**Atlantic Coast of Long Island,**
**Fire Island Inlet to Montauk Point (FIMP), New York,**
**Storm Damage Reduction Project, Reformulation Study**

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# EVALUATION OF RESTORATION OPPORTUNITIES USING THE HABITAT EVALUATION PROCEDURES (HEP) METHOD

## FINAL PHASE II REPORT

**Volume 1 – Report and Attachments**

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## JULY 2009

**Prepared by:** **U.S. Army Corps of Engineers**
**New York District, Planning Division (CENAN-PL-E)**
**26 Federal Plaza**
**New York, New York 10278-0090**

# EVALUATION OF RESTORATION OPPORTUNITIES USING THE HABITAT EVALUATION PROCEDURES (HEP) METHOD

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**Volume 1 – Report and Attachments**

**FOR THE**

## ATLANTIC COAST OF LONG ISLAND, FIRE ISLAND INLET TO MONTAUK POINT (FIMP), NEW YORK, STORM DAMAGE REDUCTION PROJECT, REFORMULATION STUDY

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## EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), New York District (District), is partnering with New York State Department of Environmental Conservation (NYSDEC) to conduct a comprehensive feasibility-level Reformulation Study (Study) of the Fire Island Inlet to Montauk Point (FIMP) Storm Damage Reduction (SDR) Project (Project) along the south shore of Long Island, New York. The Federally authorized project area (hereafter referred to as the Project area), extends approximately 83 miles along the shoreline of the Atlantic Coast of Suffolk County, Long Island, New York, beginning at Montauk Point and extending to the western boundary of Fire Island Inlet (Appendix A, Figure 1). The Project area includes the entire Atlantic Ocean shoreline and back-bay floodplain of Suffolk County, New York, and is composed of a complex mosaic of ocean fronting shorelines, barrier islands, tidal inlets, estuaries, and back-bay mainland areas.

The purpose of the Study is to evaluate a range of possible alternatives to address storm damage risk, including a screening of various SDR alternatives and their designs, analysis of potential impacts associated with various designs, design optimization, and selection of a recommended plan for the Project area. Consistent with the Project Vision Statement and the USACE's Environmental Operating Principles, the Study will take an integrated ecosystem approach to maintain and restore essential physical coastal processes, particularly hydrologic and geomorphologic processes, to increase storm damage protection and to reduce risks. Final results of the Study will include a set of recommendations that, if implemented, will provide New York State and its residents with a project designed to reduce storm damage risks and improve habitat conditions in the Project area.

These recommendations will be formulated into a project through the integration of National Economic Development (NED) and National Ecosystem Restoration (NER) operating principles. The NED approach identifies plan alternatives that will maximize SDR benefits compared to costs, whereas the NER approach identifies plan alternatives that maximize ecosystem restoration benefits compared to costs. The integrated approach utilizes collaborative planning to incorporate NED and NER goals/objectives/methods to identify alternatives that advance the SDR objectives of the Project and consider ecosystem restoration benefits of restoring physical coastal processes and improved ecosystem function.

The Habitat Evaluations Procedure (HEP) was utilized in conjunction with other evaluation tools to study and design the integrated NED/NER reformulation project evaluation. The HEP method was used by the District to facilitate efforts to characterize existing habitat conditions and to quantify the effects of various restoration alternatives on those habitats. For the NED approach, all SDR components underwent some level of HEP assessment for restoration benefits. Similarly, for the NER approach, all restoration plan components underwent a SDR benefits assessment as well as an assessment of ecosystem restoration. The outcome of the integrated NED/NER approach will result in recommended plans which can be combined to create one, comprehensive, NED/NER plan.

Although this report focuses on the methods and results of the HEP analysis, the District also has employed several other tools to evaluate restoration alternatives for the Project area. These include conducting a cost analysis, a interagency ranking matrix, and completing a restoration alternative prioritization exercise. These additional tools incorporate other factors into the evaluation including cost, professional expertise and knowledge of the Project area, social and political factors, and factors related to other environmental issues (such as coastal geological processes). A discussion of the development and application of these additional tools and their integration with the HEP results to evaluate restoration alternatives is included in this report.

Over 83 sites across the 83-mile Project area were evaluated by the District and interagency HEP Team for restoration potential. Eighteen (18) sites were selected as having real opportunities for restoration and a total of 57 restoration design alternatives (three to four per restoration site) were developed and evaluated using the methods documented in this report. The evaluation process was conducted over a 4-year period and included the use of numerous tools (i.e., HEP, CE/ICA, Ranking Matrix, and the Prioritization Exercise) to provide a comprehensive evaluation of the conceptual design alternatives and in an attempt to address interests expressed by agencies and interested parties.

The HEP Team determined that all 57 restoration alternatives will move forward for consideration as components of the FIMP SDR Project, as all were determined to be realistic and capable of being implemented. However, the information acquired through this restoration evaluation process will facilitate future evaluation and selection of alternatives based on need at the time of construction, location of SDR activities, and availability of funding and support. By conducting the rigorous framework of analysis of sites using the HEP method, cost-benefit analysis, and ranking matrix, all potential restoration alternatives are considered important by the evaluation Team and worthy of consideration. Using the evaluation tools, each alternative has been ranked to facilitate selection decisions, within the context of need and opportunity. These results provide a range of viable alternatives that may be implemented individually or in combination to improve ecological conditions in the Project area.

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF ATTACHMENTS (included in Volume 1)



## LIST OF APPENDICES (included in Volume 2)

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| 2001 dollars | Costs based on 2001 estimates, not adjusted for inflation/depreciation, etc. |
| AAHU | Average Annualized Habitat Units |
| BARWILDLF | Magnitude of Impact From Human Disturbance |
| BAYBEACH | Bay Intertidal and Bay Upper Shore Zone |
| BAYSUBSAV | Bay Subtidal and Submergent Aquatic Vegetation |
| BCR | Benefit-Cost Ratio |
| CANSAVCOV | Percent Cover of Submergent Aquatic Vegetation |
| CANTRSHRUB | Percent Cover of Shrubs and Trees |
| CANVEGCOV | Percent Cover of Vegetation |
| CEHA | Coastal Erosion Hazard Area |
| CE/ICA | Cost Effectiveness and Incremental Cost Analysis |
| CHU | Cumulative Habitat Unit |
| CY | Cubic Yards |
| District | U.S. Army Corps of Engineers, New York District |
| DMMP | Dredged Material Management Plan |
| DUNEGRASS | Dune Face, Dunes, Interdunes and Swales |
| E&D | Engineering and Design |
| EROSION | Presence of Erosion |
| FIMP | Fire Island to Montauk Point |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| HEP | Habitat Evaluation Procedures |
| HSI | Habitat Suitability Index |
| HU | Habitat Unit |
| HUMFACTOR | Presence of Human Disturbance |
| HUMMAGNIT | Magnitude of Impact From Human Disturbance |
| ICA | Incremental Cost Analysis |
| INVASIVES | Presence of non-desirable, invasive, and/or exotic species |
| IWR-Plan | Institute of Water Resources Decision Support Software |
| LF | Linear Feet |
| LIDAR | Light Detection And Ranging |
| LLW | Lower Low Water |
| na | Criteria Not Applicable to Certain Sites |
| NED | National Economic Development |
| NER | National Ecosystem Restoration |
| NPS | National Park Service |
| NYSDEC | New York State Department of Environmental Conservation |
| OCEANBEACH | Ocean Nearshore and Intertidal Zone |
| Project | Fire Island Inlet to Montauk Point Storm Damage Reduction Project |
| RICHSPP | Species Richness |
| S&A | Supervisor and Administration |
| SAV | Submerged Aquatic Vegetation |
| SDR | Storm Damage Reduction |

| | |
|---|---|
| SHOREMOD | Presence of Modified Shoreline |
| SI | Suitability Index |
| SLOPE | Average Slope of Shoreline or Dune |
| SRT | Self Regulating Tide |
| Study | Reformulation Study |
| SUBSTRATE | Availability of Appropriate Substrate |
| SY | Square Yards |
| TNC | The Nature Conservancy |
| TY | Target Year |
| TY0 | Target Year 0 (baseline conditions) |
| TY1 | Target Year 1 |
| TY5 | Target Year 5 |
| TY50 | Target Year 50 |
| UPLANDS | Dunes, Interdunes, and Swales Dominated by Shrub, Forest, or Development |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |
| VEGBEACH | Ocean Upper Beach Zone |
| WES | U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi |
| WIDTH | Average Width of Shoreline or Dune |
| WOSI | West of Shinnecock Inlet |

## 1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), New York District (District), is partnering with New York State Department of Environmental Conservation (NYSDEC) to conduct a comprehensive feasibility-level Reformulation Study (Study) of the Fire Island Inlet to Montauk Point (FIMP) Storm Damage Reduction (SDR) Project (Project) along the south shore of Long Island, New York. The Federally authorized project area (hereafter referred to as the Project area), extends approximately 83 miles along the shoreline of the Atlantic Coast of Suffolk County, Long Island, New York, beginning at Montauk Point and extending to the western boundary of Fire Island Inlet (Appendix A, Figure 1). The Project area includes the entire Atlantic Ocean shoreline and back-bay floodplain of Suffolk County, New York, and is composed of a complex mosaic of ocean fronting shorelines, barrier islands, tidal inlets, estuaries, and back-bay mainland areas.

The purpose of the Study is to evaluate a range of possible alternatives to address storm damage risk, including a screening of various SDR alternatives and their designs, analysis of potential impacts associated with various designs, design optimization, and selection of a recommended plan for the Project area. Consistent with the Project Vision Statement and the USACE's Environmental Operating Principles, the Study will take an integrated ecosystem approach to maintain and restore essential physical coastal processes, particularly hydrologic and geomorphologic processes, to increase storm damage protection and to reduce risks. Final results of the Study will include a set of recommendations that, if implemented, will provide New York State and its residents with a project designed to reduce storm damage risks as well as improved habitat conditions in the Project area.

These recommendations will be formulated into a project through the integration of National Economic Development (NED) and National Ecosystem Restoration (NER) operating principles. The NED approach identifies plan alternatives that will maximize SDR benefits compared to costs, whereas the NER approach identifies plan alternatives that maximize ecosystem restoration benefits compared to costs. The integrated approach utilizes collaborative planning to incorporate NED and NER goals/objectives/methods to identify alternatives that advance the SDR objectives of the Project and consider ecosystem restoration benefits of restoring physical coastal processes and improved ecosystem function.

The Habitat Evaluations Procedure (HEP) was utilized in conjunction with other evaluation tools to study and design the integrated NED/NER reformulation project evaluation. The HEP method was used by the District to facilitate efforts to characterize existing habitat conditions and to quantify the effects of various restoration alternatives on those habitats. For the NED approach, all SDR components underwent some level of HEP assessment for restoration benefits. Similarly, for the NER approach, all restoration plan components underwent a SDR benefits assessment as well as an assessment of ecosystem restoration. The outcome of the integrated NED/NER approach will result in recommended plans which can be combined to create one, comprehensive, NED/NER plan.

Although this report focuses on the methods and results of the HEP analysis, the District also has employed several other tools to evaluate restoration alternatives for the Project area. These include conducting a cost analysis, developing a ranking matrix, and completing a restoration alternative prioritization exercise. These additional tools incorporate other factors into the evaluation including cost, professional expertise and knowledge of the Project area, social and political factors, and factors related to other environmental issues (such as coastal geological processes). A discussion of the development and application of these additional tools and their integration with the HEP model results to evaluate restoration alternatives is included in this report.

Building upon previous habitat assessment efforts, and in particular the FIMP HEP Phase I evaluation (USACE 2006a), this Phase II evaluation describes the District's continued efforts to accomplish the following with the FIMP Study framework:

1. Quantify existing habitat conditions within the proposed Project area.
2. Identify locations for restoration opportunities in the Project area.
3. Create conceptual designs for various restoration alternatives.
4. Evaluate impacts (both beneficial and adverse) anticipated as a result of various restoration alternatives.
5. Identify restoration plans that would maximize NER benefits.
6. Identify restoration plans that would enhance NED benefits.

Specifically, this report includes a discussion of HEP Habitat Suitability Index (HSI) model development (Section 2.0), HEP analysis methods (Section 3.0), HEP data collection methods (Section 4.0), HEP analysis methods (Section 5.0), HEP results (Section 6.0), incremental cost analysis (ICA) (Section 7.0), restoration site evaluation and ranking (Section 8.0), a restoration site prioritization exercise (Section 9.0), conclusions (Section 10.0), and literature cited (Section 11.0).

Note that this report contains only a description of the process used to identify, analyze, and rank restoration alternatives, while the actual selection of restoration and SDR alternatives will be presented in the final Reformulation Report for this study. In addition, a more comprehensive evaluation of the full range of existing environmental conditions in the Project area, as well as an analysis of potential impacts to the environment (including an evaluation of effects on coastal processes) resulting from proposed restoration activities, will be presented in the Environmental Impact Statement document for the Project.

## 1.1 PROJECT AREA

The Project area extends approximately 83 miles from Montauk Point to the western boundary of Fire Island Inlet and includes barrier island, oceanfront and adjacent nearshore ocean areas, bayside areas that are connected to the mainland of Long Island, and the waterbodies and islands of Shinnecock, Moriches, and Great South bays (Appendix A, Figure 1). The Project area is characterized as a low-lying landform consisting of both rocky and sandy beaches, sand dunes, eroding cliffs, saltwater marshes, stunted forests, several natural and man-made islands, and tidal flats. Natural communities in the Project area are dynamic and are constantly moving and reshaping in response to storms, sea level changes, and wave action. The Project area serves as a buffer against storms and wave action for the coastal mainland and is known to provide essential nesting and feeding areas for many aquatic and terrestrial plants and animals, including rare species.

## 1.2 BACKGROUND

Prior to the HEP analysis and restoration alternative evaluation process described in this report, several key steps were completed by the District to characterize existing habitat conditions in the Project area and evaluate potential impacts to those habitats resulting from proposed restoration activities. These included creation of a habitat cover type map for the Project area and development of a conceptual ecosystem model (USACE 2006b).

The HEP analysis presented in this report builds upon those previous efforts by providing a method to quantify changes (both positive and negative) to habitats and to evaluate those changes in terms of cost-benefit ratios. HEP, developed by the USFWS (1980) with assistance from the USACE and U.S. Department of Agriculture (USDA) Soil Conservation Service, enables the results of such an evaluation to be incorporated into the decision-making process in a manner that is technically defensible, replicable, and can be applied consistently to a variety of different habitat types.

As background, according to the USACE Planning Guidance Notebook (Engineer Regulation 1105-2-100) "the Federal objective of water and related land resource project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements" (USACE 2000). The goal of NED refers to developing or maintaining economic opportunities through USACE actions, and includes items such as navigation and flood damage reduction. Benefits are economic in nature (e.g., dollars saved from protecting residential and commercial properties and infrastructure from future damage) and are portrayed in dollars in terms of an ICA.

A primary mission of the USACE Civil Works Program is ecosystem restoration, and the USACE objective in ecosystem restoration planning is to contribute to ecosystem restoration on a national level (i.e., NER). NER refers to increasing the net quantity and quality of desired ecosystem resources (USACE 2000). NER benefits are environmental in nature (e.g., improved wetland habitat) and are portrayed in non-monetary forms such as habitat units (i.e., HEP Habitat Units [HUs]); a dollar value is not assigned to NER benefits. However, similar to NED cost/benefit analysis, NER costs (i.e., costs associated with each restoration alternative) can be compared with benefits (i.e., HUs) to identify a plan that best maximizes benefits compared to costs (i.e., benefit-cost ratio or BCR). In evaluating both NED and NER plans, the District's objective is to select NER plan components that advance the SDR objectives of the Project and consider the ecosystem restoration benefits of restoring physical processes and improved ecosystem function.

In addition, planning for the USACE is conducted according to The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983). Among the requirements of USACE planning mandated by this guidance is the implementation of a benefit-cost analysis and a Cost

Effective/Incremental Cost Analysis (CE/ICA) for NED and NER alternatives to identify cost effective plans that can be supported by the District.

During the initial stages of the Study's restoration alternative evaluation process, the District identified an interagency Team (HEP Team) to assist the District in evaluating the habitat restoration and enhancement opportunities for the FIMP Project, developing the HEP methodology used to analyze impacts to habitats from proposed restoration activities, and to facilitate the selection of a restoration plan(s) that would maximize restoration benefit. The HEP Team included representatives from the National Park Service (NPS), and the USFWS. Other agencies and organizations, such as the U.S. Environmental Protection Agency (USEPA), the NYSDEC, and The Nature Conservancy (TNC), were provided materials for review and comment, but were not active participants in the HEP Team. Individual HEP Team members, their affiliation, and responsibilities are identified in Appendix B, Table 1.

## 1.3 HEP Purpose and Intended Use

HEP is intended to provide a consistent method for evaluating impacts associated with Project alternatives by enabling a comparison between existing and future conditions within a given habitat as well as the impacts (positive and negative) between different habitat types in the Project area. The HEP method was used by the District to facilitate efforts to characterize existing habitat conditions within the Project area and to quantify the effects of various restoration alternatives on those habitats. The objective in evaluating conceptual restoration designs with HEP was to assess a broad spectrum of alternatives that could be carried out at locations across the barrier island, to evaluate various alternatives to such projects (e.g., full restoration versus a reduced area), and to present a range of possible options and costs.

As presented in this report, the HEP method, variables, and mathematical relationships were prepared for the assessment of restoration design alternatives for the Project. Accordingly, this report contains a summary of the HEP analysis of 57 restoration alternatives at 18 sites within the Project area. While the HEP analysis incorporates consideration of coastal processes, such as sediment transport, it is beyond the scope of the HEP method to fully encompass dynamic physical and biotic processes, particularly in a large, complex coastal ecosystem such as the FIMP Project area. HEP is not intended to be a stand-alone tool for decision-making, but is intended to provide support for the decision-making process. Therefore, other tools such as a site ranking matrix, a cost analysis, and restoration prioritization exercise were used in the evaluation of alternatives for restoration sites and are discussed in Sections 7, 8 and 9 of this report. These tools were designed to provide additional information to incorporate some of the key parameters outside the scope of HEP into the evaluation process. Ultimately, the results of the HEP and other evaluation procedures presented herein will be used to assist the District with the selection of restoration designs that will be a component of the NER plan.

### 1.3.1 Restoration Goals

The primary goals of restoration for the FIMP Project are to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition, as well as to evaluate the feasibility of combining restoration efforts to supplement the proposed SDR

Project. To assist in this effort, and in support of the Vision Statement (presented in Appendix C) and U.S. Water Resources Council's Environmental Operating Principles, the District identified the following five key processes that should be considered in coastal restoration designs for the Long Island, New York area: (Detailed fact sheets for these five processes are available in Appendix C.)

1. Longshore sediment transport,
2. Cross-island sediment transport,
3. Dune development and evolution,
4. Bayside shoreline processes, and
5. Estuarine processes.

