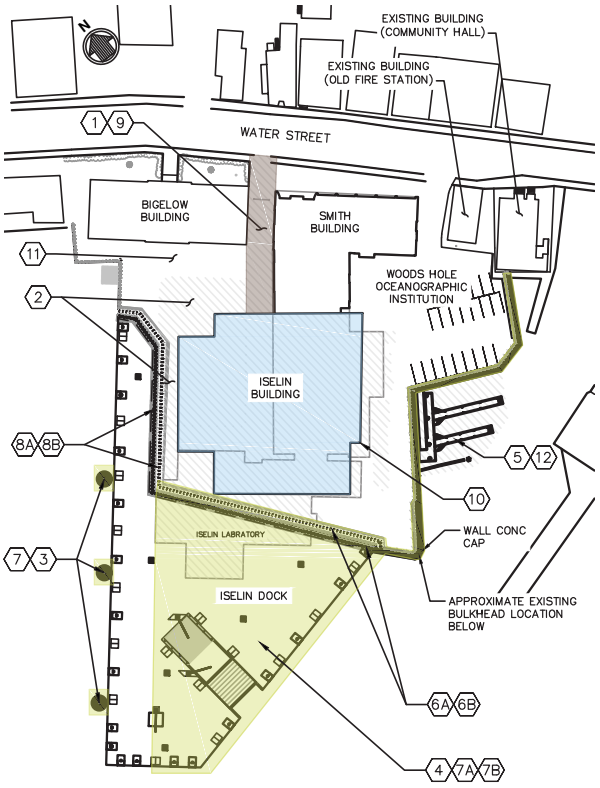

## Staged Building Construction | Limited building operations throughout.



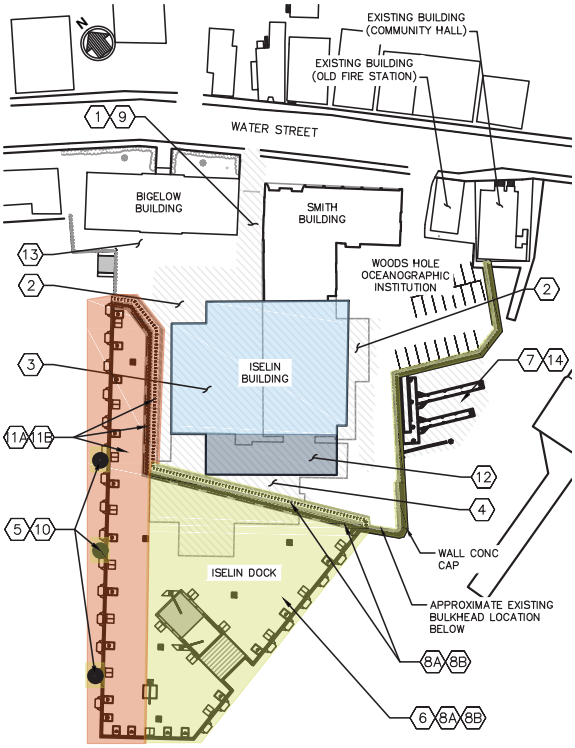

| Phase No. | Description |
|---|---|
| 1 | Construct permanent/temporary utilities for existing Iselin, Bigelow and Smith Buildings |
| 2 | Demolish Connector Buildings and Paul's Mall |
| 3 | Construct Stage 1 of new Iselin Building |
| 4 | Demolish existing Iselin Building |
| 5 | Demolish existing dock up to existing bulkhead |
| 6 | Demolish existing fixed timber piers and steel sheet wave screen |
| 7A | Construct new secant pile wall bulkhead and new dock |
| 7B | Construct new steel sheet pile bulkhead and new dock |
| 8 | Finalize construction of new utility corridor |
| 9 | Construct Stage 2 of new Iselin Building |
| 10 | Regrade existing site |
| 11 | Construct new floating docks |

## Staged Dock Construction | Limited dock operations throughout.

| Phase No. | Description |
|---|---|
| 1 | Construct permanent utilities for Bigelow and Smith Buildings and disconnect and demolish utilities to remain buildings |
| 2 | Demolish Iselin and Connector Buildings, Paul's Mall and pavement |
| 3 | Construct temporary mooring structures |
| 4 | Demolish eastern portion of existing dock up to the existing bulkhead |
| 5 | Demolish existing fixed timber piers and steel sheet wave screen |
| 6A | Construct eastern portion of new secant pile wall bulkhead and new dock |
| 6B | Construct eastern portion of new steel sheet pile bulkhead and new dock |
| 7 | Demolish temporary mooring structures and western portion of dock up to the existing bulkhead |
| 8A | Construct western portion of new secant pile wall bulkhead and new dock |
| 8B | Construct western portion of new steel sheet pile bulkhead and new dock |
| 9 | Finalize new utility corridor |
| 10 | Construct new Iselin Building |
| 11 | Regrade existing site |
| 12 | Construct new floating docks |




