APPENDIX A

Hurricane Sandy Coastal Resiliency Program

National Fish and Wildlife Foundation

Socioeconomic Monitoring Work Plan

Grant No. 55013

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Table of Contents

Project Overview

After Hurricane Sandy in 2012, the U.S. Department of the Interior (DOI) provided $304 million to fund over 160 projects within the Hurricane Sandy Coastal Resiliency Program that were designed to reduce ecosystem and community vulnerability to the growing risks from threats such as coastal storms, flooding, and erosion. In 2017, eight grants were awarded for long-term ecological and socioeconomic monitoring that will be used to assess the impact of 38 of the Hurricane Sandy Coastal Resiliency Program's projects. Each grant focuses on particular restoration activities performed by the 38 projects: restoring marshes, restoring beaches and dunes, creating living shorelines, and restoring aquatic connectivity. The monitoring grants will provide a consistent set of data in order to answer evaluation questions related to understanding the impacts of different types of resiliency projects.

This work plan describes the socioeconomic metrics that will be the focus of the monitoring effort and a methodology for determining the zone of influence for each project.

Socioeconomic Metrics

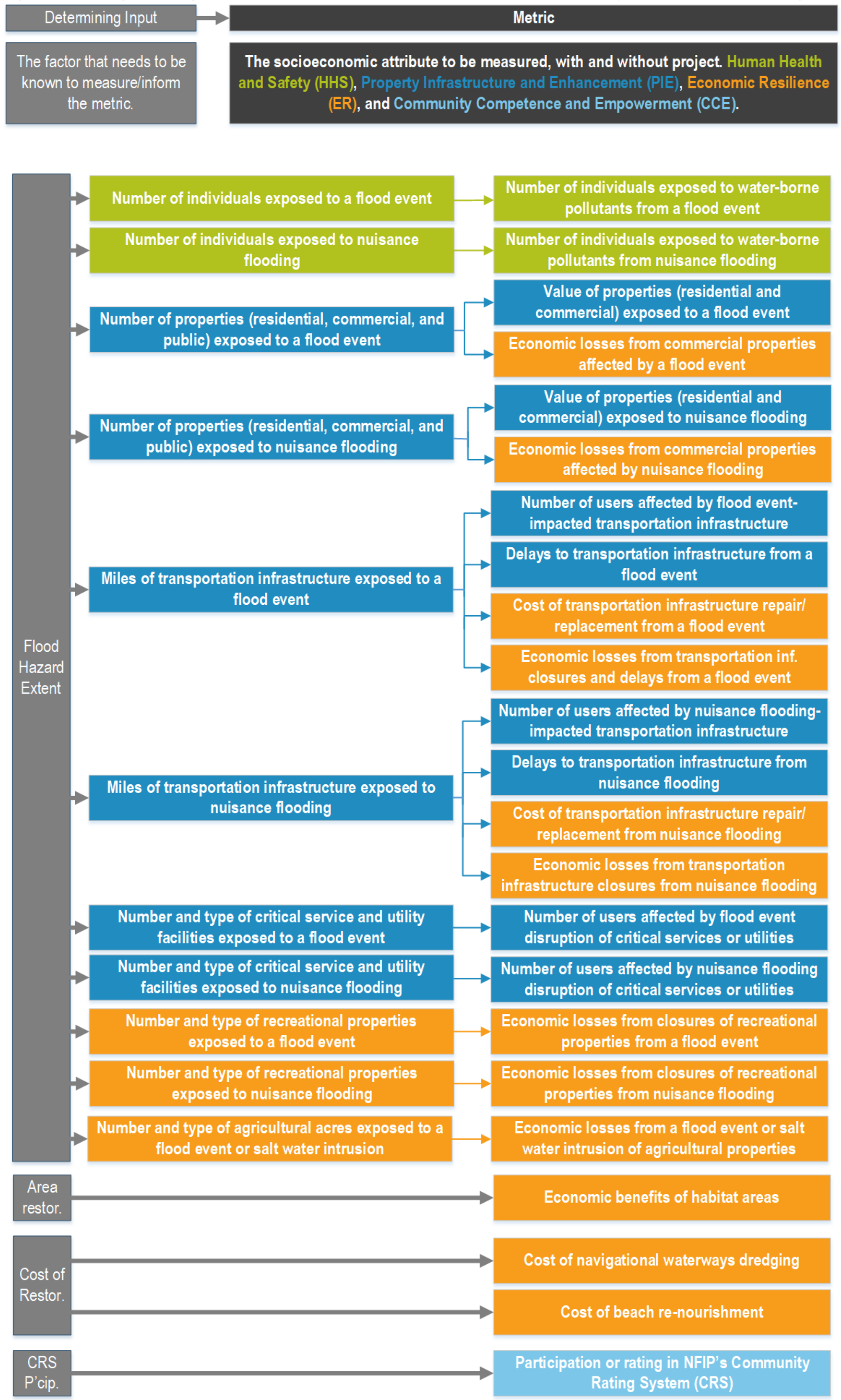
Overview

This section describes the set of metrics that has been developed for the purpose of monitoring the socioeconomic impact of Sandy restoration projects. The metrics presented in this section and proposed for use for monitoring are a result of ongoing efforts at NFWF. The project team started with the metrics that were defined in the document "*Developing Socioeconomic Metrics to Measure DOI Hurricane Sandy Project and Program Outcomes"* completed in December 2015. From this extensive list of metrics, the project team (with input from NFWF) identified those metrics that were most important to the overall assessment of the impacts of Sandy restoration projects. The revised socioeconomic metrics were organized within four subcategories:

- Human Health and Safety (4)
- Property and Infrastructure Protection (13)
- Economic Resilience (14)
- Community Competency and Empowerment (1)

Each of the metrics requires known inputs, and some metrics require known inputs from other metrics themselves, as is described in Figure 1. The majority of the socioeconomic metrics are tied to changes in flood risk to people, buildings and infrastructure. In these cases, the known input is the flood hazard extent with and without the project. In addition, some metrics are focused on the value of increased habitat areas, cost of restoration, and improvements in community competency and empowerment. The interrelationship between metrics is also summarized in Figure 1. For example, one metric under Property and Infrastructure Protection and Enhancement is "number of properties exposed to a flood event". While this metric will be reported separately, it is also required as an input for the metric "value of properties exposed to a flood event".

Figure 1. Logic Diagram of Socioeconomic Metrics for Sandy Restoration Projects



Metric Methodology

Abt developed a draft methodology for each of the thirty-two socioeconomic metrics, including potential data sources and which types of restoration projects these metrics will be applied to (Tables 2 – 4). The metric methodologies are considered draft at this point until additional evaluation of projects and availability of data sources can be conducted. While it is expected that some modifications to each approach may be needed, the information presented in the following tables provide an overview of what will be accomplished under each metric.