Other important considerations for ecosystem restoration in the Project area have been identified by personnel from agencies associated with the FIMP restoration effort and include:

1. Maximize the benefits, functions, and biodiversity of natural and native habitats;
2. Promote habitats for populations of rare, threatened, and endangered biota;
3. Re-establish natural rates of longshore and cross-island sediment transport, and bayside shoreline processes; and,
4. Improve estuarine processes into and within the bay.

### 1.3.2 HEP in Federal Cost-Benefit Analysis

HEP is used as a tool to assist in the evaluation of costs, benefits, and/or impacts from proposed activities by providing environmental outputs, in the form of Average Annualized Habitat Units (AAHUs), as required by cost-benefit analysis. AAHUs are used to evaluate restoration and SDR alternatives and provide a way to marry NED and NER goals and objectives. The NED/NER evaluation was not part of the scope of work for this Project at this time, and is therefore not presented in this report. However, the AAHUs generated from this HEP evaluation are a key component of the NED/NER evaluation planned for this Project. NER benefits are environmental in nature (e.g., improved wetland habitat) and are portrayed in non-monetary forms such as HUs derived from HEP; a dollar value is not assigned to NER benefits. However, similar to NED cost/benefit analysis, NER costs (i.e., costs associated with each restoration alternative) can be compared with HU benefits to identify a BCR plan that best maximizes benefits compared to costs.

In cases where Project activities and restoration activities occur in the same location, contributions to NED and NER can be combined in Project planning and can include trade-offs between NED and NER to maximize the sum of net benefits. Projects that maximize NED and NER benefits offer the best balance between the two Federal objectives, and result in the "best" recommended plan, which is a combined NED/NER plan (USACE 2000).

Alternatively, site selection for the Project based on economic factors (i.e., NED) can be conducted separately from site selection for restoration based on environmental factors (i.e., NER). In this case, the environmental impacts from the selected Project and proposed restoration are both identified in terms of HUs through HEP. NED and NER goals can be met through the selection of the "best" Project (in terms of BCR), and offsetting any habitat impacts from the Project through the selection of restoration sites that provide habitat benefits that are greater or more significant than Project impacts, as characterized by HEP.

Ultimately, a combined NED/NER plan will be prepared by the District that meets SDR requirements while maximizing environmental restoration outputs by including consideration of tradeoffs between NED and NER outputs. Numeric outputs from the HEP analysis, and information gained from the use of other evaluation tools as presented in this report, are used to quantify benefits in the NED/NER evaluation process and facilitate the comparison of environmental benefits of proposed alternatives relative to economic benefits and alternative costs.

## 1.4 HEP METHOD SELECTION

Early in the restoration evaluation process, the District met with the HEP Team and other Federal and state agency representatives to discuss HEP as a possible evaluation tool (see meeting minutes provided in Appendix D). Through these discussions, the Team acknowledged that the Project area is a spatial and temporal mosaic of communities in varying succession series and geomorphological conditions that cannot easily be captured through environmental/habitat models such as HEP. However, despite these recognized limitations to the HEP method, the HEP Team was unable to identify a suitable alternative evaluation method, and therefore agreed to use HEP for the characterization of habitats and evaluation of restoration alternatives for the Project.

HEP is particularly useful in assisting with the evaluation of current and future habitat conditions because it provides information for two general types of wildlife habitat comparisons: 1) the relative value of different areas at the same point in time; and 2) the relative value of the same area at different points in time (USFWS 1980). This information is useful in baseline and impact assessments to evaluate proposed actions that potentially result in a change in either habitat quantity or quality. Considering the large number of alternatives that are being considered, the many community types present in the Project area, and the need to assess these alternatives and community types temporally and spatially, the Team agreed that HEP provides a suitably robust and consistent method to achieve the goal of evaluating potential habitat effects of Project alternatives.

In addition, unlike qualitative assessments the relative value of wildlife habitats can be quantitatively expressed by using HEP through a final numerical output that is technically defensible, replicable, and can be applied consistently in a variety of different habitat types (McCrain 1992). HEP is based on combining a measure of habitat quantity with an index of habitat quality to determine an overall habitat score (USFWS 1980). The underlying assumption of HEP is that a HSI model can be used to evaluate and describe the quality of a community type or habitat.

## 1.5 HEP TEAM MEETINGS

The HEP Team assisted the District in evaluating habitat restoration and enhancement opportunities for FIMP, including the development of HEP models, identification of restoration sites and alternatives, the evaluation of alternatives, and the identification of alternatives that maximize restoration benefit. The HEP Team participated in a number of meetings and conference calls to develop the HEP methodology proposed for FIMP and to evaluate various restoration alternatives. The dates and emphasis of these meetings were as follows:

- May 12 through 14, 2004 (model selection and building).
- June 28 through July 2, 2004 (site visit and model building).
- August 25 through 27, 2004 (pilot study and model adjustments).
- November 17 through 19, 2004 (baseline and future without restoration results).
- April 21 through 22, 2005 (baseline, future without restoration, and future with restoration results for example transects).
- September 23, 2005 (baseline, future without restoration, and future with restoration results at 18 selected restoration locations).
- April 18, 2006 (comments on draft Phase I HEP report, introduction of ranking matrix).
- August 16, 2007 (ranking matrix results, prioritization of restoration alternatives).

Copies of the minutes from these meetings are provided in Appendix D.

# 2.0 HEP HSI MODEL DEVELOPMENT

The HEP Team convened on several occasions in 2004 to develop HSI models. Minutes from these workshops and meetings are provided in Appendix D and HSI model documentation is provided in Appendix E. The initial products of these efforts were a series of community models, a list of "suggested" ecosystem components, and a list of variables (with suggested sampling protocols) as described in Appendix E.

Early in the HEP process, the HEP Team recognized that the barrier island ecosystem is a spatial and temporal mosaic of communities in varying successional series and geomorphological conditions that can not easily be captured through traditional single-species/single habitat HEP Habitat Suitability Index (HSI) models. The HEP Team discussed the advantages and limitations of species-specific models and ultimately chose to develop a series of community-based models that collectively would encompass Project area ecosystems. Although species-specific approaches to HEP are traditional, the HEP Team decided to use a more holistic, community-based approach to evaluate the ecosystems rather than species-driven models, with the understanding that many wildlife species and ecosystem processes would likely benefit by establishing "optimal" conditions for representative communities found on the barrier island. In addition, community-based HSI models offer more promise for application to this Project area, compared with species-based HSI models, because they are more efficient in capturing those habitat measures necessary for restoring ecosystem integrity and can be compared across a wide range of ecosystems for prioritization purposes. Community-based HSI models indicate relative ecosystem value more inclusively than species-based models because they link habitat more broadly to ecosystem components or functions.

In this HEP study, the HEP Team considered groups of species (such as those with very specific habitat requirements, low mobility, and documented sensitivity to habitat changes), overall ecosystem processes, and the stability of natural features when developing HSI model variables. In developing the HSI models, the HEP Team recognized that all community-based models have limitations, particularly in their ability to capture geomorpholology and other dynamic variables in the ecosystem. In addition, while the models are capable of capturing broad habitat changes and effects, they are unable to capture many of the processes defined as goals for this project and socio-economic or cultural factors. However, despite these recognized limitations, HEP does provide a standardized approach that is useful in comparing and contrasting habitat quality and potential impacts to those habitats across a wide area.

## 2.1 HEP UNITS OF MEASURE

In HEP methodology, HSIs are used to determine the suitability (i.e., quality) of a given habitat or community type for a species or group of species. These models include quantifiable environmental variables that influence the species (or group of species) presence, distribution, and/or abundance to determine suitability. The HSI is defined as a score between 0.0 and 1.0, with 1.0 representing the optimum quality of a habitat variable in a defined area at a specific point in time, and assumed to be positively correlated to carrying capacity (USFWS 1980). HSI scores are multiplied by the area of available habitat or community to obtain HUs.

To use HEP as an impact assessment tool, the future conditions of the Project area must be predicted to determine how habitat quality might change with and without a proposed activity. Future HUs are derived by calculating the area of habitat (i.e., community type) and the predicted HSI score (based on future projections of habitat conditions) for the habitat, at given points in time (i.e., target years [TYs]). For use in the cost-benefit analysis, these HUs are then added across all years in the period of analysis to derive Cumulative Habitat Units (CHUs). The CHUs are then divided by the economic life of the Project or activity to generate the Average Annualized Habitat Units (AAHUs). Calculation of AAHUs permits the analysis to include impacts that may be incurred during the pre-start period of the restoration activity, as well as throughout the life of the Project, while basing the calculation on the same denominator that is used in Federal cost-benefit analysis.

The HEP method selected for this study included a 50-year evaluation horizon to allow for the impacts of a certain event (such as a breach of the barrier island or a restoration project). Therefore, the HEP method includes the capability to assess the baseline condition (TY-0), a “final condition” 50 years from the baseline (TY-50), the anticipated effect of a single event (TY-1), and an additional timeframe (TY-5) intended to provide additional precision to HEP by, for example, delaying the score a habitat receives for restoration efforts until habitats improvements are well established on site.

## 2.2 HEP General Assumptions

In developing and using the HEP process in the evaluation of the communities identified for this Project, the following determinations and assumptions were made by the HEP Team.

- **Assumptions in HEP**

  1. There is a relationship between measurable features of habitat and the habitat's carrying capacity for fish and wildlife.
  2. Measurable habitat characteristics can be described in terms of quantity and quality.
  3. Future conditions can be predicted both with and without the proposed Project or action being evaluated, as they relate to changes in habitat characteristics.

- **Assumptions for HEP Components**

  1. Quantity can be determined by accurately and meaningfully delineating and classifying the habitat.
  2. Quality can be determined when sufficient knowledge and skills are available to construct the quality input to HEP.
  3. Quantity and quality are equally important in determining the HEP output of HUs.
  4. When quantity and quality are multiplied to show HUs, high scores in both components are needed to maximize output, a low score in one or the other will reduce the output, and a zero score in one or the other will provide no output.
  5. HSI models each contain their own assumptions.
  6. Models have limitations, particularly in their ability to capture geomorpholology and other dynamic variables in the ecosystem.

- **Assumptions in Analysis**

  1. Target evaluation elements are appropriate for the evaluation being addressed. In other words, elements are significant resources and meet study objectives.
  2. Time periods used in analysis are appropriate for the evaluation elements being evaluated (target years, Project life).
  3. Errors in study design and in data collection, analysis, and interpretation are sufficiently low to provide the desired rigor of evaluation.

## 2.3 FIMP Community Models

The HEP Team reviewed conceptual transects of the Project area and evaluated the cover type information and aerial photography available for each transect to identify distinct communities represented across the Project area. The HEP Team identified six major community types and each of these was developed into a community-based HSI model. Conceptual locations of these community types across the barrier island are shown in Appendix A, Figure 2.

1. OCEANBEACH (ocean nearshore and intertidal zone) – unvegetated area dominated by sand and extending from 30 ft (10 m) depth in the ocean landward to the average daily high tide line (i.e., wrack line).

2. VEGBEACH (ocean upper beach zone) – bare or sparsely vegetated area dominated by sand extending from the average daily high tide line (i.e., wrack line) landward to the toe of the primary (i.e., fore) dune.

3. DUNEGRASS (dune face, dunes, interdunes and swales) – area dominated by sand or herbs and extending from the seaward toe of the primary dune landward to the bayside storm high water mark, or landward to the seaward edge of the upland community. Beach grass is typically the dominant species, but the community often also includes a significant component of vine species. Shrubs, when present are typically stunted and cover less than 20% of this community. The community is well interspersed throughout the island from ocean to bay.

4. UPLANDS (dunes, interdunes and swales dominated by shrub, forest or development) – area with >20% cover of non-wetland shrubs or trees and extending from the toe of the primary dune landward to the bayside storm high water mark. Herbs and/or vines are also common components of this community, but do not dominate (<20% cover).

5. BAYBEACH (bay intertidal and bay upper shore zone) – area from the bay lowest-low water (LLW) line landward to the point where the upland or dunegrass (i.e., non-wetland) community is encountered. This community may be dominated by sand, mud, or vegetated with wetland herb and/or wetland shrub communities (e.g., *Spartina, Juncus, Salicornia, Phragmites, Baccharis, Myrica*). This community includes intertidal areas and tidal ponds.

6. BAYSUBSAV (bay subtidal and submergent aquatic vegetation) – area from the bay LLW line bay ward (i.e., areas constantly covered by water). This community is typically dominated by bare sand substrate or submergent aquatic vegetation. The community also may include impounded areas (e.g., ponds) that are constantly covered by water.

The HEP Team used Community Model Builder prototype software to assist in developing HSI models for these six community types. During the work sessions, the HEP Team provided input that included the definition and measurable characteristics (i.e., variables) of the communities, optimal community conditions, sampling techniques, extent of communities, and significance of variable to each community. This information was entered directly into the Community Model Builder prototype database within the intent of producing baseline models and documentation for each model. Appendix E provides detailed model documentation. Copies of the minutes from HEP Team working sessions and meetings are provided in Appendix D.

The models developed for FIMP could be applied to other similar systems and processes. However, the assumption made by the HEP Team is that these models would only apply to, and be used for, the FIMP Project area.

### 2.3.1 Optimal Conditions

Optimum conditions are those characteristics of a community that are most desirable and are (when present) indicative of a healthy, functional community that will host the full range of plant and animal diversity characteristic of that habitat type. When observed in a community, optimal conditions receive an HSI score of 1.0. The optimum conditions were determined through a series of HEP Team meetings and relied on input from HEP Team members based on their professional opinion and consultation/input from professionals within their agencies. The general optimum conditions defined by the HEP Team for each of the six communities are described below. In all cases, the optimum condition assumes no effects from human-modified shoreline, no human disturbance factors, and no barriers to wildlife passage. Although the HEP Team identified the following "optimal" community conditions from which general assessments of habitat quality can be made, the HEP Team recognized that the barrier island ecosystem is a spatial and temporal mosaic of communities in varying successional series and geomorphological conditions that cannot easily be captured through HSI models.

OCEANBEACH – relatively wide (>2,000 ft) near ocean area extending from 30 ft offshore to the average high tide line, with appropriate species richness, invasive species are absent, area is traversable by wildlife, and lacks manmade structures and human disturbance.

VEGBEACH – relatively wide (>125 ft) upper beach area extending from the wrack line to the toe of dune and with a shallow slope from 0 to 5%. Herbaceous vegetation is present and density is close to 40% cover, no unnatural erosion, invasive species are absent, area is traversable by wildlife, and area lacks manmade structures and human disturbance.

DUNEGRASS – dune face includes a wide zone (>45 ft) from toe to crest of dune with a slope between 20 and 25%, dune face not sloughing, herbaceous vegetation is present in densities between 40 and 50% cover, invasive species are absent, area is traversable by wildlife, and area lacks manmade structures and human disturbance.

UPLANDS – a diversity of cover types based on vegetation including high coverage of shrubs and/or trees, any erosion is primarily "natural," area is traversable by wildlife, *Phragmites* or other invasive species are not present, and area also lacks manmade structures and human disturbance.

BAYBEACH – a high number of the appropriate species present, invasive species are absent, any erosion is primarily "natural," area is traversable by wildlife, and site lacks manmade structures and human disturbance.

BAYSUBSAV – a high number of the appropriate species present, including submerged aquatics, invasive species are absent, factors that limit eelgrass growth are absent, and the area lacks manmade structures and human disturbance.

### 2.3.2 Model Variables

In defining the HEP communities, the HEP Team identified 13 variables, or measurable characteristics, of each community that could be evaluated to determine the overall quality of each community. Variables were identified and evaluated by the HEP Team throughout a series of HEP meetings (see the meeting minutes in Appendix D and HEP Documentation in Appendix E). Variables were modified, added, or removed as needed to refine the community models. A final list of all variables evaluated for each community is presented in Appendix B, Table 2. Variables evaluated included the following:

1. Species Richness (RICHSPP)
2. Presence of non-desirable, invasive, and/or exotic species (INVASIVES)
3. Percent Cover of Submergent Aquatic Vegetation (CANSAVCOV)
4. Average Width of Shoreline or Dune (WIDTH)
5. Average Slope of Shoreline or Dune (SLOPE)
6. Percent Cover of Vegetation (CANVEGCOV)
7. Percent Cover of Shrubs and Trees (CANTRSHRUB)
8. Presence of Human Disturbance (HUMFACTOR)
9. Magnitude of Impact From Human Disturbance (HUMMAGNIT)
10. Impact of Barriers to Wildlife Passage (BARWILDLF)
11. Presence of Erosion (EROSION)
12. Presence of Modified Shoreline (SHOREMOD)
13. Availability of Appropriate Substrate (SUBSTRATE)

See Section 4.0 below for field measurements and methods used in evaluating these variables.

## 2.4 MODEL DATA PROCESSING

### 2.4.1 Suitability Indices

The relationship between a given HSI variable and an estimate of habitat suitability are expressed by mathematical equations and described graphically using suitability index (SI) curves and histograms for given environmental variables. These SI curves/histograms were developed by the HEP Team for each community model and are presented in Appendix E. A spreadsheet developed by the USACE's Waterways Experiment Station (WES) (i.e., HEP Curves Spreadsheet) provided the interface for raw field data entry and baseline variable SI calculations for each variable, based on the curves/histograms identified by the HEP Team.

### 2.4.2 Mathematical Equations

Mathematical functions were created to define the relationships between model variables based on input from the HEP Team regarding the "weight" each variable should have in defining the overall HSI community score. For example, a very undesirable condition in a community may be factored into an equation (i.e., weighted) whereby its presence would significantly lower the HSI score. The accuracy and utility of the proposed models were "tested" (i.e., validated and verified) with specific field and planning exercises on the District's ongoing FIMP SDR and ecosystem restoration feasibility study. The equations were evaluated by the HEP Team (see the HEP documentation in Appendix E for details) and modified as needed based on HEP Team input. A spreadsheet developed by the USACE, (WES) (i.e., HEP Equations Spreadsheet) was used to calculate the overall HSI score for each community based on variable SI scores.

The HEP Team considered three components when developing variables to facilitate an understanding of how equations are constructed: biota, geomorphology, and human influences. The mathematical functions (Appendix B, Table 3) used to combine variables and the assumptions and logic for decisions on combining and weighting variables within those models are provided in the Model Development section of Appendix E.

## 3.0 HEP ANALYSIS METHODOLOGY

### 3.1 HU CALCULATIONS

The FIMP HEP Equations spreadsheet was used to calculate HUs by multiplying the cover type acreage (*i.e.*, available habitat) by the average HSI score for each community at a given transect or restoration/project site. As noted, the HSI score is a result of raw input of field data into the HEP Curves spreadsheet then further analysis within the HEP Equations spreadsheet. Simply put, HUs are a numerical representation of habitat quality and habitat quantity where:

Habitat Quality = Habitat Suitability Index (HSI)

Habitat Quantity = Area (i.e., acres)

*Therefore*

**HSI x Acres = HUs**

Acreages for communities at restoration sites were obtained from the cover type map[1]. Acreages for communities at the shoreline stabilization Project locations were obtained by estimating the width of each community from aerial photography, then multiplying by the length of each community (i.e., potential Project area) as identified from shoreline stabilization designs being considered. Data from shoreline stabilization designs were used instead of aerial photography in cases where designs provided both the length and width for a given community (e.g., beach width or foredune width).