## Staged Building & Dock Construction | Partial building and dock operations throughout.




| Phase No. | Description |
|---|---|
| 1 | Construct permanent utilities for existing Iselin, Bigelow and Smith Buildings and disconnect and demolish utilities to remaining buildings |
| 2 | Demolish Connector Building, Paul's Mall and pavement |
| 3 | Construct Stage 1 of new Iselin Building |
| 4 | Demolish existing Iselin Building |
| 5 | Construct temporary mooring structures |
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| 9 | Finalize new utility corridor |
| 10 | Demolish temporary mooring structures and western portion of dock up to the existing bulkhead |
| 11A | Construct western portion of new secant pile wall bulkhead and new dock |
| 11B | Construct western portion of new steel sheet pile bulkhead and new dock |
| 12 | Construct Stage 2 of new Iselin Building |
| 13 | Regrade existing site |
| 14 | Construct new floating docks |

# Permitting, Financing, Community Impact & Project Risks

## Permitting

Port modernization and waterfront construction projects in Massachusetts must submit a multitude of environmental permit applications and undergo environmental reviews from regulatory authorities at the local, regional, state and federal levels. The two dock concepts (Replace In-Kind and Dock Extension) will face different levels of regulatory scrutiny.

The permitting process for the Replace In-Kind concept will be straightforward because there are few regulatory hurdles for replacing a structure already in-place. Permitting may take as long as 16 months because new Chapter 91 licenses have recently taken approximately 12 months for review and approval.

The Dock Extension concept exceeds a number of regulatory thresholds that will likely require an EIR and a review from the Cape Cod Commission. Furthermore, because the Dock Extension will encroach Marine Biological Laboratory's (MBL) property to the west, WHOI will need written consent from MBL for this concept to be permitted.

## Financing

Based on the construction plan scenarios, the estimated capital costs are high. Given the expense, the working assumption that underpins the funding strategy is that a single grant source will not be sufficient to fund the Iselin Dock reconstruction effort fully.

However, there are promising federal and state opportunities worth pursuing, largely focused around leveraging the Institution's relationships and the state of Massachusetts's support of the maritime industry and the blue economy overall. A few examples include:

- NSF's Established Program to Stimulate Competitive Research & Oceanographic Facilities & Equipment Support.
- NOAA's Broad Agency Announcement for projects related to climate adaptation and mitigation, weather-ready nation, healthy oceans and resilient coastal communities and economies.
- Massachusetts Executive Order 569 to respond to and prepare for extreme weather, SLR, inland flooding and other climate impacts.

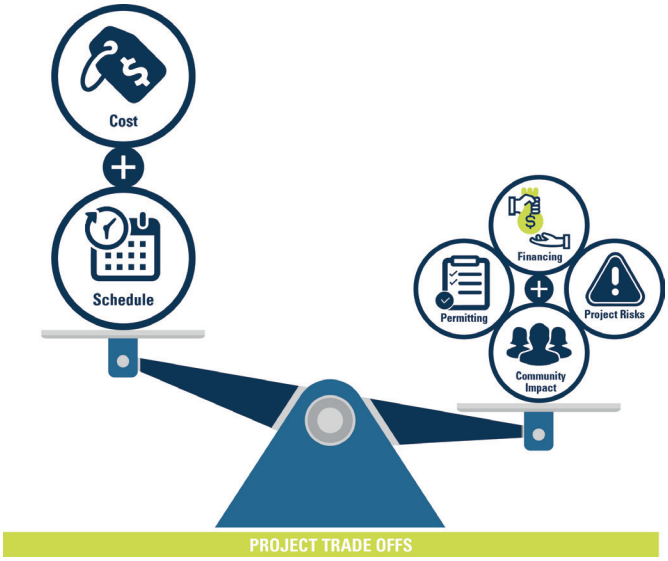
## Community Impact

Beyond the impacts to the Institution's operations, WHOI understands the affects the project will have on the Village of Woods Hole. Given the project's size and location, proactive and effective management of traffic and noise leading up to and during construction will be critical. It will be important to maintain open lines of good communication with Village businesses and residents throughout the project. To that end, the Institution has established a Community Advisory Committee, which has regular community meetings to facilitate project discussions. These efforts along with additional press releases will continue throughout the project's development.

## Project Risks

While this Study established the basic framework and options for this important decision, this project still carries a number of risks impacting its outcome and potentially its viability. The most critical of which include:

1. Funding sources in addition to public grants will likely be necessary.
2. MBL consent needed for Dock Extension concept.
3. Building code and FEMA thresholds may change in the project planning horizon.
4. Historic building reclassification may affect project design.



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