Table 2: Human Health and Safety Metrics				
Metric No.	**Health Risk Measure**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
1	Number of individuals exposed to a flood event	• Overlay spatial footprint of inundation (with and without project) with census block data. • Use area-weighting to modify census block data using NLCD or parcel data to identify populated area within census block. Caveats • Uncertainty around protection afforded by restoration projects. • Modeling based on static water level (bathtub modeling) for coastal projects	• US Census – 2010 Block level data • National Land Cover Database (NLCD - 2016) • County parcel data (landgrid.com • High-resolution digital elevation data (DEM) from USGS or county-level Lidar • Mean Higher-High Water level derived from historic tide gauge data (NOAA) • Highest Observed Water Level (HOWL) from tide gauges • Flood footprint data from NOAA (discrete 1-ft increments) • Sea, Lake, and Overland Surges from Hurricanes (SLOSH) • FWS hydrologic model output for aquatic connectivity • Project elevation data and/or extent of restoration extent	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
2	Number of individuals exposed to nuisance flooding	• Overlay spatial footprint of inundation with census block data. • Use area-weighting to modify census block data using NLCD or parcel data to identify populated area within census block. Caveats • Uncertain which restoration projects will have nuisance flooding issues	• US Census – Block level data • National Land Cover Database (NLCD - 2011) • High-resolution digital elevation data (DEM) from USGS or county-level Lidar • Historic daily tide gauge data • Project elevation data and/or restoration extent	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)

Table 2: Human Health and Safety Metrics				
Metric No.	**Health Risk Measure**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		and whether or not we will be able to estimate effects (need to know information on where and when nuisance flooding has occurred) • May require additional research, interviews on effects of nuisance flooding with individuals familiar with local project conditions • May need to make assumptions on effect of project on nuisance flooding (based on outcomes from an analogue location)	• Spatial/temporal information on nuisance flooding historically	
3	Number of individuals exposed to water-borne pollutants during a flood event	• Overlay spatial footprint of inundation (with and without project) with census block data and layers showing hazardous sites (hazardous waste locations or other high risk facilities) • Use area-weighting to modify census block data using NLCD or parcel data to identify populated area within census block. • Examine hydrological connectivity of hazardous sites and inundated census blocks to determine number of people with potential exposure. • Will utilize distance criteria to dampen vulnerability (i.e., reduction in threat based on distance of hazardous source to population)	• US Census – 2010 block level data • National Land Cover Database (NLCD - 2016) • County parcel data (landgrid.com) • High-resolution digital elevation data (DEM) from USGS or county-level LIDAR • Mean Higher-High Water level derived from historic tide gauge data (NOAA) • Highest Observed Water Level (HOWL) from tide gauges • Flood footprint data from NOAA (discrete 1-ft increments) • Sea, Lake, and Overland Surges from Hurricanes (SLOSH) • Project elevation data and/or extent of restoration project • FWS hydrologic model output for aquatic connectivity	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity

Table 2: Human Health and Safety Metrics				
Metric No.	**Health Risk Measure**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		Caveats • Uncertainty around protection afforded by restoration projects. • Modeling for coastal projects based on static water level (bathtub modeling)	• U.S. EPA Facility Registry Service (2016 or later) • USGS National Structures Dataset (2015 or later) for waste water treatment plants • U.S. Energy Information Administration: EIA-815, Monthly Bulk Terminal and Blender Report; EIA-820 Refinery Capacity Report (2015 or later) • U.S. Energy Information Administration, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; EIA-757, Natural Gas Processing Plant Survey (2015 or later)	
4	Number of individuals exposed to water-borne pollutants from nuisance flooding	• Overlay spatial footprint of inundation with census block data and layers showing hazardous sites (hazardous waste locations or other high risk facilities). • Use area-weighting to modify census block data using NLCD or parcel data to identify populated area within census block. • Examine hydrological connectivity of hazardous sites and inundated census blocks to determine number of people with potential exposure. Caveats/Considerations • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to	• US Census – 2010 block level data • National Land Cover Database (NLCD - 2016) • High-resolution digital elevation data (DEM) from USGS or county-level Lidar • Historic daily tide gauge data (NOAA) • Project elevation data and/or extent of restoration project • U.S. EPA Facility Registry Service (2016 or later)) • U.S. EPA TRI Database • USGS National Structures Dataset (2015 or later) for waste water treatment plants • U.S. Energy Information Administration: EIA-815, Monthly Bulk Terminal and	• Marsh Creation • Beach and Dune Restoration • Living Shorelines Aquatic Connectivity (if tidal influences are present)

Table 2: Human Health and Safety Metrics				
Metric No.	**Health Risk Measure**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		estimate effects May need to make assumptions on effect of project on nuisance flooding (based on outcomes from an analogue location)	Blender Report; EIA-820 Refinery Capacity Report (2015 or later) • U.S. Energy Information Administration, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; EIA-757, Natural Gas Processing Plant Survey (2015 or later)	

Table 3: Property and Infrastructure Protection and Enhancement Metrics				
Metric No.	**Health Risk Measure**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
5	Number of properties (residential, commercial, and public) exposed during a flood event	• Overlay spatial footprint of inundation with HAZUS or parcel data to determine number and type of properties at risk (with and without project). Caveats • Uncertainty around protection afforded by restoration project. • Modeling for coastal projects based on static water level (bathtub modeling)	• County parcel data (landgrid.com) • HAZUS data (FEMA) • High-resolution digital elevation data (DEM) from USGS or county-level Lidar • Mean Higher-High Water level derived from historic tide gauge data (NOAA) • Highest Observed Water Level (HOWL) from tide gauges • Flood footprint data from NOAA (discrete 1-ft increments) • Sea, Lake, and Overland Surges from Hurricanes (SLOSH) • Project elevation data and/or extent of restoration project • FWS hydrologic model output for aquatic connectivity	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
6	Number of properties (residential, commercial, and public) exposed to nuisance flooding	• Overlay of spatial footprint of inundation with HAZUS or parcel data to number of properties impacted by nuisance flooding Caveats/Considerations • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects • May need to make assumptions on effect of project on nuisance	• County parcel data (landgrid.com) • HAZUS data (FEMA) • Elevation data to update projected inundation extent • High-resolution digital elevation data (DEM) from USGS or county-level Lidar • Historic daily tide gauge data (NOAA) • Project elevation data and/or extent of restoration project	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)

		flooding (based on outcomes from an analogue location)		
7	Value of properties (residential and commercial) exposed to a flood event	• Overlay spatial footprint on inundation with HAZUS or parcel data to determine value of properties at risk with and without project. Caveats: • Uncertainty around protection afforded by restoration project • Modeling of coastal projects will be based on static water level (bathtub modeling)	• HAZUS structure/damage database • County parcel data (landgrid.com) • High-resolution digital elevation data (DEM) from USGS or county-level LIDAR • Mean Higher-High Water level derived from historic tide gauge data (NOAA) • Highest Observed Water Level (HOWL) from tide gauges • Flood footprint data from NOAA (discrete 1-ft increments) • Sea, Lake, and Overland Surges from Hurricanes (SLOSH) • Project elevation data and/or extent of restoration • FWS hydrologic model output for aquatic connectivity	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
8	Value of properties (residential and commercial) exposed to nuisance flooding	• Overlay spatial footprint on inundation with HAZUS or parcel data to determine value of properties at risk with and without project. Caveats: • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects	• HAZUS structure/damage database (FEMA) • County parcel data (landgrid.com) • High-resolution digital elevation data (DEM) from USGS or county-level LIDAR • Historic daily tide gauge data (NOAA)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines Aquatic Connectivity (if tidal influences are present)

9	Miles of transportation infrastructure exposed to a flood event	• Overlay spatial footprint of inundation with layers identifying transportation infrastructure Caveats: • Uncertainty around protection afforded by restoration project. • Assumptions may be based on research from other areas on effectiveness.	• Hazus Database • National Highway Planning Network: National Transportation Atlas Database (v.11.09 or later) or ESRI Streetmap • Runways: National Transportation Atlas Database: Airport Runways (2015 or later) • Railroads: DOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later) • FWS hydrologic model output for aquatic connectivity	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
10	Miles of transportation infrastructure exposed to nuisance flooding	• Overlay spatial footprint of inundation with layers identifying transportation infrastructure Caveats: • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects	• Hazus Database • National Highway Planning Network: National Transportation Atlas Database (v.11.09 or later) or ESRI Streetmap • Runways: National Transportation Atlas Database: Airport Runways (2015 or later) • Railroads: DOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)
11	Number of users affected by flood-event impacted transportation infrastructure	• Utilize results of PIPE Metric #9 which identifies transportation infrastructure impacted with and without project.	• National Highway Planning Network: National Transportation Atlas Database (v.11.09 or later) or ESRI Streetmap	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity

		• Apply road transportation metrics (users/mile) to roads impacted by project • Identify any airports affected by project and determine through the number of landings, etc. how many users would be affected • Identify if any passenger train routes would be impacted by project and apply ridership metric to determine number of users Caveats • Availability of metrics (users/mile) for type of transportation infrastructure affected. • Uncertainty around protection afforded by restoration project.	• Runways: National Transportation Atlas Database: Airport Runways (2015 or later) • Railroads: DOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later) • FWS hydrologic model output for aquatic connectivity	
12	Number of users affected by nuisance flooding-impacted transportation infrastructure	• Utilize results of PIPE Metric #10 which identifies transportation infrastructure impacted with and without project. • Apply road transportation metrics (users/mile) to roads impacted by project: • Identify any airports affected by project and determine through the number of landings, etc. how many users would be affected • Identify if any passenger train routes would be impacted by	• National Highway Planning Network: National Transportation Atlas Database (v.11.09 or later) or ESRI Streetmap • Runways: National Transportation Atlas Database: Airport Runways (2015 or later) • Railroads: DOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)

		project and apply ridership metric to determine number of users eats: • Uncertainty around protection afforded by restoration project. • Assumption on number of affected users for each type of transportation infrastructure		
13	Number and type of critical service and utility facilities exposed to a flood event	• Overlay spatial footprint of inundation with critical service and utility data Caveats: • Uncertainty around protection afforded by restoration projects. • Uncertainty around data set accuracy	• HAZUS (FEMA) for electrical power infrastructure, emergency, health care facilities, • USGS National Structures Dataset (2015 or later) • Data centers and communication infrastructure • Wastewater treatment facilities USGS National Structures Dataset (2015 or later) • Data and communication sites	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
14	Number and type of critical service and utility facilities exposed to nuisance flooding	• Overlay spatial footprint of inundation with critical service and utility data Caveats: • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects	• Hazus (FEMA) • Wastewater treatment facilities USGS National Structures Dataset (2015 or later) • Data and communication sites	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)
15	Number and type of recreational properties exposed to a flood event	• Overlay spatial footprint of inundation with information on various recreational facilities (e.g. boat ramps, beaches, marinas,	• HAZUS (FEMA) • Public land ownership data by type (e.g., Fed, State, local parks, refuges, etc.)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines

		etc.) from HAZUS and other data sets Caveats: • Uncertainty around protection afforded by restoration projects.		• Aquatic Connectivity
16	Number and type of recreational facilities exposed to nuisance flooding	• Overlay of spatial footprint of inundation with information on various recreational facilities (e.g. boat ramps, beaches, marinas, etc.) from HAZUS and other data sets Caveats: • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects	• HAZUS (FEMA) • Public land ownership data by type (e.g., Fed, State, local parks, refuges, etc.)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)
17	Number and type of agricultural acres exposed to a flood event or salt water intrusion	• Overlay spatial footprint of inundation with land cover and agricultural data Caveats: • Uncertainty around protection afforded by restoration projects. • Assumptions may be based on research from other areas on effectiveness.	• National Land Cover Database (NLCD - 2016) • USDA NAIP (National Agricultural Imagery Program) • Agricultural data (USDA)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
18	Economic losses from commercial properties affected by a flood event	• Utilize results from PIPE Metric #5 (number and type of businesses impacted)Estimate expected damages to structures under specific flood events (with and without project) • Estimate loss in business activity for each type of commercial property (e.g. loss in sales from business not being open due to flooding) Caveats: • Assumption of sales per business type associated with disruption. • Assumption on temporal length of disruption/closure • Uncertainty around protection afforded by restoration project	• Hazus Indirect Economic Loss Module	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
19	Economic losses from commercial properties affected by nuisance flooding	• Utilize results from PIPE Metric #6 (number and type of businesses impacted) • Estimate expected damages to structures with nuisance flooding (with and without project) • Estimate loss in business activity for each type of commercial property (e.g. loss in sales from business not being open due to nuisance flooding) Caveats:	• Hazus Indirect Economic Loss Module	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		• Assumption of sales per business type associated with disruption. • Assumption on temporal length of disruption/closure • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects		
20	Delays to transportation infrastructure from a flood event	• Utilize results from PIPE Metric #9 (miles of transportation infrastructure impacted) • Use a detour transportation route script to estimate added distance, time traveled for roads and highways. • Identify which (if any) airports are affected and look at number of landings, etc. to determine any time delays • Identify which rail lines (if any) are affected and estimate time associated with delays in moving cargo and passengers Caveats: • Uncertainty around protection afforded by restoration projects effectiveness. • Uncertainty on duration of flooding and/or damage caused (repair time) of different transportation infrastructure		• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
21	Delays to transportation infrastructure from nuisance flooding	• Utilize results from PIPE Metric #10 (miles of transportation infrastructure impacted) • Use a detour transportation route script to estimate added distance, time traveled.		• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		• Identify which (if any) airports are affected and look at number of landings, etc. to determine any time delays • Identify which rail lines (if any) are affected and estimate time associated with delays in moving cargo and passengers Caveats: • Uncertainty around protection afforded by restoration projects. • Uncertainty of duration of nuisance flooding • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects		influences are present)
22	Economic losses from transportation infrastructure closures and delays from a flood event	• Utilize results of ECON Metric #20 (delays) • Estimate costs of delays (e.g. lost work hours/days; cost of transportation substitute – truck vs rail; cost to re-route truck traffic) Caveats: • Assumption of costs associated with disruption. • Uncertainty around protection afforded by restoration project.		• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
23	Economic losses from transportation infrastructure from delays and	• Utilize results of ECON Metric #21 (delays) • Estimate costs of delays (e.g. lost work hours/days; cost of transportation		• Marsh Creation • Beach and Dune Restoration • Living Shorelines

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
	closures from nuisance flooding	substitute – truck vs rail; cost to re-route truck traffic) Caveats: • Assumption of costs associated with disruption. • Uncertainty around protection afforded by restoration project. • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects (need to know information on where and when nuisance flooding has occurred)		• Aquatic Connectivity (if tidal influences are present)
24	Cost of transportation infrastructure repair/replacement from a flood event	• Utilize results from PIPE Metric #9 (miles of transportation infrastructure impacted) • Estimate costs of damages caused by flooding to transportation infrastructure eats: • Uncertainty around protection afforded by restoration projects. Based on research from other areas on effectiveness. • Assumptions on damages and costs of repairs.	• Hazus Flood Model	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
25	Cost of transportation infrastructure repair/replacement from nuisance flooding	• Utilize results from PIPE Metric #10 (miles of transportation infrastructure impacted) • Estimate costs of damages caused by flooding to transportation infrastructure eats:	•	• Marsh Creation

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		• Uncertainty around protection afforded by restoration projects. Based on research from other areas on effectiveness. • Assumptions on damages and costs of repairs.		
26	Number of users affected by flood even disruption of critical services or utilities	• Utilize PIPE Metric #13 (Number and type of critical infrastructure) • Overlay of spatial footprint of inundation with critical service facilities/utilities service area to estimate number of customers affected by project Caveats: • Uncertainty around protection afforded by restoration project • Availability of data to define utility service areas.	• Utility/Service area data	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity
27	Number of users affected by nuisance flooding disruption of critical services or utilities	• Utilize PIPE Metric #14 (Number and type of critical infrastructure) • Overlay of spatial footprint of inundation with critical service facilities/utilities service area to estimate number of customers affected by project Caveats: • Uncertainty around protection afforded by restoration project • Availability of data to define utility service areas.	• Utility/Service area data	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)
28	Economic losses from closures of recreational	• Utilize PIPE Metric #15 (Recreational properties affected)	• Hazus Indirect Economic Loss Module	• Marsh Creation • Beach and Dune Restoration