### 3.2 AAHU AND CUMULATIVE HU CALCULATIONS

The HEP analysis provides the numeric input (i.e., HSIs) for use in determining which Project or restoration alternatives are cost-effective and/or incrementally justified based on the environmental benefits provided by the action (i.e., HEP HUs), and when combined with costs result in a cost per unit benefit (i.e., cost per HU). Benefits are environmental in nature (e.g., improved habitat) and are portrayed in non-monetary terms.

[1] The cover type map was developed for this study area using various Geographic Information System (GIS) data sources, followed by ground-truthing along selected transect areas (USACE 2005).

The process of determining AAHUs described below was achieved through use of WES's FIMP AAHU Generator spreadsheet. This spreadsheet is linked to the HEP Equations spreadsheets described previously for automated input of baseline raw HSI scores and acres, future no-action HSI scores and acres, and future with-action (i.e., restoration) HSI scores and acres, to calculate AAHUs and net AAHUs gained for each restoration alternative. The resulting net AAHU was used in the cost analysis described in Section 7.0.

To evaluate habitat conditions over time, four TYs were identified for the Study and included TY0 (baseline conditions), TY1 (first year that conditions are expected to deviate from the baseline condition), TY5 (to provide additional precision to the Study, enabling the model to capture changes between TY1 and TY50) and TY50 (last year in the period of analysis). The HSI score at TY5 is carried through to TY50, with the assumption that the action occurring between TY1 and TY5 is self sustaining or, if not self-sustaining, management activities will occur to sustain the results of the action. The HUs (HSI score x acres), form the basis for the calculation of the CHUs and AAHUs. CHUs were calculated by using the generalized formula outlined in the HEP Manual (USFWS 1980) and is presented below:

$$\text{Cumulative HUs} = (T_2 - T_1)\left[\left(\frac{A_2H_2 + A_1H_1}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

WHERE:

$T_1$ = first target year of a time interval

$T_2$ = last target year of a time interval

$A_1$ = area of available habitat (*i.e.*, cover type) at beginning of the time interval

$A_2$ = area of available habitat (*i.e.*, cover type) at end of the time interval

$H_1$ = HSI at beginning of the time interval

$H_2$ = HSI at end of the time interval

3 and 6 = constants derived from integration of HSI x Area for the interval between any two target years

Habitat gains or losses were annualized by summing CHUs across all target years, and dividing the total by the number of years in the life of the Study to obtain an AAHU value. CHUs and AAHUs were calculated on a per transect/per site basis.

### 3.3 MODEL ASSUMPTIONS IN EVALUATING FUTURE TRENDS

The HEP Team evaluated the six HEP communities to determine how the quality and characteristics of each might be expected to change over a 50-year period under two scenarios: 1) future no-action, which represents site conditions should no future restoration activities take place; and, 2) future with-action, which represents conditions should restoration activities occur. The HEP Team developed assumptions regarding the future habitat conditions within restoration sites based on HEP Team discussion, professional opinion, and expected results based on previous studies.

### 3.3.1 Future No-Action

The purpose of evaluating no-action alternatives is to examine changes that are anticipated throughout the area if no actions (i.e., restoration or Project activities) were to occur. Conditions with the proposed restoration or Project activity are compared to conditions without the action to identify the beneficial and adverse effects of a proposed activity. These comparisons provide the framework for evaluating alternative plans. In HEP analysis, projections of with- and without-project conditions consider expected future environmental conditions, especially trends in ecosystem change. The future without-project is defined as the most likely future conditions in the absence of a proposed Federal project. It forms the base condition against which the benefits and impacts of alternative plans are assessed.

Factors such as ongoing natural succession, coastal erosion, and land and infrastructure development were not fully evaluated or incorporated into the future model due to the challenges of predicting future site conditions with any degree of confidence. However, some general trends (e.g., continued erosion of the bay shoreline and ocean beach/dunes in areas currently experiencing high rates of erosion) were taken into consideration and included in calculations of future conditions. In many cases, communities are expected to shift across the barrier island, whereby decreases in size and/or habitat quality (i.e., downward trend of HUs), would occur in some locations, but increases in size and/or habitat quality (i.e., upward trend of HUs) would offset this change in other locations. For HEP evaluation purposes, some modifications to individual HSI scores were accounted for in the model calculations. The assumptions and future predictions are discussed in the meeting minutes in Appendix D and summarized in Appendix B, Table 5.

When calculating future no-action conditions for restoration alternatives, the following assumptions/rules were applied:

1) Baseline habitat quality and quantity at TY0 (i.e., baseline) would be the same as those documented for baseline from 2004 and 2005 field surveys regardless of when TY1 actually occurs;
2) Future habitat conditions at TY50 for restoration sites were based on application of HEP Team professional judgment regarding changes to the habitat suitability scores over the life of the Project (Appendix B, Table 5); and,
3) Future habitat conditions at TY50 for restoration sites would be the same as those at TY5; management activities would keep the habitat conditions stable between TY5 and TY50 if necessary.

### 3.3.2 Future Trends With Restoration

The purpose of evaluating future trends with a proposed restoration action is to determine how habitat quality and quantity are expected to change over time should a proposed activity occur. These changes could be positive, negative, or have no affect on a community. When calculating future habitat conditions with restoration alternatives, the rules/assumptions applied include the following:

1) All changes in habitat conditions would gradually be realized from TY1 to TY5, and will achieve full benefit in TY5.
2) Conditions in TY5 would remain consistent through TY50.
3) Additional target years to account for a decline in habitat conditions over time or an improvement in conditions due to maintenance activities are not included in the models.
4) Changes in habitat quality and quantity of target communities at TY5 for restoration sites were based on professional judgment, HEP Team input, and an assessment of likely outcomes based on similar restoration efforts.
5) Habitat quality and quantity at non-target communities is equal to baseline. Based on the assumption that restoration and SDR activities in the area would minimize loss of quality or quantity of non-target communities.
6) Any maintenance activities necessary for the long-term success of the restoration activity through TY50 would be carried out over the life of the Project; either by the USACE or non-Federal sponsor, or local interested parties. This assumption is only valid with local sponsor buy-in as a result.
7) There is a need for local sponsor buy-in for restoration projects. If projects are not monitored and managed after being constructed, site conditions could change from natural succession or invasion of non-native species or human disturbances, which could severely limit habitat suitability.

## 4.0 DATA COLLECTION METHODOLOGY

The following sections describe the methodology used to collect and analyze the habitat variables necessary to characterize the baseline ecological resources located within the Project area. The sampling effort used GIS cover type map analysis in conjunction with field data measurements to evaluate the HSI variables associated with the six community type models developed by the HEP Team. HEP data were collected at 21 transect locations across the barrier island thought to be most representative of habitat conditions in the Project area (Appendix A, Figure 3). Data from these transects were then extrapolated to areas similar in community characteristics for a full evaluation of restoration design alternatives at 18 locations within the Project area.

### 4.1 COVER TYPE MAP PREPARATION

To quantify habitat conditions, the HEP process requires the Project area to be divided into manageable sections and quantified in terms of acres. This process, referred to as “cover typing,” allows the user to define the differences between vegetative covers (e.g., ocean, beach, shrub, forest, salt marsh, bay), hydrology and topographic characteristics, and clearly delineate these distinctions on a map. The final classification system, based primarily upon dominant vegetation cover, captures “natural” settings and common land-use practices in a specific and orderly fashion that accommodates the USACE Plan Formulation Process.

Cover type maps (depicting the six target HEP communities) were initially created for the vicinity of each HEP data collection transect and were based upon a review of existing data and maps, including maps produced during the District's development of the conceptual ecosystem model (USACE 2006b). ARCView® and ARC/INFO® GIS software were used for cover type map preparation and editing (Environmental Systems Research Institute [ESRI] 2000). Several existing cover type maps, aerial photography, and baseline GIS data layers, of varying degrees of coverage, accuracy, and level of detail, were evaluated for potential use as base maps in the HEP evaluation process (National Oceanic and Atmospheric Administration 1998, Marine Sciences Research Center 2002). The best available cover type map data were selected to create individual cover type maps for each HEP transect area and provided the foundation for future cover type map updates and revisions as were needed to refine the maps for use in HEP. For example, maps required consolidation and retyping of vegetated communities for use with the six defined HEP community types (i.e., all upland habitat types were lumped into one upland cover type) and included a disturbed community type to document areas of overall minimal habitat value due to significant modification or disturbance (e.g., roads, parking lots, residential communities, marinas, sites devoid of natural vegetation or characteristics). Color aerial photographs from 2002 and 2004 and standard stereoscopic photo-interpretation methods were also used to assist in the evaluation and refinement of the cover type map.

Cover type maps were created for communities in the vicinity of potential restoration or SDR sites and included areas within the extent of perceived potential direct impact from either restoration or SDR activities. Therefore, the length and width of the areas mapped for each location varied depending on proposed actions in a given area. In general, mapped communities on the barrier island extended from 30 feet in depth on the ocean side to 500 feet beyond the LLW mark on the bayside. On the mainland sites, mapped areas extended 500 feet from the LLW mark bayside landward for 500 feet beyond the point where a contiguous upland community was encountered. All communities on islands and extending up to 500 feet beyond the LLW mark of islands were mapped. It is recognized that indirect impacts could occur beyond the mapped area. However, analysis did not include evaluation of potential indirect effects from proposed restoration or Project activities. Cover type maps were used to generate acreages for baseline conditions and for the evaluation of restoration and potential SDR actions.

In addition, during data collection activities, wherever possible, cover types were ground-truthed to confirm the accuracy of existing cover type maps. As a result, some areas required adjustments to polygon boundaries and/or habitat type classifications to improve the accuracy of the maps. A Global Positioning System (GPS) was used to record significant discrepancies between notations on the draft Cover Type Map and to field verify conditions.

## 4.2 DATA COLLECTION TRANSECT LOCATIONS

HEP data collection transects were placed in locations that incorporated the highest number of the six community types identified for HEP and in areas that had some restoration potential. The location and direction of transects were initially identified by the District based on information collected during numerous site visits conducted by the District in 2004. The following selection criterion was used in identifying data collection transects:

1. Unique community and habitat type among Project area
2. Unique species among Project area

3. Threatened and endangered species and known areas of usage
4. Feasibility of (long-term) success
5. Sustainability (long-term) of site
6. Maintenance needs
7. Existing (known) anthropogenic use
8. Federal, state and local landowner support
9. HEP team member recommendation
10. Coastal process restoration potential
11. Habitat/species restoration potential

In selecting data collection transect locations, the District conducted a visual evaluation of over 83 potential areas, including 24 sites on the barrier island and oceanfront areas of the mainland, 15 dredge disposal islands, 21 dredge disposal sites on the mainland, and areas within Wertheim and Seatuck Wildlife Refuges. As noted, numerous transect locations were initially identified by the District. For each of these areas, the HEP Team was provided orthoquad imagery at 1-foot resolution and team members were invited to participate in a field site visit to the proposed transect locations. As a result, the locations of some data collection transects were modified and additional transect locations were identified based on input from the HEP team.

From the areas evaluated, 21 sites were selected for use in HEP data collection activities and are listed in Table 1 below and shown in Appendix A, Figure 3. Sites were selected based on representative habitat types, accessibility, feasibility of restoration, and the type of restoration likely at each site and included developed and undeveloped areas of the barrier island, the south shore of mainland Long Island, and dredge islands located between the barrier island and the south shore of Long Island. In addition, Appendix K provides representative photographs of the community types found along of the data collection transects.

**Table 1. HEP Data Collection Transects**

| | | |
|---|---|---|
| Robert Moses Lot 4 | WOSI (west of Shinnecock Inlet) | Democrat Point |
| Sunken Forest | Ocean Beach | Oak Beach |
| Reagan Property | Georgica Pond | Ponquogue Spoil Island |
| Old Inlet | Ditch Plains Road | Warner (east) |
| Great Gun | Ranch Road Bluffs | John Boyle |
| Pikes Breach | Hook Pond | New Made |
| Tiana | Mastic Community | East Inlet |

## 4.3 FIELD SAMPLING DESIGN

Sampling was conducted within a 250-foot wide area along each HEP transect. A 125-foot area located on either side of the transect was evaluated, except in cases where sampling procedures called for a larger evaluation area. For example, an area up to 1,000 feet on either side of the transect was evaluated for presence of modified shoreline. A unique data form and set of field variables was utilized for each community. Examples of the field data forms are provided in Appendix F.

One field data form was designed for each unique community type to facilitate data management tasks such as data collection, data entry, and data verification. The HEP data forms contained sections for the documentation of general plot characteristics, HSI and data analysis related variables, and an area to record general notes and/or observations associated with a specific transect. Unique features and examples of the community types encountered along each transect were documented with photographs. To ensure accurate estimates, field members estimated habitat variables independently and recorded the average, or came to consensus on the best estimate.

## 4.4 FIELD MEASUREMENTS

A team of biologists (field team) conducted field data collection activities for HEP during the summer and fall of 2004 and during the spring and summer of 2005. The District determined the methods used in field data collection. The District field-tested the sampling approach, collected data on several pilot study areas, and reviewed preliminary results (both in the field and at HEP meetings) with the HEP Team. The community models, variables, and data collection methods were revised as needed to address recommendations made by the HEP Team (see the meeting minutes in Appendix D for details).

Data collection activities included field verification of cover type maps, evaluation of potential restoration sites, HEP transect selection, HEP data collection, and development of conceptual restoration designs. Data were collected at 21 locations along the Project area that were representative of the habitat conditions found along the barrier island and representative of locations where future restoration or Project activities might occur (Appendix A, Figure 3). Data were extrapolated from these areas to areas with similar characteristics for a full evaluation of 18 restoration sites.

The HEP Team agreed that, when possible, existing data from previous studies in the area (e.g., benthic, finfish, submergent aquatic vegetation) could be used as surrogates to field data or used in support of field data. Specifically, the District used data from submergent aquatic vegetation (SAV) and beach invertebrate community studies conducted within the Project area in the HEP analysis as indicated below (USACE 2003, 2004a).

The following text describes how the variables for each community type were measured in the field. All values were based on a qualitative assessment of conditions except for species richness, species abundance, percent cover of eelgrass, number of community types, and width of cover type HSI variables (which were based on quantitative values). Unless otherwise noted, the average condition was recorded for each variable within a 250-foot survey area (125 feet on both sides of the transect). Data from these variables were used to produce HSI scores based on the variable suitability indices presented in Appendix E and mathematical formula relationships.

*Species Richness (RICHSPP)* – total number of unique species of native flora and fauna identified in a given community (the total number of individuals observed was not factored into this score). Several sampling methods were used to collect data for variables relating to species richness including pit fall trapping (small mammals), clam raking (aquatic invertebrates), 1-meter quadrats (vegetation), and seining (fish). All HEP data collection included a one-time sample effort conducted during the summer/fall of 2004 or the spring/summer of 2005. When available, data from previous District studies were used. However, the sampling effort from previous studies was more rigorous (e.g., covered numerous intertidal and upper beach zones) than that conducted for HEP (which targeted only one zone). Therefore, only data from the supra zone were used from the 2003 pit fall data and only data from the mid zone were used from the 2003 benthic core data (USACE 2003).

Richness for the BAYBEACH community included data from general observations, quadrat sampling, benthic grabs, raking, and pit fall trapping. Pitfall trapping involved the random placement of five 4-inch deep and 3-inch diameter pitfall wells along the 250-foot wide transect just above the mean high water line. Traps were left in place over a 24-hour period. Samples were collected, stored in alcohol solution, identified to unique species and counted. Quadrat sampling included documenting the number and percent cover of plant species from five 1-meter square quadrats randomly dispersed within salt marsh areas of the community. One benthic grab was taken at the mid tide line of each transect. Samples were preserved in formalin, identified to unique species (when feasible), and counted. Raking included documenting species and number of macrofauna collected using a standard clam rake with a 2-foot rake width.

Richness for the BAYSUBSAV community included data from general observations, quadrat sampling, seining, and raking. An area within approximately 500 feet of the survey transect was evaluated for presence of SAV. When found, surveys were conducted within the SAV bed. Alternately, if no SAV was found, surveys were conducted below the LLW line and within the approximately 250-foot wide transect area. Five, 50-foot, seine surveys (using a 50-foot seine net with ¼-inch mesh) were conducted in the BAYSUBSAV communities. All species, and the average number of each species, were recorded. Raking included documenting all species of macrofauna, and the average number of each species, collected using a standard clam rake with a 2-foot rake width. Five, randomly placed, 50-foot long areas were surveyed. Quadrat sampling included documenting the number and percent cover of eelgrass from five 1-meter square quadrats randomly dispersed within submergent aquatic vegetation within 500 feet of the transect.

*Presence of Non-desirable, Invasive, and/or Exotic Species (INVASIVES)* – the average percent cover of invasive species found within a community (based on a visual assessment of the average condition). The HEP Team identified a list of undesirable species, which would indicate an less than healthy, or low quality community; species included common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and Says mud crab (*Dyspanopeus sayii*). The field team recorded the collective number of undesirable species encountered and the approximate percent cover during general observations, quadrat sampling, raking, seining, and pitfall trapping.

*Percent Cover of Submergent Aquatic Vegetation (CANSAVCOV)* – the average percent cover of eelgrass collected from five randomly placed 1-meter quadrats in each SAV bed. This variable differs from richness in that percent cover is documented. The field team sampled known SAV locations from previous SAV studies by the District when the beds were located within 500 feet of the transect. Otherwise, the field team sampled within the 250-foot wide transect area below the LLW line. If no SAV was found within the 250-foot wide transect, the percent cover of submergent vegetation was recorded as zero.

*Average Width of Shoreline or Dune (WIDTH)* – the field team measured the linear distance that the centerlines of each transect traversed each community type. Suitability scores, which were based on linear distance and separate suitability indices (e.g., width criterion) were used to evaluate each community. In addition, because beach and dune characteristics can vary greatly over a broader area than that covered by HEP, elevation information from Light Detection and Ranging (LIDAR) data and engineering models were used to further refine the value for the average width of beaches and dunes in the general vicinity of the transect.

*Average Slope of Shoreline or Dune (SLOPE)* – the field team recorded the average slope of the VEGBEACH community and the average slope of the dune face in the DUNEGRASS community using a clinometer. Suitability scores were based on percent slope and separate suitability indices (e.g., slope criterion) were used to evaluate each community. As was the case with the width variable, information from LIDAR data and engineering models were used to further refine the value for the average slope of beaches and dunes in the general vicinity of the transect.

*Percent Cover of Vegetation (CANVEGCOV)* – the percent of vegetative cover within each zone of the 250-foot wide transect (based on a visual assessment of the average condition observed throughout the transect area) were recorded for the VEGBEACH and DUNEGRASS community types. Suitability scores were based on average percent cover throughout the community and separate suitability indices (e.g., percent cover criterion) were used to evaluate each community. All vegetation (e.g. herb, tree, shrub) was included collectively in the estimate of percent cover for these communities.