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
	properties from a flood event	• Transportation route script to estimate properties affected. • Estimates of recreational use by activity by project location • Estimates of expenditures by recreation use ($/day) Caveats: • Uncertainty around protection afforded by restoration project. Based on research from other areas on effectiveness. • Estimate on recreational visits at affected properties and expenditures		• Living Shorelines • Aquatic Connectivity
29	Economic losses from closures of recreational properties from nuisance flooding	• Utilize PIPE Metric #16 (Recreational properties affected) • Transportation route script to estimate properties affected. • Estimate recreational use by activity by project location • Estimate expenditures by recreation use ($/day) Caveats: • Uncertainty around protection afforded by restoration projects. • Estimate on recreational visits at affected properties and expenditures • Uncertain which projects will have nuisance flooding issues and whether or not we will be able to estimate effects	• Hazus Indirect Economic Loss Module	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity (if tidal influences are present)
30	Economic benefits of habitat areas	• Quantification of size and type of habitat restored or generated by each project	• Number and type of habitat areas restored or developed by	• Marsh Creation

Table 3: Economic Metrics				
Metric No.	**Economic Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
		• Value of habitat areas based on previous research (e.g. benefits transfer Caveats: • Uncertainty around protection afforded by restoration projects. • Locating habitat values for similar quantity and quality of habitats associated with Sandy restoration projects • Estimate of ecological services generated and associated value	each project type (project and monitoring data) • Quantity and quality of habitat areas restored by various Sandy Restoration projects (Grantees or Monitoring project) • Value of habitat areas obtained by previous studies or research	• Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity

31	Economic losses from a flood event or salt water intrusion of agricultural properties	• Utilize PIPE Metric #17 (agricultural areas affect by project)
		• Overlay of spatial footprint on inundation with layer(s) showing acres and crop type affected by the project
		• Using data on average production values and crop prices, estimate losses in revenue from flooding with and without project
		
		Caveats:
		• Assumption of length of time of inundation and/or impact to agricultural sector (e.g., timing of inundation critical – if during planting/harvest season, etc.)
		• Assumption of impact of salt water intrusion
		• Uncertainty around protection afforded by restoration project.
			• Hazus Indirect Economic Loss Module
			• Agricultural data (USDA)
			  ○ Average yield per crop type
			  ○ Crop prices
			  ○ Acreage by crop type
				• Marsh Creation
				• Beach and Dune Restoration
				• Living Shorelines
				• Aquatic Connectivity

Table 4: Community Competency and Empowerment Metric				
Metric No.	**CCE Metric**	**Methodology**	**Expected Data Sources**	**Restoration Project Applicability**
32	Participation or rating of National Flood Insurance Programs' (NFIP) Community Rating System	• Identify which areas near Sandy Restoration Projects that participate in the NFIP • Determine if participation is impacted by project implementation • Determine if program implementation affects flood insurance rates Caveats: • Assumptions regarding effects of Sandy Restoration Projects on CRS rating • Does the CRS affect flood insurance rates	• County/local data on NFIP participation (FEMA) • FEMA floodplains (all zones that may be subject to NFIP)	• Marsh Creation • Beach and Dune Restoration • Living Shorelines • Aquatic Connectivity

Zone of Influence

In order to measure the socioeconomic impacts of these projects, the project team will identify a **Zone of Influence (ZOI)** for each restoration project. The ZOI is defined as the physical geo-boundary (area) that would be influenced by each restoration project's on-the-ground activities.[1] In many cases the ZOI will be identified by the change in flood risk (both frequency and magnitude) from coastal and/or riverine processes to assets of importance. These assets may include housing, businesses and other critical infrastructure, land use/land cover classes of importance, recreational areas, and critical habitat types as well as human populations that may be affected by the project. Below, we identify the approach we will take to identify the ZOI for the different project types.

Approach for Projects Affecting Event-Driven Flooding

Monitored coastal restoration projects can fall into four types of restoration activities: marsh restoration, beach and dune restoration, aquatic connectivity, and living shorelines. The specific designs and goals of each restoration project vary as determined by the project team, therefore the ZOI for each project is based on how the restoration activities affect the spatial distribution of flooding. Depending on the data and information available for each project, Abt will use one of three approaches for defining the ZOI including:

- Hydrologic and Hydraulic (H&H) or other modeling results
- Physical Geographic Information System (GIS) modeling framework
- Analogue approach

These approaches are discussed in more detail below.

Hydrologic and Hydraulic and other Modeling

Several of the restoration projects, especially the aquatic connectivity projects, have completed some variation of H&H modeling. In these cases, the project team will rely on H&H modeling conducted by the projects themselves or monitoring grantees to define the ZOI. As output from the H&H modeling is project-specific, we will incorporate available information into our GIS framework to determine the ZOI. Some examples of potential H&H model output/information we will utilize include:

- GIS layers of polygon or raster data showing the spatial extent and depth of flooding (e.g., revised floodplain boundary);
- GIS layers of point features of flow at specific locations;

[1] Note that the ZOI as defined here is likely to be different than the project site/area defined by the grantees. For example, restoring 30 acres of salt marsh (project site) will not be the same as the ZOI for the project under a specific storm event.

- Tabular information of flow (expressed in absolute terms or as change in flow from baseline) at stream gauges;
- Descriptive information on change in flood recurrence (e.g., changes in recurrence interval for the 100- or 500-year flood);
- Other descriptive information on the protective effects of the project (e.g., "project will protect against flooding from dam failure" or "project will protect against 3-foot storm surge")

If H&H GIS layers have been provided by grantees or monitoring PIs, we will use those to define the ZOI. In cases where flow information is provided, Abt will incorporate the flow data (along with high-resolution elevation data) into hydraulic models such as the USACE HEC-RAS to determine the ZOI. Alternatively, if only descriptive information is provided, Abt will estimate the ZOI where possible. For example, information about the change in flood recurrence can be used with corresponding FEMA floodplains (i.e., the 100-year floodplain becomes the 500-year floodplain) or storm surge information can be combined with elevation data to determine the ZOI (explained more below).

Develop a Physical GIS Modeling Framework

For projects that do not have any type of modeling available, the project team will take a GIS based modeling approach to determine the ZOI. At its most basic level, the development of physical GIS modeling framework will require information regarding the elevations and spatial extent of the restoration project. We will identify available datasets (e.g., pre- and post-restoration monitoring data) provided by the grantees and monitoring PIs as well as publically-available datasets and information including:

- High-resolution elevation data (including Lidar);
- Tide gauge data;
- Existing infrastructure;
- Project design specifications that include information on the spatial extent, elevation, and land cover/land use; and
- Storm scenarios generated from National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS).

To identify the ZOI, we will conduct a spatial analysis under two scenarios: one with conditions including the project activities (post-project scenario) and one with conditions assuming no project activities (pre-project scenario).

The first step in our analysis will be to model the spatial extent of inundation and the static (i.e., non-dynamic) depth of water without any restoration projects. As impacts are associated with any length of flooding event, we will run our analysis relative to the mean higher high water (MHHW) tidal datum, which represents the average height in elevation of the highest daily tide. NOAA's VDatum software[2] allows us to generate a matrix of points with MHHW elevations for the area of interest. We will generate a MHHW surface (raster layer) through a spline interpolation of MHHW points across a restoration project. This MHHW layer will serve as the baseline water level without the influence of storms.

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[2] See https://vdatum.noaa.gov

To model the impact of storm events we will incorporate additional static water and wave heights from significant historic storm events (such as Hurricane Sandy) into our MHHW surface. Historic water level data (e.g., Highest Observed Water Level – HOWL) is available for tide gauges in the region from NOAA[3]. We will compare the HOWL height to the MHHW surface and adjust the value accordingly for a particular storm event. Similarly, historic wave and wind information (Wave Information Studies – WIS) is available for select locations along the coast from the U.S. Army Corps of Engineers (USACE)[4]. We will use the weather information for the same date as the HOWL from the closest WIS station location as input into a USGS wave model[5] (USGS, 2012) to estimate the additional wave heights in the area of interest. We will then incorporate the wave output into the HOWL water surface. In addition, if additional scenarios have been developed by the projects themselves or monitoring grantees using H&H modeling, we will incorporate those results into our analysis to the degree possible.