*Percent Cover of Shrubs and Trees (CANTRSSHRUB)* – the average percent cover of vegetative cover of shrubs and trees (based on a visual assessment of the average condition observed throughout the transect area) were recorded for the UPLAND community type. This differs from CANVEGCOV in that it applies only to the UPLAND community and did not include herbs.

*Presence of Human Disturbance* and *Magnitude of Impact From Human Disturbance (HUMFACTOR + HUMMAGNIT)* – the HEP Team identified a list of nine general disturbance factors that when present would reduce the quality of a community type. Disturbance factors included vehicle use, hard structures, major development, minor development, periodic maintenance, trash/debris, sources of pollution, active human use for recreation, and degraded due to filling, excavating or land clearing. The field team tallied the number of disturbance factors observed in each community type and ranked the magnitude of the disturbance. Ranking permitted the field team to account for varying effects from the disturbance. For example, in some areas only one disturbance factor may be noted, but the effects from that disturbance on the community may be severe. Alternately, some areas may have multiple disturbance factors, but the overall impacts are low.

*Presence of Impact of Barriers to Wildlife Passage (BARWILDLF)* – the HEP Team identified a variety of conditions that when present may restrict access for small to medium-sized wildlife species. Barriers included extremely dense vegetation that could preclude chicks or terrapins from passage (e.g., dense monocultures of *Phragmites*), curbs, walls, fences, development, steep banks, and roadways. The HEP Team tallied the number of barriers observed in each community and ranked the severity of the impact to wildlife as a result of the barriers. The HEP Team recognized that most wildlife species can navigate around structures, so the evaluation area for wildlife barriers was expanded to 500 feet to either side of the transect. For example, a building may cover much of the width of the 250-foot transect. However, species may have complete accessibility to other community types by navigating around the building. In this case, the building was not recorded as a major barrier to wildlife. The building was noted, but ranked as a minor impact. Alternately, a 4-foot tall fence extending for 1,500 feet along the shoreline was noted as a major wildlife barrier.

*Presence of Erosion (EROSION)* – the field team answered yes or no to this question based on visual evidence of erosion such as slumping banks, undercutting, gullies, obvious runoff or sedimentation observed within the 250-foot transect. The field team made no distinction between erosion resulting from natural or unnatural sources.

*Presence of Modified Shoreline (SHOREMOD)* – the field team answered yes or no to this question based on visual evidence of hard structures (e.g., groins, jetties, sea walls, bulkheads, marinas, docks) observed within 1,000 feet on either side of the transect.

*Availability of Appropriate Substrate (SUBSTRATE)* – based on visual observation, the HEP Team answered yes or no regarding the question of whether suitable substrate was present in the evaluation community. When answering, it was assumed that issues such as pavement, asphalt, etc. were addressed by the HUMFACTORS variable. This variable evaluated whether mudflat, sand, and soil substrates were appropriately placed. The intent of this variable was to ensure that an existing substrate type was not changed to a different substrate type as a result of a project (e.g., to avoid an existing area of cobble habitat becoming a sand beach).

## 5.0 HEP DATA ANALYSIS

The HEP field data were determined to be representative of the typical habitat conditions likely to be encountered in the six community types commonly found across the barrier island and therefore, the baseline data from the 21 data collection transects were used to evaluate some additional sites across the island. For example, HEP data collected along transects located in highly developed areas, such as Ocean Beach and Reagan, could be applied to other highly developed areas with similar characteristics, such as Davis Park, without having to revisit each location to collect additional HEP data. Therefore, the HEP data collected at the 21 representative locations along the barrier island were used to evaluate 18 restoration sites (Appendix A, Figure 4). Detailed descriptions of all proposed restoration activities are provided in Attachment I and conceptual restoration designs are provided in Attachment II.

**Table 2. Potential Restoration Site Locations**

| | | |
|---|---|---|
| Sunken Forest | Georgica Pond | Davis Park |
| Reagan Property | John Boyle Island | Atlantique to Corneille |
| Great Gun | New Made Island | Kismet |
| Tiana | East Inlet Island | Warner Island East |
| WOSI (West of Shinnecock Inlet) | Islip Meadows | Atlantique |
| Ocean Beach | Seatuck Refuge | Fair Harbor |

For consistency and to facilitate evaluation and modeling efforts, transect nomenclature for those transects from the original 21 HEP data collection transects was carried through the entire evaluation process. The resulting "gaps" in some HEP tables are a reflection of this. That is, original transect T-1 was excluded from further consideration as a potential restoration site at some point in the evaluation process; therefore, there is not a T-1 in the list of restoration sites within the text and appendices of this report. T-2, Sunken Forest, was selected as a potential restoration site and thus, references to this restoration site are made within the report and appendices.

The District compared the characteristics of each community found in the eight new sites with those from the original 21 HEP transects to select data from similar community types for use in the HEP analysis. Averages were used in cases where a community at the new site was similar in characteristics to the same community in more than one HEP transect. Appendix B, Table 5 provides a list of the restoration sites and the associated HEP data that was used to calculate the HSI scores for each. HEP analysis for the 18 restoration sites included baseline conditions, future conditions without restoration, and future conditions with restoration and included the calculation of HSI, HU, and AAHU scores as summarized below. Appendix G provides additional supporting analysis results.

## 5.1 BASELINE CONDITIONS

When calculating baseline conditions, the raw field data collected in 2004 at the HEP transect locations were entered into the FIMP HEP Curves database to generate the individual HSI scores for each variable. The resulting HSI variable scores from those HEP transects that corresponded to each restoration site (in accordance with Appendix B, Table 5) were then incorporated into the FIMP HEP Equations database. Scores for HSI variables were combined using the HSI model equations, as described in Section 2.4 to generate a final HSI score for each community type. The resulting HSI score, and acreage, for each habitat at baseline condition are input into the AAHU Generator spreadsheet for calculation of AAHUs. An example of this process is provided in Section 6.0, HEP Results. Attachment II provides a cover type maps depicting baseline conditions for each restoration site.

## 5.2 FUTURE CONDITIONS WITHOUT RESTORATION ACTION

Future estimates of habitat conditions in the Project area were calculated for each site by entering the raw field data into a modified FIMP HEP Curves database to generate the individual HSI scores for each variable in each community type. These HSI scores were then incorporated into a version of the FIMP HEP Equations database which had been modified to reflect HEP Team decisions regarding how a community might change over the 50-year life of the Project without a proposed activity as discussed in Section 2.4 and presented in Appendix B, Table 5. Modifications were made to the FIMP HSI model variables if the change in future condition was determined to directly affect the extent or quality of the variable or community. The resulting HSI score, and acreage, for each habitat anticipated under future conditions are input into the AAHU Generator spreadsheet for calculation of AAHUs. An example of this process is provided in Section 6.0, HEP Results.

## 5.3 FUTURE CONDITIONS WITH RESTORATION ACTION

The HEP Team developed three to four potential restoration alternatives for each of the 18 restoration sites as depicted on Figure 4 in Appendix A. Where feasible, restoration options were developed that support one or more of the five coastal processes and that targeted other restoration goals and objectives as identified in Section 1.3.1. In a dynamic and heavily populated area such as coastal Long Island, numerous constraints exist that restrict, and in some cases prohibit, otherwise desirable restoration goals and objectives from being met. Working within these constraints and with the underlying goal of identifying opportunities to improve the environmental conditions in the Project area, the District developed a diversity of restoration options for evaluation, and encouraged HEP Team input into the development of conceptual restoration design alternatives. However, the alternatives proposed are not necessarily supported by all members of the HEP Team and they have not been fully evaluated or supported by entities outside of the HEP Team. The designs presented and evaluated herein are conceptual in nature and are presented to evaluate and make comparisons between a range of possible scenarios that could be implemented to address restoration needs in the Project area.

The conceptual restoration designs and general description of proposed restoration alternatives for each site are presented in Table 3 and detailed in Attachment I (description of restoration alternatives) and Attachment II (conceptual restoration designs). Components of the restoration designs included the following: 1) habitat enhancements that would change HSI scores but not affect acreages; 2) habitat enhancements that would change HSI scores and affect acreages (some projects focus on developing natural processes or habitats that could alter existing HEP communities); 3) conversion of disturbed areas (non-HEP communities) into a HEP community.

Similar to the process followed for calculating the future without restoration conditions, the future with restoration scenarios were calculated for each site by first entering the raw field data into a modified FIMP HEP Curves database then incorporating the values from appropriate transects into a modified version of the FIMP HEP Equations database. However, in this case, the HEP Equations database was modified based on HEP Team input, professional judgment, and results from related studies, regarding the direct effect that restoration of a given location/community would have on the HSI model variables or community. Modifications were made to the HSI variable scores to account for assumed changes and were documented directly in the FIMP HEP Equations database for each alternative.

**Table 3. Restoration Sites and Proposed Restoration Alternatives.**

| Restoration Site | Restoration Transect and Alternative ID | Baseline Restoration Goal/Target |
|---|---|---|
| **T-2 Sunken Forest** | | |
| Alternative 1 | T-2-1 | stabilize eroding bayside shoreline |
| Alternative 2 | T-2-2 | enhance upper beach and dune |
| Alternative 3 | T-2-3 | enhance upland and interior dune areas |
| Alternative 4 | T-2-4 | remove marina |
| **T-3 Reagan Property** | | |
| Alternative 1 | T-3-1 | stabilize eroding bayside shoreline |
| Alternative 2 | T-3-2 | enhance upland and interior dune areas |
| Alternative 3 | T-3-3 | remove bulkhead along bayside shoreline |
| **T-5 Great Gun** | | |
| Alternative 1 | T-5-1 | enhance and expand existing salt marsh |
| Alternative 2 | T-5-2 | enhance upper beach and dune |
| Alternative 3 | T-5-3 | enhance upland and interior dune areas |
| Alternative 4 | T-5-4 | remove marina |
| **T-7 Tiana** | | |
| Alternative 1 | T-7-1 | stabilize bayside shoreline and enhance upper beach and dune |
| Alternative 2 | T-7-2 | enhance upland and interior dune areas |
| Alternative 3 | T-7-3 | enhance submergent aquatic vegetation beds |
| **T-8 WOSI** | | |
| Alternative 1 | T-8-1 | enhance and expand existing salt marsh |
| Alternative 2 | T-8-2 | enhance bay shoreline and upper beach and dune |
| Alternative 3 | T-8-3 | enhance upland and interior dune areas |
| Alternative 4 | T-8-4 | create salt marsh |
| **T-9 Georgica Pond** | | |
| Alternative 1 | T-9-1 | remove and control *Phragmites* along pond |
| Alternative 2 | T-9-2 | remove and control *Phragmites* in coves |
| Alternative 3 | T-9-3 | remove groins, enhance upper beach and dune |
| **T-10 East Inlet Island** | | |
| Alternative 1 | T-10-1 | create nesting habitat for shorebird species |
| Alternative 2 | T-10-2 | control *Phragmites* in salt marsh |
| Alternative 3 | T-10-3 | stabilize island shoreline |
| **T-11 John Boyle Island** | | |
| Alternative 1 | T-11-1 | create nesting habitat for shorebird species |
| Alternative 2 | T-11-2 | create habitat for heron species |
| Alternative 3 | T-11-3 | stabilize island shoreline |
| **T-14 Ocean Beach** | | |
| Alternative 1 | T-14-1 | remove hard structures on beach |
| Alternative 2 | T-14-2 | enhance upper beach and dune |
| Alternative 3 | T-14-3 | enhance upper beach and dune through buy outs |

| Restoration Site | Restoration Transect and Alternative ID | Baseline Restoration Goal/Target |
|---|---|---|
| **T-15 New Made Island** | | |
| Alternative 1 | T-15-1 | create nesting habitat for shorebird species |
| Alternative 2 | T-15-2 | create habitat for heron species |
| Alternative 3 | T-15-3 | stabilize island shoreline |
| **T-22 Islip Meadows** | | |
| Alternative 1 | T-22-1 | improve and manage hydrology in salt marsh |
| Alternative 2 | T-22-2 | reconfigure tidal channels in marsh |
| Alternative 3 | T-22-3 | create tidal pools and control *Phragmites* |
| **T-23 Seatuck Refuge** | | |
| Alternative 1 | T-23-1 | improve and manage hydrology in salt marsh |
| Alternative 2 | T-23-2 | reconfigure tidal channels in marsh |
| Alternative 3 | T-23-3 | remove bulkhead and restore salt marsh in footprint |
| **T-24 Davis Park** | | |
| Alternative 1 | T-24-1 | create dune |
| Alternative 2 | T-24-2 | enhance upper beach and dune |
| Alternative 3 | T-24-3 | enhance upper beach and dune through buy outs |
| **T-25 Atlantique to Corneille** | | |
| Alternative 1 | T-25-1 | create sand lobe on bayside |
| Alternative 2 | T-25-2 | create salt marsh bayside |
| Alternative 3 | T-25-3 | enhance upper beach, dune, and upland areas |
| **T-26 Kismet** | | |
| Alternative 1 | T-26-1 | enhance upper beach and dune |
| Alternative 2 | T-26-2 | enhance upper beach and dune through buy outs within the Coastal Erosion Hazard (CEHA) line |
| Alternative 3 | T-26-3 | enhance upper beach and dune through buy outs within 50 feet landward of CEHA line |
| **T-27 Warner Island East** | | |
| Alternative 1 | T-27-1 | create nesting habitat for shorebird species |
| Alternative 2 | T-27-2 | create habitat for heron species |
| Alternative 3 | T-27-3 | stabilize island shoreline |
| **T-28 Atlantique** | | |
| Alternative 1 | T-28-1 | enhance upper beach and dune |
| Alternative 2 | T-28-2 | enhance upper beach and dune through buy outs within the CEHA line |
| Alternative 3 | T-28-3 | enhance upper beach and dune through buy outs within 50 feet landward of CEHA line |
| **T-29 Fair Harbor** | | |
| Alternative 1 | T-29-1 | enhance upper beach and dune |
| Alternative 2 | T-29-2 | buy outs of structures within CEHA line and restoration of impacted area |
| Alternative 3 | T-29-3 | buy outs of structures within 50 feet landward of CEHA line and restoration of impacted area |

The changes in habitat quality or quantity anticipated as a result of restoration activities, were applied between TY1 and TY5 and were then assumed to remain constant through TY50. Additional target years to account for a decline in habitat conditions over time or an improvement in conditions due to maintenance activities are not included in the models. In this evaluation, is assumed that any maintenance events needed to ensure the habitat conditions at TY5 are maintained over the 50-year life of the Project (i.e., vegetation removal, invasive species control, beach renourishment, minimization of human impacts, etc.) would occur. It is recognized that should maintenance activities not occur, a general decrease in habitat quality would likely result over time and these conditions are not accounted for in the HEP method under the with-restoration scenario. Although management will be necessary to ensure long-term sustainability of restored sites, it is assumed that management activities will be funded by Project sponsors or funded under separate USACE authority.

The resulting HSI score, and acreage, for each habitat under future condition following various restoration alternatives are input into the AAHU Generator spreadsheet for calculation of AAHUs. An example of this process is provided in Section 6.0, HEP Results. Attachment II provides a cover type map depicting future restored conditions for potential restoration alternatives evaluated by the District for each site.

### 5.4 COST ESTIMATES

Conceptual cost estimates were developed for the conceptual restoration designs and are presented in Appendix H. Implementation costs for each restoration alternative were calculated based on general estimates of removal, regrading, fill material, well relocation, structure installation, excavation and material movement, invasive species control, planting and bioengineering, and other miscellaneous Project costs. All costs were adjusted to a “per acre” or “per each” cost, with notes and assumptions stated in the table. Costs were adjusted to acres to facilitate future cost-benefit analysis and incremental cost analysis for Project and restoration options. The following describes the derivation of cost estimates used in the calculation of costs. Costs were derived from R.S. Means Site Work & Landscape Cost Data 20th Edition (R.S. Means 2001) and based on previous assessments and restoration designs for USACE projects in New York and New Jersey (USACE 1998, 2001, 2003, 2004b, 2006c).

Removal costs include costs associated with removal and disposal of bulkheads, rubbish/debris, sod/plant material, building demolition, fencing, pavement, and riprap/groins. The following assumptions were included in the cost analysis:

1. Bulkhead removal costs are based on bulkhead installation costs, with the assumption that material and disposal costs would be roughly equivalent. Bulkhead removal costs per acre assume 208.71 linear feet (LF) per acre (i.e., 208.71 LF is the distance across one square acre, or the square root of 43,560 square feet in an acre).
2. Debris removal costs include rubbish/debris handling, machine loading into a

dump truck, hauling up to 2 miles to the dump, and dumping fees. This cost assumes 250 cubic yards (CY) of rubbish per acre.

3. Plant removal costs include removal of material by hand, hand loading into a dump truck, hauling up to 2 miles to the dump, and dumping fees. This cost assumes that a 1-foot of depth of plant material would need to be removed per acre, or 4,840 square yards (SY) (i.e., 1,613.33 CY per acre). Assuming 3 CY per ton, 537.78 tons of plant material would be removed and require disposal per acre.
4. Building demolition and disposal costs include costs to demolish and load building materials from a two family, two story, wooden frame house, haul materials up to 20 miles, and dispose of materials. This cost is per building demolished, and assumes 500 CY of building materials would be produced per building.
5. Fence removal costs are based on hand removal of wooden fencing, 4 to 6 feet high. This cost includes hand loading removed fencing into a dump truck, hauling up to 2 miles to the dump, and dumping fees. Fence removal costs assume there would be 208.71 LF of fencing per acre. Assuming a 6-foot high fence, that would equal 1,252.26 cubic feet per acre, or 46.38 CY per acre. Assuming 3 CY per ton, 15.46 tons of fencing would be removed and require disposal per acre.
6. Pavement removal costs include removal of pad sites and disposal, with up to a 5-mile haul. This cost assumes that the pavement is 1 foot deep, and is based on the fact that there are 4,840 SY per acre, or 1,613.33 CY per acre.
7. Groin/riprap removal costs are based on riprap placement costs, with the assumption that material and disposal costs would be roughly equivalent. Groin removal costs (per each) assume that an average groin is 5 feet wide, 30 feet long, and 20 feet deep (i.e., 3,000 cubic feet, or 111.11 CY).

Re-grading costs are for grading of new material or re-grading of existing material. This cost is based on the fact that there are 1,613.33 CY per acre and assuming a 1-foot depth of re-grading.

Fill material costs are based on data provided in the Dredged Material Management Plan for the Port of New York and New Jersey (DMMP) (USACE 2006c). The following assumptions were included in the cost analysis:

1. Sand fill will be used for beach/dune bird habitat creation. Sand fill costs are based on the DMMP projections for placement costs for the beneficial use of dredge material in bird habitat creation. This cost assumes the placement of material 1 foot in depth, and is based on the fact that there are 1,613.33 CY per acre.
2. Loam fill will be used for salt marsh creation/restoration. Loam fill costs are based on the DMMP projections for placement costs for the beneficial use of dredge material in marsh creation. This cost assumes that a combination of cap/cover and sub-fill material would be required.

Relocation costs are for the relocation of a domestic water supply well. This cost assumes that the relocated water supply well has a 24-inch diameter casing and 18-inch diameter screen, includes the gravel and casing, and is gravel packed to 40 feet deep.

Installation costs are included for culverts, tide gates, sand fences, and boardwalks. The following assumptions were included in the cost analysis:

1. Culvert/headwall costs are based on installing a cast-in-place, 48-inch diameter, concrete culvert, with 4–6-foot long wing walls. Costs are per each culvert/ headwall set-up, and include installation of headwalls on both ends of the culvert.
2. Flap gate costs are for the installation of one, 48-inch diameter, aluminum, hydraulic flap gate. Costs are per each unit installed.
3. Self-regulating tide gate costs are included for both a 24-inch and a 36-inch diameter gate. Costs are per each unit installed.
4. Sand fencing costs are based on cost estimates from previous District projects involving work in a coastal/dune environment (USACE 1998, 2001, 2003, 2004b). Sand fencing installation costs assume there will be 208.71 LF of sand fence installed per acre (i.e., 208.71 LF is the distance across one square acre, or the square root of 43,560 square feet in an acre).
5. Boardwalk/recreation access costs are based on cost estimates from previous District projects involving work in a coastal/dune environment (USACE 1998, 2001, 2003, 2004b). Costs are per each unit installed.

Excavation and material movement costs are included for creation of emergent/salt marsh habitat and subtidal/tidal creek habitat. These costs are based on tidal and subtidal excavation and material movement costs from a previous District project and all costs include an additional 10 percent for the operating contractors overhead and profit. Costs are presented for both onsite and offsite disposal of excavated material. The following assumptions were included in the cost analysis:

1. Costs are based on 2006 estimates and have not been adjusted to account for inflation, depreciation, etc.
2. Costs for creation of tidal elevations with offsite disposal are based on a base cost of $18/CY, and assumes that an average of 1 foot of thatch material is removed and requires offsite disposal.
3. Costs for creation of subtidal elevation with offsite disposal are based on a base cost of $18/CY assumes that an average of 3.7 feet of material is removed and requires offsite disposal.
4. Costs for creation of tidal/salt marsh elevations with onsite use of material are based on $5/CY excavation, $3/CY hauling, and $2/CY grading costs. This cost assumes that 1.1 feet of material is excavated and used onsite for filling old channels and plugging ditches.
5. Costs for creation of subtidal/tidal creek elevations with onsite use of material are based on $5/CY excavation, $3/CY hauling, and $2/CY grading costs. This cost

assumes that 3.7 feet of material is excavated and used onsite for filling old channels and plugging ditches.

Invasive species control costs include herbicide and manual removal treatments to control common reed (*Phragmites australis*). The following assumptions were included in the cost analysis:

1. Herbicide treatment costs are based on use of a glyphosate-based herbicide, such as Rodeo®, which is applied through a variety of means, potentially including broadcast aerial spraying from a helicopter, spraying from a low ground pressure vehicle, and backpack-type sprayers.
2. Manual removal costs assume the removal of an average of 1 foot of thatch material with offsite disposal of removed material. This cost is based on a base cost of $18/CY (2001 dollars) for thatch removal and offsite disposal.

Planting and bioengineering costs are based on contact with nursery and forestry suppliers with species-specific experience, and based on a review of pertinent literature. The following assumptions were included in the cost analysis:

1. Dune grass costs are based on information obtained from Pinelands Nursery & Supply for planting desirable dune grass species. Costs are based on planting 2–3 inch diameter plugs, 24 inches on center (i.e., 10,890 plants per acre).
2. Upland costs are based on information obtained from Pinelands Nursery & Supply, New England Wetland Plants, Inc., and Sylva Native Nursery and Seed Co. for planting desirable upland shrubs. Costs are based on planting seedlings that are 6–24 inches high, 10 feet on center (i.e., 436 plants per acre).
3. Bay Beach – Costs for emergent vegetation are based on information obtained from Pinelands Nursery & Supply for planting desirable emergent vegetation. Costs are based on planting 2-inch diameter plugs, 18 inches on center (i.e., 19,360 plants per acre).
4. Bay Beach – Costs for shrubs are based on information obtained from Pinelands Nursery & Supply for planting desirable shrubs. Costs are based on planting seedlings that are 6–24 inches high, either 6 feet or 10 feet on center (i.e., 1,210 or 436 plants per acre).
5. BaySub submerged aquatic vegetation (SAV) costs are based on published literature on harvesting eelgrass from a donor bed and transplanting it in a project site.
6. Bioengineering costs are based on using BioD-Mat 70 mats, measuring 13.1 feet wide by 83 feet long (120 square yards) to stabilize soils and minimize erosion. This cost assumes that 5 BioD-Mat 70 mats would be required to stabilize one acre, covering an area 26 feet wide by 208.71 feet long.
7. Supporting products include metal stakes for holding the bioengineering mats in place. This cost assumes that three boxes of 500 stakes will be needed to stabilize the mats per acre.

Other costs include mobilization and demobilization, contingency, engineering and design (E&D), and supervision and administration (S&A) costs. The following assumptions were included in the cost analysis:

1. Mobilization and demobilization costs are the costs for the initiation and cessation of activities at the site, including obtaining and transporting equipment, and the removal of temporary site features and equipment upon completion of the Project. Mobilization and demobilization costs are estimated to be 2 percent of the total Project cost.
2. Contingency costs are calculated as 20 percent of the total Project cost, to account for uncertainty in the final design and/or implementation of the restoration alternatives.
3. E&D and S&A costs are calculated as 15 percent of the total Project cost, including mobilization and demobilization, and contingency costs.

## 6.0 HEP RESULTS

This section presents the results of the HEP analysis for 57 conceptual restoration alternatives distributed at each of 18 restoration sites (i.e., transects). An example of the HEP process leading to the results is presented first, followed by presentation of the baseline HSI and HU results in Section 6.2. Section 6.3 includes HSI and HU results for the future-no action scenario, followed by HSI and HU results for the various proposed restoration alternatives (i.e., actions) in Section 6.4. Section 6.6 presents AAHU results for all sites.

The HSI and HU scores presented below provide the numeric values needed in AAHU calculations to determine net AAHUs gained or lost at a given site as a result of a proposed action. As stated previously, HSI scores and HUs are a direct reflection of a number of individual variables, including the baseline quality of a habitat, habitat size, anticipated future factors that may positively or negatively affect an area, and the type and magnitude of an activity proposed for an area. Therefore, because these factors vary by site and alternative, direct comparisons between HEP results at sites, without consideration of these underlying variables, run the risk of an “apples and oranges” type of comparison. However, HEP results are useful in showing which sites have overall highest or lowest current habitat quality, as well an indication of the changes in habitat quality and quantity anticipated for a given site over time should no action be taken. In addition, the future with-Project HSI and HU scores do provide an indication of which alternatives could yield a higher overall gain (or loss) in habitat quality and quantity. But, it should be kept in mind that the restoration and Project alternatives vary significantly in terms of the level of habitat impact/improvement, types of restoration, and size. For example, some of the alternatives presented are proposed for an extensive area of coverage (i.e., large number of acres). Thus, as expected, overall HUs for these alternatives are often far greater than other alternatives. As discussed previously, these baseline, future no-action, and future with-action are used in calculating net AAHU (net environmental benefit) and those numbers are combined with costs to determine which alternatives would provide the highest overall improvement to habitat quality and quantity for the level of costs expended.

Summaries of results of the HEP analysis for the restoration sites are provided in Appendix G. HSI results presented below are based on the average HSI score for each site (i.e., raw HSI score for all communities combined/number of communities). Acreages are based on the total acres of all communities in a given area. AAHUs are based on raw (i.e., not weighted, or averaged) HSI and HU values.

## 6.1 EXAMPLE OF THE AAHU CALCULATION PROCESS

As noted, AAHUs are the numeric output from HEP that shows the net gain or loss in habitat quality and quantity over time (i.e., from baseline conditions to 50 years) and is calculated for two scenarios; 1) future no-action – assuming that no action is taken at a site; and, 2) future with-action – assuming that a proposed action is taken. In the case of this evaluation, the actions evaluated include various restoration alternatives. Net AAHUs are produced by combining AAHU values for each community into an overall AAHU value for a proposed activity (with-action), and comparing this value to the no-action overall AAHU score. The Net AAHU score for each site represents the change in habitat quality and quantity at a site if a proposed action takes place. For example, generally speaking, according to the HEP HSI models used in this study, the bay shoreline in some areas will continue to erode at a rapid rate and thus if nothing interferes with this ongoing process, the BAYBEACH community's HSI and HU scores will decrease over time and would result in a relatively low AAHU. However, should the shoreline be stabilized and additional measures taken to improve the site conditions (i.e., plantings), the erosion would be minimized and habitat quality would be expected to improve and remain relatively stable over time. This would be expected to yield a relatively high AAHU. When comparing the no-action condition against the with-action condition, the resulting Net AAHU would show an improvement for this site. That is, habitat quality and quantity would be improved by taking the action to stabilize the shoreline versus taking no action at the site.

### 6.1.2 Step 1 - Calculate HSI Scores

Calculation of AAHUs begins with the input of field data that describes each community according to the variables identified for each community model (as identified in Appendix B, Table 2) into the HEP Curves and HEP Equation spreadsheets as described in Section 5.0. For example, the OCEANBEACH community includes field data related to six variables (described previously in Section 3.4): Presence of Modified Shoreline; Width of Cover Type (ft); Impact of Barriers to Wildlife Passage; Presence of Human Disturbance Factors; Magnitude of Impact From Human Disturbance (%); Suitability of Substrate for Given Area. Using the HEP Equations spreadsheet, data for these seven variables was incorporated into the HEP community model for OCEANBEACH to produce individual HSI scores for each variable, and then combined using the equations presented in Appendix B, Table 4 to produce and overall HSI score for the OCEANBEACH community.

### Calculate HSI Scores for each Model Variable

As an example, the baseline OCEANBEACH community data at Sunken Forest results in HSI scores as follows for each of the six variables (the range is 0.0 to 1.0, with 1.0 being highest or optimal condition).

| | |
|---|---|
| Presence of Modified Shoreline: | 1.00 |
| Width of Cover Type (ft.): | 0.60 |
| Impact of Barriers to Wildlife Passage: | 1.00 |
| Presence of Human Disturbance Factors: | 0.90 |
| Magnitude of Impact from Human Disturbance (%): | 0.70 |
| Suitability of Substrate for Given Area: | 1.0 |

**Calculate HSI Scores for Each Transect**

This process of incorporating raw data into community models was repeated for each of the six community types at each of the restoration sites, to determine community HSI scores for each community at each site. This process of raw data input into the HEP Curves spreadsheet for each variable and the calculation of HSI scores for each community using the HEP Equations spreadsheet was repeated for baseline conditions, future without Project conditions, and future with Project conditions. The baseline conditions represent the current condition of communities/habitats and the condition which future conditions are compared against, future without Project conditions represent the conditions of the communities should no restoration take place, and future with Project conditions represent the quality of communities should restoration efforts take place.

Continuing the example for Sunken Forest, **baseline (current) conditions**, community HSI scores are as follows:

| | |
|---|---|
| OCEANBEACH: | 0.55 |
| VEGBEACH: | 0.57 |
| DUNEGRASS: | 0.69 |
| BAYBEACH: | 0.20 |
| BAYSUBSAV: | 0.64 |
| UPLANDS: | 0.78 |

Sunken Forest, **future no-action conditions, (in other words, conditions on site in 50 years if no action is taken),** results in community HSI scores are as follows:

| | |
|---|---|
| OCEANBEACH: | 0.48 |
| VEGBEACH: | 0.52 |
| DUNEGRASS: | 0.39 |
| BAYBEACH: | 0.12 |
| BAYSUBSAV: | 0.51 |
| UPLANDS: | 0.42 |

Applying this same process at Sunken Forest for the **future (after 50 years) with restoration alternative 1**, conditions results in community HSI scores as follows:

| | |
|---|---|
| OCEANBEACH: | 0.54 |
| VEGBEACH: | 0.57 |

| | |
|---|---|
| DUNEGRASS: | 0.79 |
| BAYBEACH: | 0.55 |
| BAYSUBSAV: | 0.64 |
| UPLANDS: | 0.78 |

The difference in HSI scores between the baseline and future with-restoration alternative 1 conditions for the DUNEGRASS and BAYBEACH communities reflect the anticipated effects of the restoration activities at the Sunken Forest site, which include enhancing the eroding bayside shoreline and intertidal zone and removing approximately 210 LF of bulkhead material located west of the marina. Soft bioengineering structures and plantings would be utilized to stabilize the 900 LF of shoreline and minimize further erosion and loss of habitat. Therefore, the future HSI scores for the DUNEGRASS and BAYBEACH communities at this site as a result of the proposed restoration activities are greater than the baseline scores and scores should no action be taken, and thus results in an overall improvement to the habitat quality in this area over time. Detailed descriptions of all proposed restoration activities are provided in Attachment I and conceptual restoration designs are provided in Attachment II.

The raw HSI scores for each community are incorporated into AAHU calculations (that is, averages or weighted scores were not used) as documented in the AAHU tables provided in Appendix G.

#### 6.1.2 Step 2 - Calculate HU Scores

HSI scores represent habitat quality and do not factor in changes in the size of the habitat. To develop HUs, which incorporate habitat quantity, the HSI scores were multiplied by the acreages of each community type (from cover type mapping) at each restoration sites and for each alternative evaluated. For the Sunken Forest baseline condition, this results in a baseline of 59 HUs for the OCEANBEACH community (HSI score of 0.54 multiplied by 109 acres). These HU calculations were repeated for each community type at each of the restoration sites.

#### 6.1.3 Step 3 - Calculate AAHU Scores

As described in Section 3.0, for each community type, using the FIMP AAHU Generator spreadsheet, HU scores were then integrated over the time period being assessed (i.e., 50 years) to develop cumulative HUs, and then annualized to determine AAHUs. Net AAHUs are produced by combining AAHU values for each community into an overall AAHU value for a proposed activity (with-action), and comparing this value to the AAHUs under the no-action scenario. Net AAHUs provide the environment input needed to conduct a cost-benefit analysis of Project impacts and benefits, and thus are a key output of the HEP analysis.

Continuing the Sunken Forest example, the without-Project AAHU values (i.e., habitat conditions assuming existing trends in habitat quality and quantity continue uninterrupted over 50 years) and future with restoration alternative 1 AAHU values are presented in Table 4. The Net AAHU values for each community are also presented with a total net AAHU gain of 11.58 resulting from implementation of restoration alternative 1 at Sunken Forest. This gain is because of several factors:

1. Beach erosion at the site in the without Project condition, lowering the HU value of OCEANBEACH community because of smaller acreage and lower HSI value compared to the with-restoration condition. The HU value of the VEGBEACH community is also similarly lower because of a slightly lower HSI value.
2. Enhanced DUNEGRASS and BAYBEACH HU values because of higher HSI values stemming from the proposed activities in restoration alternative 1, described above and in Attachment I.
3. A lower HU value in the without Project condition of the UPLANDS community because of a degradation in the HSI value over the 50-year time period of the analysis.

**Table 4. AAHU Values at Sunken Forest Example.**

| Community | Without Project AAHU | Future with Restoration Alternative 1 AAHU | Net Gain in AAHU |
|---|---|---|---|
| OCEANBEACH | 53 | 59 | 6 |
| VEGBEACH | 3 | 3 | 0 |
| DUNEGRASS | 5 | 6 | 1 |
| BAYBEACH | 0 | 1 | 1 |
| BAYSUBSAV | 13 | 14 | 1 |
| UPLANDS | 9 | 12 | 3 |
| TOTAL | 83 | 95 | 12 |

This process is conducted for each restoration sites and alternatives to determine the net AAHU gain when comparing site conditions for future without restoration efforts, against future conditions with restoration efforts to identify the gain or loss in habitat quality over time between various proposed alternatives. Restoration AAHU results are provided in Section 6.5.

## 6.2 BASELINE RESULTS (EXISTING CONDITIONS) ALL RESTORATION SITES

Baseline scores represent the habitat quality (HSI) and quantity (HSI x acres) at each location at the time of field data collection. These values represent TY0 in the HEP method. For this evaluation, it is assumed that these baseline habitat conditions represent the year before the Projects targeted year of construction and that conditions at the time of construction will be similar to baseline conditions as evaluated in 2004 and 2005.

Following the process described in Section 6.1, Table 5 presents the baseline HSI and HU scores for all of the 18 restoration sites. When considering habitat quality (HSI scores) at the time of the analysis (2004), WOSI, Tiana, and Sunken Forest have the best habitat quality while Warner Island East, Ocean Beach, and New Made Island have the lowest overall habitat quality. However, when acres proposed for restoration are considered, the results for overall HU scores (HSI x acres) identify Seatuck, Davis Park, and WOSI as the sites with HUs. Although two of these sites did not score highest in habitat quality, the quantity of the habitat available offsets this.

**Table 5. Baseline HSI and HU Results for all Potential Restoration Sites.**

| Site | Acres | HSI | HU |
|---|---|---|---|
| Sunken Forest | 167.7 | 0.569 | 94.20 |
| Reagan Property | 117.1 | 0.440 | 57.80 |
| Great Gun | 152.8 | 0.466 | 75.50 |
| Tiana | 134.4 | 0.582 | 76.66 |
| WOSI | 210.1 | 0.508 | 167.11 |
| East Inlet Island | 164.6 | 0.310 | 82.42 |
| John Boyle Island | 106.5 | 0.310 | 53.52 |
| Ocean Beach | 206.2 | 0.293 | 36.73 |
| New Made Island | 42.5 | 0.288 | 20.89 |
| Georgica Pond | 1776.2 | 0.483 | 355.80 |
| Islip Meadows | 68.6 | 0.313 | 42.00 |
| Seatuck Refuge | 234.2 | 0.313 | 139.96 |
| Davis Park | 405.7 | 0.374 | 187.35 |
| Atlantique to Corneille | 188.7 | 0.374 | 87.68 |
| Kismet | 128.2 | 0.374 | 48.01 |
| Atlantique | 73.8 | 0.374 | 34.51 |
| Fair Harbor | 92.4 | 0.374 | 36.56 |
| Warner Island East | 30.5 | 0.235 | 16.09 |

### 6.3 FUTURE NO-ACTION CONDITIONS FOR ALL RESTORATION SITES

Future habitat conditions are then calculated for each restoration site by incorporating certain assumptions about how habitats may change over time, and re-calculating HSI and HU scores as described in Section 5.2. The various anticipated changes are applied to baseline conditions at TY5 then gradually increased through TY50 years and in accordance with future assumptions presented in Appendix B, Table 5, which include factors such as continued shoreline erosion, human disturbance, loss of vegetative cover, loss of dune and beach, etc. These results represent what is expected to happen to the baseline habitat quality (HSI) and quantity over a 50-year period assuming no intervention in the processes and factors currently affecting sites. Based on HSI scores alone (Table 6), if no future action is taken at the 18 restoration sites evaluated, Warner Island East, New Made, East Inlet, and John Boyle Islands would have the lowest HSI scores after 50 years. Similar to baseline conditions, WOSI, Tiana, and Sunken Forest would continue to have the highest scores.