Once the baseline MHHW-HOWL and storm event layers have been developed, we will then overlay these surfaces onto the local topography based on the highest-resolution digital elevation model (DEM) data publically-available. The DEM may be provided by the grantees or monitoring PIs or acquired or derived from public agencies (e.g., National Atlas, State, County, etc.) and include such data types as Lidar, high-resolution DEMs, GIS data (e.g., point elevations, contours, raster data sets, etc.) as well as maps or descriptive information that may be available. As both the MHHW and storm event layers are expressed in terms of elevation, we can generate an inundation layer by calculating the difference in elevation between the DEM and the respective water surface (i.e., areas below the projected water level). In our analysis, we will also determine whether flooded areas are hydrologically connected to the open water as well as the depth of inundation. The resulting output are GIS layers of the spatial extent and depth of inundation under the pre-project scenario.

The same process will be repeated for the post-project scenario – incorporating any spatial and elevation information into the DEM before running the inundation analysis. For example, for a dune or beach restoration projects, we will incorporate the spatial footprint of the dune or beach area restored as well as the associated elevations. The corresponding change in topography will likely affect the ZOI (spatial footprint of the area inundated) as the restoration activity will serve as a barrier to hydrologic connectivity to the open water – thereby protecting features that are landward of the project. Similarly, for marsh restoration projects, if the restoration results in a change in marsh height, the change in elevation can directly influence the spatial inundation footprint – similar to that of dune or beach restoration noted above.

However, if absolute elevation data (or H&H modeling data) are not available, we may be able to approximate the elevation heights using the relationship between the type of marsh (including vegetation species-specific information) being restored, its tolerance to saline environments, and information about the frequency of inundation obtained from tide gauges. For example, low salt marsh is located in the intertidal zone and experiences regular inundation at every tide but is exposed during low tide. Alternatively high salt marsh is located between the low marsh and upland (outside of the tidal zone) and is generally only inundated during higher than average tides. As the tide

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[3] See https://tidesandcurrents.noaa.gov
[4] See http://wis.usace.army.mil
[5] U.S. Geological Survey, Waves Model (2004, updated in 2012).
Available: https://www.umesc.usgs.gov/management/dss/wind_fetch_wave_models.html

information is known relative to absolute elevations, the height of the marsh can be then assigned an elevation and incorporated into the analysis. Once the scenario-specific (with and without project) inundation layers have been generated, we will overlay the respective layers with all GIS asset datasets (i.e., number of people and structures affected, critical infrastructure, land use/land cover, etc.) to identify both the assets impacted as well as the depth of inundation.

If possible, we will run spatial analyses to quantify the potential disruption time and/or access to important assets. For example, to analyze disruption caused by flooding of roads, we will use a GIS network analysis to determine detours around the flooded roads, and accumulate the additional distance and disruption time to quantify the impact. We will also note the potential "damage" associated with loss of use if the impacted road is the only means of access to the asset.

To quantify damage to structures from flooding, we identify the structures impacted and the depth of inundation from the overlays of building footprints (available from Microsoft[6]) and valuation from FEMA Hazus data with the flood inundation footprint. We will use depth-damage functions within Hazus software or from USGS regression analysis to quantify damage to structures based on the detailed structural and valuation values provided in the parcel data or the attributes contained within the Hazus database.

Analogue Approach

In cases where restoration projects lack H&H modeling or other relevant information needed to develop a physical model, the project team will apply an analogue method to define the ZOI. In other words, the ZOI will be defined based on the characteristics of other similar restoration sites. We will conduct a literature review to identify metrics that could be used to estimate the ZOI based on observations from other areas with similar marsh and environmental characteristics (i.e., marsh type, fetch, etc.).

Some types of restoration performed can result in additional storm mitigation. For example, in addition to the protective potential of the marsh afforded by increased elevations, marshes also have the ability to diminish wave energy and wave heights from coastal storms. Unless relevant information is available through project-specific H&H modeling, we will use the USGS 2012 wave model (as noted above) to examine wave energy and height. However, while the wave model captures the zone of influence for waves that encounter obstructions (i.e., for projects above the water level), it does not appear to capture the wave buffering effects from minimally-inundated marshes. In these cases, we will evaluate using wave attenuation decay functions from the literature to estimate the additional benefits that the restoration activity may provide[7]. Similarly, living shorelines provide protective capacity. We will conduct a similar literature review to

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[6] See https://github.com/microsoft/USBuildingFootprints

[7] For example, Jadhav and Chen reference exponential wave decay functions across marsh (Jadhav, R. S., & Chen, Q. (2012). Field Investigation Of Wave Dissipation Over Salt Marsh Vegetation During Tropical Cyclone. *Coastal Engineering Proceedings*, *1*(33), waves.41. https://doi.org/10.9753/icce.v33.waves.41)

quantify the buffering capacity of the restoration activity based on the specifics of the project compared to what has been found for similar projects.[8]

Approach for Projects Affecting Nuisance Flooding

NOAA scientists define nuisance flooding as "minor, recurrent flooding that takes place at high tide"[9]. They further note that it has become more prevalent recently as a result of sea level rise and is not necessarily linked to storms or heavy precipitation events. Understanding the impact of restoration projects on nuisance flooding can be complex due to the number of factors (discussed below) potentially involved and the synergistic effects between them. Because of these complexities, we will only evaluate the marsh restoration projects for effects on nuisance flooding. The methodology to assess whether a marsh project will have an impact on nuisance flooding will require three steps:

1. Run physical GIS model for pre-project scenario to determine which areas have nuisance flooding issues based on daily tide heights and land elevation
2. Collect data and information on nuisance flooding conditions
3. Run physical GIS model for post-project scenario

These steps are discussed in more detail below.

Run Physical GIS Model for Pre-project Scenario

In order to determine whether a particular marsh project will have an impact on the nuisance flooding, we will run the physical GIS model described above using daily tide heights derived from tide gauges (instead of MHHW) to determine if certain environmental conditions exist that would result in frequent flooding conditions.

Collect Data and Information on Nuisance Flooding Conditions

For areas that we determine under step 1 that are prone to nuisance flooding, we will collect additional data and information that will help determine what factors may be important to reducing this type of flooding. For instance, we will need to know whether the flooding is associated with specific tide events (identified by looking at the timing of the flood gleaned from information such as recorded observations, anecdotal information, the timing of various tide levels, and the elevation data) and/or whether the flooding occurs as a result of only tides or if it is due to a combination of tide and rainfall events. Additionally, if the flooding occurs in proximity to a river, upstream flow may be a

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8 See https://coast.noaa.gov/data/digitalcoast/pdf/living-shoreline.pdf

9 See https://www.climate.gov/news-features/understanding-climate/understanding-climate-billy-sweet-and-john-marra-explain

factor as well. We will utilize daily or hourly climate data available from the NOAA[10] from station data in close proximity to the area of interest as well as river flow data from USGS river gauges (National Water Information System (NWIS)[11]. We will examine both the timing and value of precipitation or flow to determine whether there is a relationship to the tides and flooding.

Run Physical GIS Model for Post-Project Scenario

Once we have determined the frequency and timing of the nuisance flooding events, we will determine whether the restoration project is likely to affect these processes using the physical GIS model that was developed for the "event-flooding scenarios". For example, the U.S. EPA has found that the ability of wetlands to store water (1 acre of wetlands can store 3 acres-feet of water) can reduce flood heights[12]. If the nuisance flooding is infrequent or minor, it is possible that the marsh restoration project may have the ability to lessen the frequency and/or magnitude of flooding events. With a physical model, we will take into account the factors associated with the nuisance flooding. For example, if the flooding is associated with tides and the restoration project is seaward of the flood impacted area, the marsh may be able to absorb the additional water. We can use the water holding capacity of the marsh and calculate the volume of water associated with the nuisance flooding event from the extent and depth of the flooding to estimate the ability of the marsh to reduce flooding. Similarly, if the nuisance flooding and restored marsh are along a floodplain, we can estimate volume of water from a precipitation event and the water holding capacity of the marsh to model the potential effect on nuisance flooding.