**Table 6. Future No-action HSI and HU Scores for Restoration Sites.**

| Site | Acres | HSI | HU |
|---|---|---|---|
| Sunken Forest | 156.2 | 0.408 | 70.51 |
| Reagan Property | 109.4 | 0.287 | 42.71 |
| Great Gun | 139.8 | 0.323 | 54.77 |
| Tiana | 123.7 | 0.401 | 52.39 |
| WOSI | 193.4 | 0.345 | 109.49 |
| East Inlet Island | 163.5 | 0.171 | 55.90 |
| John Boyle Island | 106.9 | 0.171 | 35.94 |
| Ocean Beach | 196.1 | 0.195 | 31.52 |
| New Made Island | 41.9 | 0.168 | 13.27 |
| Georgica Pond | 1776.2 | 0.334 | 251.05 |
| Islip Meadows | 67.4 | 0.214 | 29.74 |
| Seatuck Refuge | 226.4 | 0.214 | 92.88 |
| Davis Park | 378.0 | 0.276 | 150.22 |
| Atlantique to Corneille | 174.5 | 0.276 | 67.91 |
| Kismet | 120.6 | 0.276 | 37.83 |
| Atlantique | 95.7 | 0.276 | 27.54 |
| Fair Harbor | 98.9 | 0.276 | 29.34 |
| Warner Island East | 46.3 | 0.177 | 10.53 |

## 6.4 FUTURE CONDITIONS WITH RESTORATION ACTIONS FOR RESTORATION SITES

Continuing with the HEP analysis for all restoration sites, HSI and HU scores are then calculated for future conditions assuming various restoration enhancements take place at each restoration site. For this evaluation, future habitat conditions were applied to baseline conditions at TY5 through TY50, and in accordance with anticipated changes based on professional judgment regarding anticipated affects on habitat quality from proposed actions, and data from field surveys and engineering models as described in Section 5.3. Restoration and Project designs used in this analysis are conceptual and intended only for use in HEP and for general comparisons of sites and various restoration and Project alternatives. Descriptions of the restoration sites and alternatives are presented in Attachment I and conceptual restoration designs are provided in Attachment II.

Table 7 presents the future with-action HSI and HU scores at restoration sites for various conceptual restoration alternatives considered for the Project area. Results indicate similar ranking as the baseline and no-action scenarios for the sites with highest HUs and include Georgica Pond, Seatuck Refuge, and Davis Park. Under the scenarios for alternative 1, Warner Island East, New Made Island, and Reagan Property have the lowest HUs. Results for alternative 2 are similar and include Warner Island East and New Made Island, but Islip Meadows replaces the Reagan Property as one of the three lowest scoring sites (Table 7). The rankings for three lowest scoring sites under alternative 3 are the same as with alternative 1 (Table 7).

**Table 7. Future With-action HSI and HU Scores for Restoration Alternatives.**

| | HSI | | | | | HU | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Alternative 1** | **Alternative 2** | **Alternative 3** | **Alternative 4** | **Acres** | **Alternative 1** | **Alternative 2** | **Alternative 3** | **Alternative 4** |
| Sunken Forest | 0.647 | 0.637 | 0.632 | 0.749 | 167.7 | 94.98 | 98.68 | 103.73 | 106.64 |
| Reagan Property | 0.499 | 0.559 | 0.552 | | 117.1 | 58.09 | 62.33 | 60.91 | |
| Great Gunn | 0.499 | 0.550 | 0.588 | 0.683 | 152.8 | 77.70 | 82.49 | 88.30 | 92.81 |
| Tiana | 0.706 | 0.703 | 0.621 | | 134.4 | 83.47 | 82.09 | 81.95 | |
| WOSI | 0.544 | 0.613 | 0.596 | 0.534 | 210.1 | 172.19 | 176.14 | 174.65 | 172.74 |
| East Inlet Island | 0.417 | 0.341 | 0.370 | | 164.6 | 87.96 | 95.02 | 100.54 | |
| John Boyle Island | 0.453 | 0.405 | 0.370 | | 106.5 | 61.58 | 55.78 | 61.86 | |
| Ocean Beach | 0.408 | 0.385 | 0.421 | | 206.2 | 69.47 | 39.59 | 33.26 | |
| New Made Island | 0.373 | 0.383 | 0.348 | | 42.5 | 21.62 | 21.49 | 21.30 | |
| Georgica Pond | 0.532 | 0.524 | 0.670 | | 1776.2 | 401.51 | 393.58 | 445.42 | |
| Islip Meadows | 0.328 | 0.318 | 0.328 | | 68.6 | 46.08 | 43.11 | 45.88 | |
| Seatuck Refuge | 0.328 | 0.328 | 0.326 | | 234.2 | 151.83 | 151.21 | 147.63 | |
| Davis Park | 0.411 | 0.519 | 0.449 | | 405.7 | 189.46 | 194.79 | 189.93 | |
| Atlantique to Corneille | 0.374 | 0.426 | 0.472 | | 188.7 | 86.79 | 89.21 | 93.30 | |
| Kismet | 0.439 | 0.479 | 0.467 | | 128.16 | 48.98 | 50.19 | 49.50 | |
| Atlantique | 0.439 | 0.479 | 0.467 | | 73.75 | 35.34 | 35.94 | 35.72 | |
| Fair Harbor | 0.439 | 0.475 | 0.467 | | 92.42 | 37.32 | 38.17 | 38.66 | |
| Warner Island East | 0.338 | 0.394 | 0.210 | | 30.46 | 17.84 | 19.03 | 15.86 | |

### 6.5 AAHU SUMMARY

The HSI and HU values for baseline, future no-action, and future with restoration conditions are combined to determine AAHUs for each restoration alternative. AAHUs are essentially the average increase in habitat units realized by implementing restoration actions (i.e., difference between baseline and future no-action conditions compared to baseline and future with action conditions).

As noted in Section 5.0. several spreadsheets are used in the analysis of raw field data and the calculation of HSI scores for each restoration site and alternative. However, it is the FIMP AAHU Generator spreadsheet that is used to combine the resulting baseline, future no-action, and future with restoration HSI scores and acreages for the final calculation of AAHUs and Net AAHUs. The actual output tables from the FIMP AAHU Generator spreadsheet are provided in Appendix G, HEP Analysis Results.

Table 8 presents the net AAHUs for future conditions at each restoration site, which are calculated by subtracting the AAHUs for each community without restoration activities from the AAHUs for each community with restoration.

Sites with the highest number of net AAHUs gained from Alternative 1 include Georgica Pond (90.1 AAHUs), Ocean Beach (33.03 AAHUs), and Seatuck Refuge (32.64 AAHUs). AAHU summaries for restoration sites are also presented in Appendix G.

Highest AAHUs for Alternative 2 (Table 8) include Georgica Pond (82.65 AAHUs), WOSI (34.98 AAHUs), and Seatuck Refuge (31.88 AAHUs). AAHU summaries for restoration sites are also presented in Appendix G.

Highest AAHUs for Alternative 3 (Table 8) include Georgica Pond (132.96 AAHUs), WOSI (33.54) AAHUs), and East Inlet Island (29.06 AAHUs). AAHU summaries for restoration sites are also presented in Appendix G.

**Table 8. Average Annualized Habitat Unit Results.**

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Net Gain in AAHU Rank | Restoration Target |
|---|---|---|---|---|---|
| Georgica Pond | T-9 | 3 | 132.96 | 1 | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, replacing the dune at the open cut, removing all groins, and installing a tide gate to manage tidal flow |
| Georgica Pond | T-9 | 1 | 90.10 | 2 | Control *Phragmites* in Georgica Pond by manually removing *Phrag.* and lowering elevations along the shoreline to improve tidal flow, and spot planting of native marsh species |
| Georgica Pond | T-9 | 2 | 82.65 | 3 | Control *Phragmites* in coves adjacent to Georgica Pond by manually removing *Phrag.* and lowering elevations along the shoreline to improve tidal flow and spot planting native salt marsh species in excavated areas |
| WOSI | T-8 | 2 | 34.98 | 4 | Reduce disturbance on site by raising the existing oceanside boardwalk and restoring the dune, regrading the bayside shoreline slope and filling existing cuts, and placing a walkover at the existing bayside shoreline access cut, plant as needed to stabilize |
| WOSI | T-8 | 4 | 33.54 | 5 | Create new salt marsh in the area located to the west of the existing parking lot by lowering elevations of upland areas, making a cut in the bay shoreline to introduce tidal flow, and planting native salt marsh species |
| WOSI | T-8 | 3 | 33.54 | 6 | Remove asphalt parking lot to reduce impervious surface, remove existing walkway on oceanside, regrade site to natural contours, plant as needed to stabilize |
| Ocean Beach | T-14 | 1 | 33.03 | 7 | Remove groins and relocate water supply well, regrade as needed to stabilize |
| Seatuck Refuge | T-23 | 1 | 32.64 | 8 | Restore hydrologic connection by excavating and removing existing undersized culverts, install larger culverts, control *Phragmites* using hydrology, convert disturbed areas to salt marsh by removing fill material and planting |
| Seatuck Refuge | T-23 | 2 | 31.88 | 9 | Excavate site as needed to reconfigure existing tidal channels, control *Phragmites* with herbicides |
| WOSI | T-8 | 1 | 31.31 | 10 | Enhance the existing salt marsh through the use of herbicides to control *Phragmites* |
| East Inlet Island | T-10 | 3 | 29.06 | 11 | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| Seatuck Refuge | T-23 | 3 | 28.7 | 12 | Remove bulkhead along small inlet, regrade shoreline, stabilize shoreline using coir log bio-engineering, and restore marsh through plantings |
| Davis Park | T-24 | 2 | 23.98 | 13 | Enhance upper beach/dune slope, width, and height throughout the site, raise existing walkovers, plant as needed to stabilize |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Net Gain in AAHU Rank | Restoration Target |
|---|---|---|---|---|---|
| East Inlet Island | T-10 | 2 | 23.88 | 14 | Control *Phragmites* throughout island using herbicides |
| Great Gunn | T-5 | 4 | 21.54 | 15 | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with coir log bio-engineering and plantings |
| Great Gunn | T-5 | 3 | 21.54 | 16 | Restore interior upland and dune areas of the site to natural conditions by removing most hard structures, removing boardwalks and dune walk overs, closing off and regrading most disturbed areas/roads/trails (except one to provide access from marina) |
| Davis Park | T-24 | 3 | 19.39 | 17 | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas, restore portions of disturbed upland surrounding marina, plant disturbed areas. |
| Davis Park | T-24 | 1 | 18.96 | 18 | Add sand fill to restore dune and beach at large vehicle access cut, plant as needed to stabilize |
| Sunken Forest | T-2 | 4 | 18.27 | 19 | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, add fill as needed, stabilize with coir log bio-engineering and plantings |
| Sunken Forest | T-2 | 3 | 18.27 | 20 | Restore interior upland and dune areas of the site to more natural conditions by removing most hard structures, boardwalks and dune walk overs, and closing off and regrading many of the existing disturbed areas/roads/trails (except one to provide access from marina) |
| Tiana | T-7 | 1 | 17.36 | 21 | Restore salt marsh by removing fill material, using herbicide to control *Phragmites*, regrading and replanting bay shoreline. Restore dune at access cut and provide access by installing a wooden dune walkover. |
| East Inlet Island | T-10 | 1 | 17.24 | 22 | Regrade portions of dunegrass to remove *Phragmites* and dense vegetation and create conditions more favorable for shorebird nesting |
| Tiana | T-7 | 2 | 16.22 | 23 | Remove parking lot to reduce impervious surface on site, regrade to natural contours, plant a portion of the site to stabilize and reduce parking area size |
| Tiana | T-7 | 3 | 16.14 | 24 | Plant existing SAV beds |
| Great Gunn | T-5 | 2 | 16.09 | 25 | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create dune walkover, and restore dune at access areas and cuts |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Net Gain in AAHU Rank | Restoration Target |
|---|---|---|---|---|---|
| John Boyle | T-11 | 3 | 15.76 | 26 | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| John Boyle Island | T-11 | 1 | 15.50 | 27 | Regrade portions of the dunegrass community to remove dense vegetation to create shorebird nesting habitat, control *Phragmites* throughout site |
| Atlantique to Corneille Estates | T-25 | 3 | 15.05 | 28 | Enhance upper beach/dune slope, height, and width throughout site, reduce human disturbance by closing off some access roads/trails, add topsoil to facilitate upland creation in disturbed areas, plant site as needed to stabilize |
| Sunken Forest | T-2 | 2 | 14.26 | 29 | Enhance upper beach/dune width/slope/height, reduce disturbance by raising the existing boardwalks to create a dune walkover, and restoring dune at cuts |
| Great Gunn | T-5 | 1 | 11.74 | 30 | Enhance salt marsh by restoring hydrologic connection via culvert beneath the road, excavate as needed to achieve desired elevation, add culvert, restore road access, plant as needed to stabilize |
| Sunken Forest | T-2 | 1 | 11.58 | 31 | Remove bulkhead adjacent to marina, regrade shoreline and stabilize using bio-engineering, control *Phragmites* |
| Reagan Property | T-3 | 2 | 11.10 | 32 | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create a dune walkover and restore dune at cuts |
| Atlantique to Corneille Estates | T-25 | 2 | 10.60 | 33 | Create new salt marsh by regrading upland areas and bay shoreline, plant native salt marsh species |
| John Boyle | T-11 | 2 | 10.04 | 34 | Grade and add topsoil to convert portions of dunegrass to tree covered upland habitat for heron species, regrade a portion of shoreline to promote wildlife access, plant as needed to stabilize |
| Reagan Property | T-3 | 3 | 9.80 | 35 | Bury bulkhead, regrade shoreline and create intertidal area, add fill as needed, stabilize shoreline using bio-engineering |
| Islip Meadows | T-22 | 1 | 9.40 | 36 | Restore hydrologic connection by excavating to remove sediment, install two flap gates to manage tidal flow |
| Islip Meadows | T-22 | 3 | 9.21 | 37 | Plug ditches and create tidal pools, excavate site as needed to achieve desired elevations of pool and obtain plug material, *Phragmites* control using herbicides |
| Atlantique to Corneille Estates | T-25 | 1 | 8.13 | 38 | Deposit sediment and regrade area to create bayside sand bar |
| Reagan Property | T-3 | 1 | 7.16 | 39 | Regrade eroding bayside shoreline and stabilize using bio-engineering (vegetated gabions) |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Net Gain in AAHU Rank | Restoration Target |
|---|---|---|---|---|---|
| Kismet | T-26 | 2 | 6.83 | 40 | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Islip Meadows | T-22 | 2 | 6.61 | 41 | Excavate marsh to reconfigure existing tidal channels |
| Kismet | T-26 | 3 | 6.07 | 42 | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Ocean Beach | T-14 | 3 | 5.71 | 43 | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas |
| Kismet | T-26 | 1 | 5.55 | 44 | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Fair Harbor | T-29 | 3 | 5.27 | 45 | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Warners Island East | T-27 | 2 | 5.17 | 46 | Enlarge island size and create heron nesting habitat by filling baybeach areas, add topsoil and plant as needed |
| Ocean Beach | T-14 | 2 | 5.03 | 47 | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, raising boardwalks above dunes and restoring dune, plant as needed to stabilize |
| Fair Harbor | T-29 | 2 | 4.95 | 48 | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Atlantique | T-28 | 2 | 4.65 | 49 | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Atlantique | T-28 | 3 | 4.33 | 50 | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| New Made Island | T-15 | 1 | 4.14 | 51 | Fill existing *Phragmites*-dominated baybeach to control *Phragmites* and create open dune habitat favorable for shorebird nesting, regrade a portion of shoreline to promote wildlife access |
| Warners Island East | T-27 | 1 | 4.10 | 52 | Enlarge island size and create shorebird nesting habitat by filling baybeach areas and planting |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Net Gain in AAHU Rank | Restoration Target |
|---|---|---|---|---|---|
| New Made Island | T-15 | 2 | 4.02 | 53 | Add topsoil to existing dunegrass community to create tree covered upland habitat for heron |
| Fair Harbor | T-29 | 1 | 4.01 | 54 | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Atlantique | T-28 | 1 | 3.95 | 55 | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| New Made Island | T-15 | 3 | 3.85 | 56 | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |
| Warners Island East | T-27 | 3 | 2.28 | 57 | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |

## 7.0 INCREMENTAL COST ANALYSIS

In the HEP results presented above, it may first appear that the most desirable restoration alternative(s) would be those alternatives that provide the highest overall gain in AAHUs over time. Thus, based on the information in Table 8 alone, the most favorable locations for restoration activities would be at Georgica Pond, Great Gun, East Inlet Island, or Seatuck. However, these habitat improvements come at a cost that must be considered when evaluating restoration or Project components to determine which alternatives provide the best benefit for the cost expended. To accomplish this, the District conducted a CE/ICA to determine the cost associated with each incremental gain in habitat quality.

Using the CE/ICA process, estimates of Project cost (Conceptual Costs for Proposed Restoration Activities, Appendix H) and projected environmental output (AAHUs, Appendix G) are developed for each potential alternative for each site. A cost effectiveness analysis is conducted to identify the lowest cost alternative for each possible level of habitat output. Then an incremental cost analysis is performed to reveal changes in cost relative to increasing levels of environmental output.

In an attempt to use the cost analysis to facilitate development and selection of a plan for the Project the District considered conducting the CE/ICA using the following three approaches:

1. individual alternatives (57 results);
2. combinations of alternatives at a given site (126 results); and,
3. combinations of alternatives across sites (thousands of results).

In evaluating the results from the three approaches, the District and HEP Team decided to use the results from the simplified first approach to facilitate discussion and evaluation of the restoration alternatives. This decision was further supported by the assumption that each individual cost-effective alternative could reasonably be combined with any other cost-effective alternative to create a restoration plan that would meet the restoration goals and objectives identified in Section 1.3.1 of this report as well as the District's NER goals and objectives in accordance with Federal planning guidelines. This approach allowed for more flexibility in plan selection as several other selection factors remained to be considered.

A CE/ICA was undertaken for the 57 restoration alternatives and are summarized in Table 9 and details are presented in Appendix I. For each site, and each alternative, the HEP results (net AAHUs) and restoration cost estimates for each alternative were input into the IWR-Plan, which is the Corps software used for the analysis (USACE-IWR 2005). The outputs from the IWR-Plan identify the cost-effective, moderately cost-effective, and not cost-effective alternatives, and the comparison of incremental costs. In summary, of the 57 alternatives evaluated by the District, 34 alternatives were determined to be cost-effective, seven to be moderately cost-effective, and 16 to not be cost-effective (Table 9). Breakpoints in the annual cost per net AAHU were observed at $2,500 and $5,000 with plans above $5,000 per net AAHU not supported. In accordance with USACE planning guidelines, the 41 cost-effective and moderately cost-effective alternatives are viable options that could be supported under the NER plan and combined with SDR actions as the preferred NED+NER plan for the FIMP Project.