Approach for Projects Affecting Habitat and Aquatic Connectivity

To estimate the impact of the aquatic connectivity restoration project, our analysis will be primarily based on H&H analysis that might be available from the grantees and compare pre- and post-project outputs of the spatial extent of flooding as well as the depth. If H&H output is not available, our analysis will be focused mainly on the FEMA 100 and 500-year floodplains and how the project may affect the probability of flooding within those boundaries under different precipitation events. By understanding the volume of water within the respective floodplain, we may be able to estimate how the water holding capacity of wetlands (from research noted above) may reduce the flooding event and to what degree. For instance, the 500-year event may become the 100-year event, which will impact both the spatial extent of flooding as well as the depth. Gridded data available from NOAA's Atlas 14 Precipitation Frequency Estimates[13] may be used in this effort. Using the different flood extent boundaries, we will estimate the change in the ZOI and damage or disruptions associated with the project through overlays and analytic procedures outlined above.

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[10] https://www.ncdc.noaa.gov/cdo-web/
[11] Available at: https://waterdata.usgs.gov/nwis/sw
[12] See https://www.epa.gov/sites/production/files/2016-02/documents/flooding.pdf
[13] https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html

Appendix I – GIS Data Source

Table A-1 below shows the data sets anticipated to be used in the socioeconomic monitoring, and links to their respective sources.

Table A-1: Data sets and sources

Data set	Source
Census – Block level data	https://www.census.gov/programs-surveys/acs; https://www2.census.gov/geo/tiger/TIGER_DP/
onal Land Cover Database (NLCD - 2016)	https://www.mrlc.gov/data?f%5B0%5D=year%3A2016
nty parcel data (Abt, in-house)	https://landgrid.com/parcels
-resolution digital elevation data (DEM) from USGS or county-level LIDAR (Abt-NFRCT data)	https://viewer.nationalmap.gov/basic/ or through bulk data delivery (e.g., for nationwide or statewide high resolution DEMs)
n Higher-High Water level derived from historic tide gauge data (NOAA)	https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels
iest Observed Water Level (HOWL) from tide gauges	https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels
d footprint data from NOAA (discrete 1-ft increments)	https://www.fema.gov/national-flood-hazard-layer-nfhl
, Lake, and Overland Surges from Hurricanes (SLOSH)	https://www.nhc.noaa.gov/surge/slosh.php
ect elevation data and/or extent of restoration project	From project materials or through bulk data delivery (e.g., for nationwide or statewide high resolution DEMs)
A floodplains	https://msc.fema.gov/portal/home; https://www.fema.gov/risk-map-flood-risk-products
tial/temporal information on nuisance flooding historically	https://tidesandcurrents.noaa.gov http://water.weather.gov/ahps/forecasts.php
oric daily tide gauge data	https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels
EPA Facility Registry Service (2016 or later)	In-house at Abt
S National Structures Dataset (2015 or later) for waste water treatment plants	http://nationalmap.usgs.gov; direct geodatabase download: https://prd-tnm.s3.amazonaws.com/StagedProducts/Struct/GDB. Also in-house at Abt.
Energy Information Administration: EIA-815, Monthly Bulk Terminal and Blender Report; EIA-820 Refinery Capacity Report (2015 or later)	In-house at Abt
Energy Information Administration, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; EIA-757, Natural Gas Processing Plant Survey (2015 or later)	In-house at Abt
US data (FEMA)	https://www.fema.gov/hazus/
hydrologic model output for aquatic connectivity	From project materials
ation data to update projected inundation extent	http://nationalmap.usgs.gov
m event inundation (SwATH)	https://water.usgs.gov/floods/swath/

Table A-1: Data sets and sources	
Data set	**Source**
onal Highway Planning Network: National Transportation Atlas Database (v.11.09 or later) or ESRI Streetmap	https://data-usdot.opendata.arcgis.com/datasets/national-highway-planning-network. Also in-house at Abt.
ways: National Transportation Atlas Database: Airport Runways (2015 or later)	In-house at Abt
roads: DOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)	In-house at Abt
s: USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)	In-house at Abt
et-specific or street type (category) usage data	https://data-usdot.opendata.arcgis.com/datasets/travel-monitoring-analysis-system
er plants: the Annual Electric Generator Report; EIA-923, Power Plant Operations Report (2016 or later)	In-house at Abt
oleum terminals and refineries: U.S. Energy Information Administration: EIA-815, Monthly Bulk Terminal and Blender Report; EIA-820 Refinery Capacity Report (2015 or later)	In-house at Abt
ural gas terminals and processing plants U.S. Energy Information Administration, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; EIA-757, Natural Gas Processing Plant Survey (2015 or later)	https://www.eia.gov/totalenergy/data/browser/
lic land ownership data by type (e.g., Fed, State, local parks, refuges, etc.)	
cultural data (USDA)	https://www.nass.usda.gov/AgCensus/
y/Service area data	Sourced from utilities if available
et network (ESRI streetmap or street network on portal)	https://www.esri.com/en-us/arcgis/products/streetmap-premium-for-arcgis/overview
reational use data and associated value	https://www.recreation.gov; https://www.fs.fed.us/
oeconomic data from US Census (income, education, age)	https://www.census.gov/programs-surveys/acs; https://www2.census.gov/geo/tiger/TIGER_DP/
itat data (Endangered and Threatened species, Essential Fish Habitat and Habitat Areas of Particular Concern, Critical Habitat for ESA listed species, Endangered and Threatened species, Important Bird Areas)	https://ecos.fws.gov/ecp/report/table/critical-habitat.html
calendars (when crops are planted, harvested, etc., in area)	https://www.nass.usda.gov/AgCensus/

APPENDIX B

National Coastal Resilience Fund 2018 Restoration Projects

Organization	Project Title	Project Description	Project Location States
The Nature Conservancy	Helen Wood Park Shoreline Protection and Habitat Restoration (AL)	Protect a half mile of shoreline with 10 acres of intertidal nearshore breakwater habitat and enhance 12 acres of intertidal marsh and seagrass beds in Alabama. Project will increase resilience to a local waterfront community and infrastructure frequently impacted by storms and threatened by sea level rise.	Mobile Bay, Alabama
Mote Marine Laboratory, Inc.	Maintain Coastal Protection of Florida's Reefs through Restoration of Resilient Corals	Restore more than 130 acres of coral reef to strengthen coastal resiliency to storm enhanced waves and expand essential fisheries habitat for sustainable commercial and recreational use. Project will recover threatened and endangered coral species in the Florida Keys through the culture and out-planting of disease and temperature resilient corals.	Miami-Dade and Sarasota Counties, Florida
National Wildlife Federation	Restore New England's Largest Saltmarsh for Resilience and Ecological Enhancement (MA)	Build and enhance resilience of the 25,000-acre Great Marsh coastal habitat to help protect critical community infrastructure. Project will improve drainage of marsh pools, restore native vegetation, remove invasive species, and plant eelgrass to reduce erosion and improve channel stabilization.	Salisbury, Newburyport, Newbury, Rowley, Amesbury, Essex, Gloucester, and Ipswich, Essex County, Massachusetts
The Nature Conservancy	Wetlands Restoration for Ecosystem and Community Resilience in He'eia, Oahu (HI)	Establish a natural constructed wetlands system in the He'eia wetlands to protect and enhance the ecosystem and community of Kane'ohe Bay, Hawaii. Project will minimize flood events, reduce sediment and nutrient run-off, and create habitat and fish passage for marine and estuarine species.	He'eia watershed, Oahu, Hawaii
Superior Watershed Partnership	Reduce Storm Related Impacts for Lake Superior Coastal Communities through Habitat Restoration (MI)	Implement green-gray infrastructure to restore and strengthen natural systems along the Lake Superior shoreline in Michigan. Project will protect public infrastructure, restore public access to the shoreline, and create contiguous coastal habitat for resident and migratory wildlife including birds, pollinators, native fish and mammals.	Marquette, Michigan
Alaska Native Tribal Health Consortium	Managed Community Retreat and Ecological Restoration of Coastal Wetlands (AK)	Decommission 12 houses and all associated infrastructure to restore 3 acres of coastal wetland habitat in Newtok, Alaska. Project will prevent contamination of the Yukon Delta National Wildlife Refuge and build twelve new houses in the community relocation site of Mertarvik.	Yukon Delta National Fish and Wildlife Refuge, Alaska

Organization	Project Title	Project Description	Project Location States
James River Association	Building Adaptive Shorelines and Resilient Communities in the Lower James River (VA)	Implement three living shoreline management and green infrastructure projects on public land within the Hampton, Virginia area to address community and habitat vulnerability to sea level rise. Project will strengthen natural systems to protect the Hampton Roads region from the impacts of flooding and storm events and enable communities to recover more quickly.	Hampton Roads, Isle of Wight, Prince George and Surry Counties, Virginia
Audubon South Carolina	Habitat Restoration of Crab Bank Island Seabird Sanctuary to Protect Coastal Shorelines (SC)	Restore Crab Bank Seabird Sanctuary, a critical nesting island in Charleston Harbor, South Carolina. Project will protect 1.5 miles of coastal property and provide 28 acres of suitable nesting habitat for the brown pelican, royal tern, black skimmer, American oystercatcher, and other seabird and shorebird species.	Crab Bank Island, Charleston, South Carolina
Ducks Unlimited, Inc.	Terrebonne Basin Coastal Wetland Habitat Restoration and Community Resiliency (LA)	Restore 575 acres of coastal wetlands in the Terrebonne Basin, Louisiana. Project will prevent additional wetland erosion and provide storm surge protection for the Golden Meadow, Pointe aux Chene, and Isle de Jean Charles communities.	Terrebonne Basin, Louisiana
University of Puerto Rico at Aguadilla	Strengthen Resilience from Extreme Weather through Ecological Restoration of Sand Dunes (PR)	Restore high-priority areas of storm-damaged coastal dunes along the north and west coasts of Puerto Rico. Project will use innovative sand-trapping devices, exclusion fences and wooden boardwalks to promote the accumulation of sand and an increase in the vegetation cover on breached and eroded sites.	Aguada, Isabela, Camuy, Hatillo, Arecibo, Manatí, Dorado, Carolina, San Juan, Loiza and Luquillo municipalities of Puerto Rico
University of Hawaii, Hawaii Institute of Marine Biology	Enhance Coastal Protection with Resilient Coral Reefs along Oahu (HI)	Identify thermally tolerant coral stocks for restoration of reefs in Oahu to enhance shoreline protection from wave and storm energy. Project will propagate resilient corals in nurseries and partner in the out-planting at three sites to test the efficacy of this strategy and evaluate best practices to increase restoration efforts across the state.	Airport, Kane'ohe Bay, and Maunalua Bay, O'ahu, Hawai'i
Ducks Unlimited, Inc.	John Heinz National Wildlife Refuge Tidal Marsh Restoration to Restore Hydrological Function (PA)	Restore 180 acres of tidal marsh habitat through the installation of a new water control structure and pump system on the U.S. Fish and Wildlife Service wetland impoundment at John Heinz National Wildlife Refuge in Pennsylvania. Project will restore tidal flows and improve management capabilities within the impounded wetland for flood control and benefits to wetland-dependent birds and wildlife.	John Heinz National Wildlife Refuge, Pennsylvania

Organization	Project Title	Project Description	Project Location States
North Carolina Coastal Federation, Inc.	Living Shorelines for North Carolina Coastal Communities	Construct living shorelines at two coastal locations to protect the entrance channels of harbors and historic shorelines of coastal North Carolina. Project will naturally stabilize and protect the eroding shorelines to maintain existing navigation channels, prevent flooding and build fisheries habitats.	Carteret and Pamlico Counties, North Carolina
Para la Naturaleza, Inc.	Reforestation and Habitat Enhancement of Hacienda La Esperanza Nature Reserve (PR)	Strengthen the natural resilience of Hacienda La Esperanza Nature Reserve and neighboring communities in Puerto Rico to protect from future storm and flooding events while enhancing fish and wildlife habitat. Project will engage in diverse forest restoration activities to promote the enhancement of floodplains, wetlands and coastal forests.	Hacienda La Esperanza Nature Reserve, Puerto Rico
City of Wilmington, DE	South Wilmington Freshwater Tidal Wetland Habitat Restoration for Flood Prevention (DE)	Restore 14 acres of degraded wetland to a high functioning freshwater tidal wetland habitat in South Wilmington, Delaware. Project will reduce flooding, enhance resiliency, restore freshwater tidal exchange, filter polluted runoff, improve soil and water quality, and restore habitat for a variety of fish and wetland and aquatic wildlife.	City of Wilmington, New Castle County, Delaware
City of Norfolk	Lindenwood-Barraud Park Community Resilience Living Shoreline (VA)	Construct a hybrid living shoreline and riparian buffer expansion in Norfolk, Virginia along the Lafayette River. Project will improve the shoreline along a lower-income neighborhood and will support storm resilience, water quality, and habitat improvement goals.	Norfolk, Virginia
Washington Department of Fish and Wildlife	Leque Island Estuarine Marsh Habitat Restoration and Flood Protection (WA)	Remove a 2.4-mile long perimeter levee to restore tidal and riverine influence and improve coastal resiliency for Stanwood, Washington. Project will restore 250 acres of estuarine marsh and estuary rearing habitat for endangered chinook juvenile salmonid populations of the Stillaguamish and Skagit rivers while providing flood protecting to the surrounding community.	Puget Sound at the intersection of Port Susan Bay, Skagit Bay, and the Stillaguamish River, Washington
Humboldt County Resource Conservation District	Restore Ecosystem Function and Community Resiliency in the Salt River Watershed (CA)	Restore 7 miles of river channel and associated floodplains, wetlands, and riparian habitats in the upper reach of the Salt River in California. Project will provide area landowners with drainage to reduce flood impacts and create enhanced fish habitat and fish passage to the upper watershed.	Salt River watershed in Humboldt County, California
Galveston Bay Foundation	Dollar Bay-Moses Lake Wetlands Restoration and Protection to Reduce Erosion (TX)	Restore degraded wetlands and protect vulnerable shorelines and communities within the Dollar Bay-Moses Lake complex in Galveston Bay, Texas. Project will restore 72 acres of intertidal marsh habitat to address the loss of habitat in Galveston Bay due to historical land surface subsidence and shoreline erosion.	Dollar Bay-Moses Lake in Galveston County, Texas

Organization	Project Title	Project Description	Project Location States
Sandy River Basin Watershed Council	Floodplain Reconnection to Restore Wild Salmon Habitat and Enhance Community Resilience (OR)	Restore 418 acres along one mile of floodplain and enhance instream habitat to bolster resilience from intensification of storms and streambank erosion. Project will restore conditions for threatened wild salmon and steelhead while increasing resiliency of surrounding community infrastructure.	Sandy and Salmon Rivers, Oregon