**Table 9. Cost Effectiveness and Incremental Cost Analysis Results.**

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Annual Cost /Net AAHU | CE/ICA Rank | Cost-Effectiveness | Restoration Target |
|---|---|---|---|---|---|---|---|
| WOSI | T-8 | 1 | 31.31 | $17.24 | 1 | Cost-effective | Enhance the existing salt marsh through the use of herbicides to control *Phragmites* |
| East Inlet Island | T-10 | 2 | 23.88 | $40.19 | 2 | Cost-effective | Control *Phragmites* throughout island using herbicides |
| WOSI | T-8 | 3 | 33.54 | $57.90 | 3 | Cost-effective | Remove asphalt parking lot to reduce impervious surface, remove existing walkway on oceanside, regrade site to natural contours, plant as needed to stabilize |
| Tiana | T-7 | 2 | 16.22 | $59.74 | 4 | Cost-effective | Remove parking lot to reduce impervious surface on site, regrade to natural contours, plant a portion of the site to stabilize and reduce parking area size |
| John Boyle Island | T-11 | 1 | 15.50 | $125.21 | 5 | Cost-effective | Grade and add topsoil to convert portions of dunegrass to tree covered upland habitat for heron species, regrade a portion of shoreline to promote wildlife access, plant as needed to stabilize |
| Davis Park | T-24 | 1 | 18.96 | $155.78 | 6 | Cost-effective | Add sand fill to restore dune and beach at large vehicle access cut, plant as needed to stabilize |
| Tiana | T-7 | 3 | 16.14 | $172.78 | 7 | Cost-effective | Plant existing SAV beds |
| East Inlet Island | T-10 | 1 | 17.24 | $185.43 | 8 | Cost-effective | Regrade portions of dunegrass to remove *Phragmites* and dense vegetation and create conditions more favorable for shorebird nesting |
| WOSI | T-8 | 2 | 34.98 | $239.12 | 9 | Cost-effective | Reduce disturbance on site by raising the existing oceanside boardwalk and restoring the dune, regrading the bayside shoreline slope and filling existing cuts, and placing a walkover at the existing bayside shoreline access cut, plant as needed to stabilize |
| Tiana | T-7 | 1 | 17.36 | $345.04 | 10 | Cost-effective | Restore salt marsh by removing fill material, using herbicide to control *Phragmites*, regrading and replanting bay shoreline. Restore dune at access cut and provide access by installing a wooden dune walkover |
| John Boyle Island | T-11 | 3 | 15.76 | $392.90 | 11 | Cost-effective | Regrade portions of the dunegrass community to remove dense vegetation to create shorebird nesting habitat, control *Phragmites* throughout site |
| Great Gunn | T-5 | 1 | 11.74 | $408.16 | 12 | Cost-effective | Enhance salt marsh by restoring hydrologic connection via culvert beneath the road, excavate as needed to achieve desired elevation, add culvert, restore road access, plant as needed to stabilize |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Annual Cost /Net AAHU | CE/ICA Rank | Cost-Effectiveness | Restoration Target |
|---|---|---|---|---|---|---|---|
| Great Gunn | T-5 | 2 | 16.09 | $412.46 | 13 | Cost-effective | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create dune walkover, and restore dune at access areas and cuts |
| Islip Meadows | T-22 | 3 | 9.21 | $414.91 | 14 | Cost-effective | Plug ditches and create tidal pools, excavate site as needed to achieve desired elevations of pool and obtain plug material, *Phragmites* control using herbicides |
| John Boyle Island | T-11 | 2 | 10.04 | $444.84 | 15 | Cost-effective | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| East Inlet Island | T-10 | 3 | 29.06 | $512.08 | 16 | Cost-effective | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| Atlantique to Corneille | T-25 | 2 | 10.60 | $562.23 | 17 | Cost-effective | Create new salt marsh by regrading upland areas and bay shoreline, plant native salt marsh species |
| Great Gunn | T-5 | 3 | 21.54 | $714.93 | 18 | Cost-effective | Restore interior upland and dune areas of the site to natural conditions by removing most hard structures, removing boardwalks and dune walk overs, closing off and regrading most disturbed areas/roads/trails (except one to provide access from marina) |
| Reagan Property | T-3 | 1 | 7.16 | $784.03 | 19 | Cost-effective | Regrade eroding bayside shoreline and stabilize using bio-engineering (vegetated gabions) |
| Seatuck Refuge | T-23 | 1 | 32.64 | $943.72 | 20 | Cost-effective | Restore hydrologic connection by excavating and removing existing undersized culverts, install larger culverts, control *Phragmites* using hydrology, convert disturbed areas to salt marsh by removing fill material and planting |
| Islip Meadows | T-22 | 1 | 9.40 | $953.80 | 21 | Cost-effective | Restore hydrologic connection by excavating to remove sediment, install two flap gates to manage tidal flow |
| Georgica Pond | T-9 | 2 | 82.65 | $955.15 | 22 | Cost-effective | Control *Phragmites* in coves adjacent to Georgica Pond by manually removing Phrag and lowering elevations along the shoreline to improve tidal flow and spot planting native salt marsh species in excavated areas |
| Reagan Property | T-3 | 3 | 9.80 | $971.36 | 23 | Cost-effective | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create a dune walkover and restore dune at cuts |
| Sunken Forest | T-2 | 1 | 11.58 | $1,001.36 | 24 | Cost-effective | Remove bulkhead adjacent to marina, regrade shoreline and stabilize using bio-engineering, control *Phragmites* |
| New Made Island | T-15 | 3 | 3.85 | $1,178.21 | 25 | Cost-effective | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Annual Cost /Net AAHU | CE/ICA Rank | Cost-Effectiveness | Restoration Target |
|---|---|---|---|---|---|---|---|
| New Made Island | T-15 | 2 | 4.02 | $1,185.22 | 26 | Cost-effective | Add topsoil to existing dunegrass community to create tree covered upland habitat for heron |
| Georgica Pond | T-9 | 3 | 132.96 | $1,225.69 | 27 | Cost-effective | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, replacing the dune at the open cut, removing all groins, and installing a tide gate to manage tidal flow |
| Atlantique to Corneille | T-25 | 3 | 15.05 | $1,423.60 | 28 | Cost-effective | Enhance upper beach/dune slope, height, and width throughout site, reduce human disturbance by closing off some access roads/trails, add topsoil to facilitate upland creation in disturbed areas, plant site as needed to stabilize |
| Sunken Forest | T-2 | 2 | 14.26 | $1,487.98 | 29 | Cost-effective | Enhance upper beach/dune width/slope/height, reduce disturbance by raising the existing boardwalks to create a dune walkover, and restoring dune at cuts |
| Reagan Property | T-3 | 2 | 11.10 | $1,533.34 | 30 | Cost-effective | Bury bulkhead, regrade shoreline and create intertidal area, add fill as needed, stabilize shoreline using bio-engineering |
| WOSI | T-8 | 4 | 33.54 | $1,576.30 | 31 | Cost-effective | Create new salt marsh in the area located to the west of the existing parking lot by lowering elevations of upland areas, making a cut in the bay shoreline to introduce tidal flow, and planting native salt marsh species |
| Great Gunn | T-5 | 4 | 21.54 | $1,664.93 | 32 | Cost-effective | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with coir log bio-engineering and plantings |
| New Made Island | T-15 | 1 | 4.14 | $1,851.73 | 33 | Cost-effective | Fill existing *Phragmites*-dominated baybeach to control *Phragmites* and create open dune habitat favorable for shorebird nesting, regrade a portion of shoreline to promote wildlife access |
| Seatuck Refuge | T-23 | 3 | 28.70 | $2,024.99 | 34 | Cost-effective | Remove bulhead along small inlet, regrade shoreline, stabilize shoreline using coir log bio-engineering, and restore marsh through plantings |
| Davis Park | T-24 | 3 | 19.39 | $2,570.02 | 35 | Moderately Cost-effective | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas, restore portions of disturbed upland surrounding marina, plant disturbed areas. |
| Davis Park | T-24 | 2 | 23.98 | $2,920.83 | 36 | Moderately Cost-effective | Enhance upper beach/dune slope, width, and height throughout the site, raise existing walkovers, plant as needed to stabilize |
| Atlantique to Corneille | T-25 | 1 | 8.13 | $3,501.39 | 37 | Moderately Cost-effective | Deposit sediment and regrade area to create bayside sand bar |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Annual Cost /Net AAHU | CE/ICA Rank | Cost-Effectiveness | Restoration Target |
|---|---|---|---|---|---|---|---|
| Georgica Pond | T-9 | 1 | 90.10 | $4,391.79 | 38 | Moderately Cost-effective | Control *Phragmites* in Georgica Pond by manually removing *Phrag.* and lowering elevations along the shoreline to improve tidal flow, and spot planting of native marsh species |
| Sunken Forest | T-2 | 3 | 18.27 | $4,537.77 | 39 | Moderately Cost-effective | Restore interior upland and dune areas of the site to more natural conditions by removing most hard structures, boardwalks and dune walk overs, and closing off and regrading many of the existing disturbed areas/roads/trails (except one to provide access from marina) |
| Kismet | T-26 | 1 | 5.55 | $4,740.70 | 40 | Moderately Cost-effective | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Sunken Forest | T-2 | 4 | 18.27 | $4,904.86 | 41 | Moderately Cost-effective | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, add fill as needed, stabilize with coir log bio-engineering and plantings |
| Ocean Beach | T-14 | 2 | 5.03 | $5,072.46 | 42 | Not Cost-effective | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, raising boardwalks above dunes and restoring dune, plant as needed to stabilize |
| Atlantique | T-28 | 1 | 3.95 | $5,097.12 | 43 | Not Cost-effective | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Seatuck Refuge | T-23 | 2 | 31.88 | $5,532.47 | 44 | Not Cost-effective | Excavate site as needed to reconfigure existing tidal channels, control *Phragmites* with herbicides |
| Fair Harbor | T-29 | 1 | 4.01 | $5,950.56 | 45 | Not Cost-effective | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Warner Island East | T-27 | 2 | 5.17 | $6,808.58 | 46 | Not Cost-effective | Enlarge island size and create heron nesting habitat by filling baybeach areas, add topsoil and plant as needed |
| Ocean Beach | T-14 | 1 | 33.03 | $9,884.68 | 47 | Not Cost-effective | Remove groins and relocate water supply well, regrade as needed to stabilize |
| Warner Island East | T-27 | 1 | 4.10 | $10,821.61 | 48 | Not Cost-effective | Enlarge island size and create shorebird nesting habitat by filling baybeach areas and planting |
| Warner Island East | T-27 | 3 | 2.28 | $14,479.33 | 49 | Not Cost-effective | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |

| Site Name | HEP Transect ID | Alternative Number | Net Gain in AAHUs | Annual Cost /Net AAHU | CE/ICA Rank | Cost-Effectiveness | Restoration Target |
|---|---|---|---|---|---|---|---|
| Kismet | T-26 | 3 | 6.07 | $24,980.53 | 50 | Not Cost-effective | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Islip Meadows | T-22 | 2 | 6.61 | $26,935.40 | 51 | Not Cost-effective | Excavate marsh to reconfigure existing tidal channels |
| Ocean Beach | T-14 | 3 | 5.71 | $28,789.06 | 52 | Not Cost-effective | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas |
| Atlantique | T-28 | 2 | 4.65 | $34,367.69 | 53 | Not Cost-effective | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Kismet | T-26 | 2 | 6.83 | $53,895.02 | 54 | Not Cost-effective | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Fair Harbor | T-29 | 2 | 4.95 | $83,032.07 | 55 | Not Cost-effective | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Fair Harbor | T-29 | 3 | 5.27 | $177,197.84 | 56 | Not Cost-effective | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Atlantique | T-28 | 3 | 4.33 | $187,706.64 | 57 | Not Cost-effective | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |

## 8.0 RESTORATION SITE EVALUATION AND RANKING

As noted, HEP was used to document existing site conditions and to evaluate potential environmental impacts and benefits for 57 proposed restoration alternatives at 18 potential restoration sites across the Project area (18 restoration sites, three to four alternatives per site). HEP provided a general numeric output (i.e., net AAHU) that measures changes in habitat quality and quantity over a specified evaluation period. To further the evaluation of the restoration alternatives, these outputs were then combined with conceptual cost estimates for each alternative using IWR software and the cost analysis methods as described in Section 7.0 to determine environmental gains per unit cost for proposed restoration activities, and provide a standardized method for the comparative evaluations of sites and restoration options.

The CE/ICA analysis will not wholly determine the “best” restoration alternative, but it does provide a tool for determining how to accomplish the greatest habitat output for the least cost and how increases in habitat output beyond that initial increment affect the cost of the Project (Table 9). The results of the HEP and cost analysis are useful in evaluating proposed actions that will affect habitats and in identifying which projects would provide the highest environmental gain for the cost expended. The District and HEP team recognized that these evaluations alone do not provide for the analysis of other factors that are important in ultimately selecting projects for funding. Thus, in addition to HEP and the CE/ICA, a ranking matrix was developed by the District and used by the Team in the evaluation of alternatives for restoration sites. The purpose of the ranking matrix was to provide a method to address some of the key parameters outside the scope of HEP and incorporate various other factors that are vital to the successful development and completion of a restoration project into the evaluation and selection of restoration alternatives.

In completing the HEP matrix, Team members used best professional judgment and institutional knowledge to evaluate each restoration alternative relative to the following 18 evaluation criteria:

- threatened and endangered species
- land ownership
- natural sustainability
- naturalness
- maintenance and management
- anthropogenic effects
- combined approach
- institutional recognition,
- public recognition
- technical recognition
- acceptability
- effectiveness
- relative uncertainty (in ecological gain)
- 5 coastal processes (longshore sediment transport, cross island sediment transport, dune development and evolution, bayside shoreline, and estuarine processes)

Team members assigned a score from 0 (low) to 5 (high) to each variable based on how well the restoration alternative supported the variable. Any criterion not applicable to a site was identified with a “n.a.” (criteria not applicable to certain sites). A “U” was assigned to any variable that the evaluator was unable to respond to due to limited knowledge of the subject matter. See Appendix B, Table 10 for an example of the HEP Team matrix evaluation form.

Upon completion, the results of the scoring were combined to produce a ranking matrix score for each of the 57 sites/alternatives. This score was derived by calculating the average score for each of the 18 variables (na’s and u’s were excluded) for a given site/alternative, and combining all averages to obtain the ranking matrix score for each site/alternative. Raw scores ranged from a low of 24.00 (T-5, Great Gun, Alternative 3 – enhance upland and interior dune areas) to a high score of 51.33 (T-14, Ocean Beach, Alternative 3 – home buy outs and restoration of dune in disturbed areas). Results of the ranking matrix process are summarized in Table 10 and presented in detail in Appendix J.

In addition, to the calculation of the ranking matrix score the HEP Team also assessed the level of effect of each alternative on the five coastal processes important to meeting restoration and SDR goals, as well as expected benefits to rare species. Although these criteria were part of the 18 evaluation criteria used to calculate the matrix score, the HEP Team decided that it was important to evaluated these criteria individually to remove the influence of the other criteria that is part of the ranking matrix score. The evaluation consisted of combined vote that ultimately placed each alternative for each of the 5 processes into an effect category as well as, whether or not the alternative will benefit rare species. The five categories assigned to the processes were as follows:

- Significant Net Positive Effect (+ +)
- Net Positive Effect (+)
- No/Minimal Effect (0)
- Net Negative Effect (–)
- Significant Net Negative Effect (- -)

Net and significant net effects were defined as a combination of the level of effect as well as the likelihood of effect. Those alternatives that were expected to have a large effect on improving or degrading the coastal process and had a high likelihood of occurring with alternative implementation were assigned ++ or - -. Those alternatives that were expected to have a small effect on improving or degrading the coastal process and low or high likelihood of occurring with alternative implementation were assigned + or -.

Tables 6, 7, 8, and 9 within Appendix B provides the raw results of this assessment. Processes assigned a significant net positive effect or net positive effect category were considered to be targeted processes for the alternative (Table 10). If implemented, these alternatives would have a positive effect on the identified process regardless of its ranking matrix score.