National Coastal Resilience Fund 2019 Restoration Projects

Organization	Project Title	Project Description	Project Location State
Lower Columbia Estuary Partnership	Steigerwald Flood Risk Reduction and Floodplain Restoration for Salmonids and Lamprey (WA)	Reconfigure a 5.5-mile levee system to reconnect 960 acres of historic floodplain habitat, fish passage and establish native vegetation along a section of the lower Columbia River. Project will improve rearing habitat for salmon, steelhead, and lamprey; re-establish unobstructed fish passage to a 7-square mile watershed; reduce flood risk to an industrial park, municipal wastewater treatment plant, and private residences; and improve recreation opportunities.	Steigerwald Lake National Wildlife Refuge, Clark County, Washougal, WA
RESTORE THE EARTH FOUNDATION INC	Landscape-scale Restoration: A Green-Gray Approach to Gulf Coast Resiliency	Restore 4,000 acres of critical historic bald cypress forest at Pointe-aux-Chenes Wildlife Management Area in Montegut, Louisiana. Project will plant approximately 400,000 native trees to reduce vulnerability and increase protection from flood and storm risks for over 200,000 residents and habitat for native wildlife in the area.	Terrebonne Parish, Lafourche Parish, Pointe-aux-Chenes Wildlife Management Area, Louisiana
Contra Costa County Flood Control and Water Conservation District	Lower Walnut Creek Restoration (CA)	Restore wetland habitats in the lower, tidal part of Walnut Creek to provide sustainable flood management. Project will set back levees from the channel to increase flood capacity and reconnect/create new floodplains reconnecting tides to brackish wetlands, thus restoring habitats for fish and wildlife.	Walnut Creek, Pacheco Creek, San Francisco Bay Area, California
The Nature Conservancy	Building Oyster Reefs and Enhanced Saltmarsh Habitat in Wachapreague, Virginia	Build and monitor oyster reefs with two types of oyster substrate adjacent to an eroding salt marsh to enhance and protect the seaside town of Wachapreague, VA. Project will further engage the town of Waschapreague and similar communities protected by the Virginia coastal bay system in nature-based solutions to increase resilience in this vulnerable area as well as benefit people and wildlife.	Wachapreague, Accomack County Virginia
University of Miami	Using Coral Reef Restoration to Enhance Coastal Resilience of South Florida Shorelines (FL)	Restore over 150,000 coral colonies to over 125 acres of reef habitat in Miami-Dade and Broward Counties, Florida. Project will: 1) build coastal resilience to extreme weather, waves, flooding, and beach erosion, 2) incorporate state-of-the-science approaches to build climate resilience into restored corals, and 3) create essential habitat for fisheries and enhanced recreation opportunities.	Miami-Dade County, Broward County, Florida

Organization	Project Title	Project Description	Project Location State
The University of Guam	Restoring Staghorn Corals and Ecosystem Services on Reef Flats in Guam, Micronesia	Upscale current staghorn restoration efforts in Guam, Micronesia. Project will undertake additional research to develop needed best practices that assist restored coral community adaptation to projected future climate conditions.	Piti Bomb Holes, Merizo, Tumon Bay Marine Preserve, Guam, Micronesia
University of Puerto Rico at Aguadilla	Strengthening Puerto Rico's Natural Coastal Systems Through Ecological Restoration, Education and Community Engagement (PR)	Restore and monitor damaged coastal dunes using environmental education to engage local community. Project will 1) strengthen coastal resilience to mitigate future storms, floods and other natural hazards; 2) achieve ecological conservation and biodiversity through dune restoration and monitoring; 3) educate and engage the population using the Latino Earth Partnership, a 10-step restoration education process and citizen science program.	San Juan, Isabela, Loiza, Puerto Rico
The Trustees of Reservations	Using Salt Marsh Habitat Restoration for Resiliency (MA)	Implement and monitor ditch remediation to restore salt marsh in Massachusetts' Great Marsh. Project will reverse salt marsh subsidence, reestablish and maintain high marsh habitat, improve coastal resilience and demonstrate ditch remediation as a viable and cost-effective restoration strategy at the landscape level.	Crane Wildlife Refuge, Stavros Reservation, Great Marsh, Old Town Hill, Newbury, Essex, Ipswich, Massachusetts
Maine Coast Heritage Trust	Restoring and Monitoring Fish Passage at Snows Brook in Sedgwick, Maine	Construct and monitor a fish restoration project using a community-driven approach in Sedgwick, Maine. Project will invest in construction and monitoring to enhance existing efforts by a community network to restore fish passage along a designated evacuation route and transportation artery, thus raising awareness of this and other restoration projects in the region.	Snows Brook, Bagaduce River Watershed, Penobscot River Watershed, Sedgwick, Hancock County, Maine
Buzzards Bay Coalition	Marsh Island Salt Marsh Restoration Project in Fairhaven, Massachusetts	Remove historically-placed dredged material to re-introduce tidal hydrology, and plant marsh vegetation. Project will create vital fish nursery habitat, enhance water quality, provide needed sandy material for nearby municipal coastal resilience projects, as well as build upon the significant investment over the past decade to improve water quality, expand fish passage, and permanently protect natural shorelines in Buzzards Bay.	Acushnet River Estuary, New Bedford Harbor, Town of Fairhaven, Bristol County, Massachusetts
New Jersey Department of Transportation	Using Dredged Material to Enhance Marsh at Edwin B. Forsythe National Wildlife Refuge (NJ)	Restore and improve 30 acres of previously storm damaged Good Luck Point Marsh using the technique of Sediment Enrichment. Project will use dredged material to enhance the saltmarsh environment and habitat allowing for the natural sediment to remain in the estuarine system, feeding the marsh and replenishing loss from erosion and sea-level rise.	Good Luck Point, Edwin B. Forsythe National Wildlife Refuge, Berkeley Township, New Jersey
Texas General Land Office	Swan Lake Marsh Restoration (TX)	Restore approximately 80 acres of coastal marsh complex within Swan Lake in Galveston County, Texas by utilizing dredged materials to increase intertidal elevations to support marsh habitats and reduce the risk of coastal flooding. Project will protect critical port infrastructure, important aquatic nursery and wildlife habitat, and protect adjacent coastal prairies.	Swan Lake, Galveston County, Texas

Organization	Project Title	Project Description	Project Location State
Native Village of Shaktoolik	Shaktoolik Alaska Storm Surge Berm and Restoration	Build a storm surge berm between Shaktoolik and the Bering Sea using 100% nature-based local materials, restoring coastal dune habitat. Project will prevent the destruction of the community, thereby avoiding contaminating marine habitat and coastal wetlands and rivers with fuel and other hazardous and biological waste.	Shaktoolik, Alaska
Sociedad Ambiente Marino	Restoring the three-dimensional structure of hurricane-impacted coral reefs in Puerto Rico	Restore the three-dimensional structure across of coral reefs that were severely damaged by Hurricanes Irma and Maria. Project will use a multi-method restoration approach that combines the outplanitng of artificial coral colonies created with emerging 3D printing technology with multispecies outplants composed of morphologically complex branching and massive corals.	Banjo Grouper, Arrecife Amarillo, Cayo Dákity, and Cayo Luis Pena Reef, Culebra Island, Puerto Rico
Jefferson Parish Department of Environmental Affairs	Bucktown Marsh Restoration and Living Shoreline Construction and Monitoring (LA)	Rebuild a one-mile living shoreline and creating up to 70 acres of marsh, tidal creeks, and lagoons to restore water quality and ecological functions of the Lake Pontchartrain shoreline. Project will attenuate wave activity and protect the existing shoreline and levee from erosion and storm surge to mitigate impacts of future storms, and protect approximately 1,375 homes and critical infrastructure.	Lake Pontchartrain, Metairie, LA
National Audubon Society, Inc.	Removing Infrastructure to Restore Tidal Marsh to the Mastic Beach Coastline (NY)	Restore priority coastal habitat in a flood-prone area of the Town of Brookhaven to benefit priority bird species and other wildlife, reduce flooding, and better protect inland areas from rising sea levels and storm events. Project will remove portions of a coastal road that regularly floods due to sea-level rise and restore the area to tidal marsh habitat, contributing to a larger ongoing multi-faceted coastal retreat and floodplain restoration on the 7,600 acre Mastic Beach/Shirley peninsula.	Mastic Beach, Town of Brookhaven, Long Island, Suffolk County, New York