**Table 10. Ranking Matrix Results.**

| Restoration Site | HEP Transect | Alternative Number | Matrix Score | Matrix Rank | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|
| Ocean Beach | T-14 | 3 | 51.33 | 1 | D,L | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas |
| Tiana | T-7 | 3 | 49.33 | 2 | B | Plant existing SAV beds |
| Atlantique | T-28 | 2 | 48.58 | 3 | D,L | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Seatuck Refuge | T-23 | 3 | 47.08 | 4 | B,E | Remove bulkhead along small inlet, regrade shoreline, stabilize shoreline using coir log bio-engineering, and restore marsh through plantings |
| Tiana | T-7 | 1 | 46.92 | 5 | B,E | Restore salt marsh by removing fill material, using herbicide to control *Phragmites*, regrading and replanting bay shoreline. Restore dune at access cut and provide access by installing a wooden dune walkover |
| Ocean Beach | T-14 | 1 | 46.50 | 6 | D,L | Remove groins and relocate water supply well, regrade as needed to stabilize |
| Kismet | T-26 | 2 | 46.00 | 7 | D,L | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Great Gun | T-5 | 1 | 45.67 | 8 | E | Enhance salt marsh by restoring hydrologic connection via culvert beneath the road, excavate as needed to achieve desired elevation, add culvert, restore road access, plant as needed to stabilize |
| Fair Harbor | T-29 | 3 | 45.08 | 9 | D,L | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Great Gun | T-5 | 4 | 44.92 | 10 | B,E | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with coir log bio-engineering and plantings |
| Atlantique | T-28 | 3 | 44.83 | 11 | D,L | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| WOSI | T-8 | 4 | 44.67 | 12 | B,E | Remove parking lot to reduce impervious surface, remove existing walkway on oceanside, regrade site to natural contours, plant as needed to stabilize |
| Fair Harbor | T-29 | 2 | 44.58 | 13 | L,D | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Seatuck Refuge | T-23 | 2 | 43.00 | 14 | E | Excavate site as needed to reconfigure existing tidal channels, control *Phragmites* with herbicides |

| Restoration Site | HEP Transect | Alternative Number | Matrix Score | Matrix Rank | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|
| Sunken Forest | T-2 | 4 | 42.92 | 15 | B,E | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, add fill as needed, stabilize with coir log bio-engineering and plantings |
| Davis Park | T-24 | 3 | 42.00 | 16 | D,L,U | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas, restore portions of disturbed upland surrounding marina, plant disturbed areas |
| Kismet | T-26 | 3 | 41.5 | 17 | D,L | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Atlantique to Corneille | T-25 | 1 | 41.00 | 18 | B,E | Deposit sediment and regrade area to create bayside sand bar |
| Islip Meadows | T-22 | 3 | 41.00 | 19 | B,E | Plug ditches and create tidal pools, excavate site as needed to achieve desired elevations of pool and obtain plug material, *Phragmites* control using herbicides |
| Seatuck Refuge | T-23 | 1 | 40.42 | 20 | B,E | Restore hydrologic connection by excavating and removing existing undersized culverts, install larger culverts, control *Phragmites* using hydrology, convert disturbed areas to salt marsh by removing fill material and planting |
| Islip Meadows | T-22 | 2 | 40.17 | 21 | E | Excavate marsh to reconfigure existing tidal channels |
| Kismet | T-26 | 1 | 40.17 | 22 | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| East Inlet Island | T-10 | 1 | 40.08 | 23 | U,R | Regrade portions of dunegrass to remove *Phragmites* and dense vegetation and create conditions more favorable for shorebird nesting |
| New Made Island | T-15 | 1 | 39.33 | 24 | U,R | Fill existing *Phragmites*-dominated baybeach to control *Phragmites* and create open dune habitat favorable for shorebird nesting, regrade a portion of shoreline to promote wildlife access |
| Great Gun | T-5 | 2 | 39.17 | 25 | D,U | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create dune walkover, and restore dune at access areas and cuts |
| Ocean Beach | T-14 | 2 | 38.58 | 26 | D | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, raising boardwalks above dunes and restoring dune, plant as needed to stabilize |
| Warner Island East | T-27 | 1 | 38.08 | 27 | U,R | Enlarge island size and create shorebird nesting habitat by filling baybeach areas and planting |
| Georgica Pond | T-9 | 3 | 37.92 | 28 | D,L,E | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, replacing the dune at the open cut, removing all groins, and installing a tide gate to manage tidal flow |

| Restoration Site | HEP Transect | Alternative Number | Matrix Score | Matrix Rank | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|
| Islip Meadows | T-22 | 1 | 36.92 | 29 | B,E | Restore hydrologic connection by excavating to remove sediment, install two flap gates to manage tidal flow |
| Atlantique | T-28 | 1 | 36.92 | 30 | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Reagan Property | T-3 | 3 | 36.75 | 31 | B,E | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create a dune walkover and restore dune at cuts |
| Tiana | T-7 | 2 | 36.42 | 32 | C,U | Remove parking lot to reduce impervious surface on site, regrade to natural contours, plant a portion of the site to stabilize and reduce parking area size |
| John Boyle | T-11 | 1 | 36.33 | 33 | U,R | Grade and add topsoil to convert portions of dunegrass to tree covered upland habitat for heron species, regrade a portion of shoreline to promote wildlife access, plant as needed to stabilize |
| WOSI | T-8 | 1 | 36.25 | 34 | E | Create new salt marsh in the area located to the west of the existing parking lot by lowering elevations of upland areas, making a cut in the bay shoreline to introduce tidal flow, and planting native salt marsh species |
| WOSI | T-8 | 2 | 36.25 | 35 | D | Enhance existing salt marsh through the use of herbicides to control *Phragmites*. |
| Atlantique to Corneille | T-25 | 3 | 35.58 | 36 | D,U | Enhance upper beach/dune slope, height, and width throughout site, reduce human disturbance by closing off some access roads/trails, add topsoil to facilitate upland creation in disturbed areas, plant site as needed to stabilize |
| WOSI | T-8 | 3 | 34.75 | 37 | D,U | Reduce disturbance by raising the existing oceanside boardwalk, restoring the dune, regrading bayside shoreline slope, filling existing cuts, and placing a walkover at the existing bayside shoreline access cut, plant as needed to stabilize |
| Davis Park | T-24 | 1 | 34.58 | 38 | D | Add sand fill to restore dune and beach at large vehicle access cut, plant as needed to stabilize |
| Georgica Pond | T-9 | 2 | 34.42 | 39 | E | Control *Phragmites* in coves adjacent to Georgica Pond by manually removing *Phrag*. and lowering elevations along the shoreline to improve tidal flow and spot planting native salt marsh species in excavated areas |
| Georgica Pond | T-9 | 1 | 34.17 | 40 | E | Control *Phragmites* in Georgica Pond by manually removing Phrag and lowering elevations along the shoreline to improve tidal flow, and spot planting of native marsh species |
| Fair Harbor | T-29 | 1 | 34.00 | 41 | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Davis Park | T-24 | 2 | 33.92 | 42 | D | Enhance upper beach/dune slope, width, and height throughout the site, raise existing walkovers, plant as needed to stabilize |

| Restoration Site | HEP Transect | Alternative Number | Matrix Score | Matrix Rank | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|
| East Inlet Island | T-10 | 2 | 33.58 | 43 | E | Control *Phragmites* throughout island using herbicides |
| Reagan Property | T-3 | 1 | 32.50 | 44 | B,E | Regrade eroding bayside shoreline and stabilize using bio-engineering (vegetated gabions) |
| Reagan Property | T-3 | 2 | 32.00 | 45 | D,U | Bury bulkhead, regrade shoreline and create intertidal area, add fill as needed, stabilize shoreline using bio-engineering |
| Atlantique to Corneille | T-25 | 2 | 31.67 | 46 | B,E | Create new salt marsh by regrading upland areas and bay shoreline, plant native salt marsh species |
| Sunken Forest | T-2 | 1 | 31.33 | 47 | B,E | Remove bulkhead adjacent to marina, regrade shoreline and stabilize using bio-engineering, control *Phragmites* |
| Warner Island East | T-27 | 2 | 31.25 | 48 | U,R | Enlarge island size and create heron nesting habitat by filling baybeach areas, add topsoil and plant as needed |
| New Made Island | T-15 | 2 | 29.33 | 49 | U,R | Add topsoil to existing dunegrass community to create tree covered upland habitat for heron |
| Warner Island East | T-27 | 3 | 29.33 | 50 | U | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |
| Sunken Forest | T-2 | 3 | 28.25 | 51 | D,U | Restore interior upland and dune areas of the site to more natural conditions by removing most hard structures, boardwalks and dune walk overs, and closing off and regrading many of the existing disturbed areas/roads/trails (except one to provide access from marina) |
| New Made Island | T-15 | 3 | 26.42 | 52 | U | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |
| East Inlet Island | T-10 | 3 | 25.67 | 53 | U | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| John Boyle | T-11 | 2 | 24.92 | 54 | U,R | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| John Boyle | T-11 | 3 | 24.75 | 55 | U | Regrade portions of the dunegrass community to remove dense vegetation to create shorebird nesting habitat, control *Phragmites* throughout site |
| Sunken Forest | T-2 | 2 | 24.75 | 56 | D | Enhance upper beach/dune width/slope/height, reduce disturbance by raising the existing boardwalks to create a dune walkover, and restoring dune at cuts |
| Great Gun | T-5 | 3 | 24.00 | 57 | U | Restore interior upland and dune areas of the site to natural conditions by removing most hard structures, removing boardwalks and dune walk overs, closing off and regrading most disturbed areas/roads/trails (except one to provide access from marina) |

[1]B = Bayside Process, C = Cross Island Transport, D = Dune Growth and Evolution, E = Estuarine Processes, L = Longshore Transport, R = Rare Species, U = Upland

## 9.0 ALTERNATIVE PRIORITIZATION EXERCISE

The results from the HEP analysis (i.e., net gain in AAHUs), cost analysis (i.e., identification of cost-effective alternatives), and ranking matrix (i.e., an alternatives rank based on other evaluation criteria), provided the Team with three unique evaluation components to further refine the comparison and ranking of the 57 restoration alternatives. Using this information, the Team systematically discussed the results and restoration details of each alternative. Combining the results from the three evaluation components of the study considered thus far with professional judgment, knowledge of Project area and restoration site constraints, environmental need, feasibility, and agency interest and support, the Team assigned each alternative into one of four priority classes. Each priority class indicated whether Team support for the alternative (as proposed) was high (identified by the Team as a "green" option), moderate ("yellow" option), or low (red option) as shown in Table 11. The Team also identified alternatives requiring additional information to make a determination regarding a priority class (i.e., "Orange" alternatives) (Table 11).

In summary, the prioritization exercise resulted in 25 alternatives identified as high priority (green), eight as moderate priority (yellow), nine as low priority (red), and15 as lacking information (orange) (e.g., landowners support/opposition, site information, modifications to current design) (Table 11).

**Table 11. Restoration Site Prioritization Results.**

| Site Name | HEP Transect ID | Alternative Number | Annual Cost/Net AAHU | Matrix Rank | CE/ICA Rank |
|---|---|---|---|---|---|
| **GREEN – High Priority (based on HEP Team's overall assessment of HEP scores, matrix scores, costs, restoration design, and professional expertise).** | | | | | |
| Tiana | T-7 | 1 | $345.04 | 6 | 10 |
| Tiana | T-7 | 2 | $59.74 | 34 | 4 |
| Tiana | T-7 | 3 | $172.78 | 2 | 7 |
| Atlantique | T-28 | 1 | $5,097.12 | 33 | 43 |
| Atlantique | T-28 | 2 | $34,367.69 | 3 | 53 |
| Seatuck Refuge | T-23 | 1 | $943.72 | 22 | 20 |
| Great Gun | T-5 | 1 | $408.16 | 7 | 12 |
| Great Gun | T-5 | 2 | $412.46 | 24 | 13 |
| Great Gun | T-5 | 3 | $714.93 | 56 | 18 |
| WOSI | T-8 | 1 | $17.24 | 30 | 1 |
| WOSI | T-8 | 2 | $239.12 | 32 | 9 |
| WOSI | T-8 | 3 | $57.90 | 35 | 3 |
| WOSI | T-8 | 4 | $1,576.30 | 9 | 31 |
| Seatuck Refuge | T-23 | 2 | $5,532.47 | 14 | 44 |
| Atlantique to Corneille | T-25 | 1 | $3,501.39 | 16 | 37 |
| Islip Meadows | T-22 | 1 | $953.80 | 27 | 21 |
| East Inlet Island | T-10 | 1 | $185.43 | 21 | 8 |
| Seatuck Refuge | T-23 | 3 | $2,024.99 | 4 | 34 |
| New Made Island | T-15 | 1 | $1851.73 | 23 | 33 |
| Islip Meadows | T-22 | 3 | $414.91 | 17 | 14 |
| John Boyle Island | T-11 | 1 | $125.21 | 29 | 5 |

| Site Name | HEP Transect ID | Alternative Number | Annual Cost/Net AAHU | Matrix Rank | CE/ICA Rank |
|---|---|---|---|---|---|
| Atlantique to Corneille | T-25 | 2 | $562.23 | 41 | 17 |
| East Inlet Island | T-10 | 2 | $40.19 | 38 | 2 |
| Atlantique to Corneille | T-25 | 3 | $1,423.60 | 37 | 28 |
| Reagan Property | T-3 | 2 | $1,533.34 | 47 | 30 |
| **YELLOW - Moderate Priority (based on HEP Team's overall assessment of HEP scores, matrix scores, costs, restoration design, and professional expertise)** | | | | | |
| Fair Harbor | T-29 | 1 | $5,950.56 | 40 | 45 |
| Islip Meadows | T-22 | 2 | $26,935.40 | 20 | 51 |
| Fair Harbor | T-29 | 2 | $83,032.07 | 10 | 55 |
| New Made Island | T-15 | 2 | $1,185.22 | 49 | 26 |
| New Made Island | T-15 | 3 | $1,178.21 | 52 | 25 |
| John Boyle | T-11 | 2 | $444.84 | 53 | 15 |
| East Inlet Island | T-10 | 3 | $512.08 | 54 | 16 |
| John Boyle | T-11 | 3 | $392.90 | 55 | 11 |
| **RED - Low Priority (based on HEP Team's overall assessment of HEP scores, matrix scores, costs, restoration design, and professional expertise)** | | | | | |
| Atlantique | T-28 | 3 | $187,706.64 | 13 | 57 |
| Fair Harbor | T-29 | 3 | $177,197.84 | 12 | 56 |
| Sunken Forest | T-2 | 3 | $4,537.77 | 51 | 39 |
| Sunken Forest | T-2 | 2 | $1,487.98 | 57 | 29 |
| Warner Island | T-27 | 1 | $10,821.61 | 26 | 48 |
| Warner Island | T-27 | 2 | $6,808.58 | 46 | 46 |
| Warner Island | T-27 | 3 | $14,479.33 | 50 | 49 |
| Georgica Pond | T-9 | 1 | $4,391.79 | 43 | 38 |
| Georgica Pond | T-9 | 2 | $955.15 | 42 | 22 |
| **ORANGE - Additional information (e.g., landowner support/opposition, site information, modifications to conceptual design) are needed to determine which priority the alternative should be placed in.** | | | | | |
| Kismet | T-26 | 2 | $53,895.02 | 5 | 54 |
| Kismet | T-26 | 3 | $24,980.53 | 19 | 50 |
| Davis Park | T-24 | 1 | $155.78 | 39 | 6 |
| Davis Park | T-24 | 2 | $2,920.83 | 44 | 36 |
| Davis Park | T-24 | 3 | $2,570.02 | 18 | 35 |
| Great Gunn | T-5 | 4 | $1,664.93 | 8 | 32 |
| Georgica Pond | T-9 | 3 | $1,225.69 | 31 | 27 |
| Ocean Beach | T-14 | 1 | $9,884.68 | 11 | 47 |
| Sunken Forest | T-2 | 4 | $4,904.86 | 15 | 41 |
| Kismet | T-26 | 1 | $4,740.70 | 25 | 40 |
| Ocean Beach | T-14 | 2 | $5,072.46 | 28 | 42 |
| Ocean Beach | T-14 | 3 | $28,789.06 | 1 | 52 |
| Sunken Forest | T-2 | 1 | $1,001.36 | 48 | 24 |
| Reagan Property | T-3 | 1 | $784.03 | 45 | 19 |
| Reagan Property | T-3 | 3 | $971.36 | 36 | 23 |

## 10.0 CONCLUSION

The goals and objectives of using HEP and the other evaluation methods presented herein were to evaluate a range of possible restoration alternatives that could be combined with SDR Project components to maximize environmental benefit in the Project area. Over 83 sites across the 83-mile Project area were evaluated by the District and interagency HEP Team for restoration potential. Eighteen sites were selected as having real opportunities for restoration and a total of 57 restoration design alternatives (three to four per restoration site) were developed and evaluated using the methods documented in this report. The evaluation process was conducted over a 4-year period and, as documented in this report, included the use of numerous tools (i.e., HEP, CE/ICA, Ranking Matrix, and the Prioritization Exercise) to provide a comprehensive evaluation of the conceptual design alternatives and in an attempt to address interests expressed by agencies and interested parties.

Table 12 provides a comparison of each alternative according to the results of each evaluation method used by the District (i.e., columns 4 [HEP], 5 [CE/ICA] and 6 [Ranking Matrix]), and a comparison of the prioritization status assigned to each alternative by the HEP Team. The table also identifies the coastal process most targeted by each restoration alternative as determined by the HEP Team. The table is sorted based on the HEP Teams prioritization level, which indicates (of the 57 alternatives evaluated) those alternatives that the team could most strongly support (i.e., Prioritization Level = 1) to those that the Team least supported (i.e., Prioritization Level = 3). Although some alternatives were ranked higher using one evaluation method over another, some general patterns can be identified. For example, several alternatives identified as high priority by the HEP Team, also scored high for at least two of the other evaluation methods used. In comparison, alternatives generally not supported by the HEP Team tended to score very low for at least two of the evaluation methods.

Restoration is primarily by opportunity, and all 57 alternatives are realistic and capable of being implemented. Therefore, all 57 alternatives will move forward for consideration as components of the FIMP SDR Project. However, the information acquired through this restoration evaluation process and summarized in Table 12, will facilitate future evaluation and selection of alternatives based on need at the time of construction, location of SDR activities, and availability of funding and support. By conducting the rigorous framework of analysis of sites using HEP, cost-benefit analysis, and ranking matrix, all potential restoration alternatives are considered important by the evaluation Team and worthy of consideration, and each has been ranked to facilitate decisions on what projects to move forward, within the context of need and opportunity at the time of the restoration activity. These results provide a range of viable alternatives that may be implemented individually or in combination to improve ecological conditions in the Project area. These alternatives provide a starting point for restoration efforts and may be added to, expanded in size, and/or modified as need to address the myriad of opportunities that exist for ecological restoration and enhancement in the Project area.

**Table 12. Summary of Restoration Alternative Evaluation Results.**

| Site Name | HEP Transect ID | Alternative Number | RANK-Net Gain in AAHU | RANK-CE/ICA Rank | RANK - Matrix | HEP Prioritization Exercise | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|---|---|
| Tiana | T-7 | 1 | 21 | 10 | 6 | 1 | B,E | Restore salt marsh by removing fill material, using herbicide to control *Phragmites*, regrading and replanting bay shoreline. Restore dune at access cut and provide access by installing a wooden dune walkover |
| Tiana | T-7 | 2 | 23 | 4 | 34 | 1 | C,U | Remove parking lot to reduce impervious surface on site, regrade to natural contours, plant a portion of the site to stabilize and reduce parking area size |
| Tiana | T-7 | 3 | 24 | 7 | 2 | 1 | B | Plant existing SAV beds |
| Atlantique | T-28 | 1 | 55 | 43 | 33 | 1 | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Atlantique | T-28 | 2 | 49 | 53 | 3 | 1 | D,L | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Seatuck Refuge | T-23 | 1 | 8 | 20 | 22 | 1 | B,E | Restore hydrologic connection by excavating and removing existing undersized culverts, install larger culverts, control *Phragmites* using hydrology, convert disturbed areas to salt marsh by removing fill material and planting |
| Great Gunn | T-5 | 1 | 30 | 12 | 7 | 1 | E | Enhance salt marsh by restoring hydrologic connection via culvert beneath the road, excavate as needed to achieve desired elevation, add culvert, restore road access, plant as needed to stabilize |
| Great Gunn | T-5 | 2 | 25 | 13 | 24 | 1 | D,U | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create dune walkover, and restore dune at access areas and cuts |
| Great Gunn | T-5 | 3 | 16 | 18 | 56 | 1 | U | Restore interior upland and dune areas of the site to natural conditions by removing most hard structures, removing boardwalks and dune walk overs, closing off and regrading most disturbed areas/roads/trails (except access to marina) |
| WOSI | T-8 | 1 | 10 | 1 | 30 | 1 | E | Enhance the existing salt marsh through the use of herbicides to control *Phragmites*. |
| WOSI | T-8 | 2 | 4 | 9 | 32 | 1 | D | Reduce disturbance on site by raising the existing ocean side boardwalk and restoring the dune, regrading the bayside shoreline slope and filling existing cuts, and placing a walkover at the existing bayside shoreline access cut, plant as needed to stabilize |

| Site Name | HEP Transect ID | Alternative Number | RANK-Net Gain in AAHU | RANK-CE/ICA Rank | RANK - Matrix | HEP Prioritization Exercise | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|---|---|
| WOSI | T-8 | 3 | 6 | 3 | 35 | 1 | D,U | Remove asphalt parking lot to reduce impervious surface, remove existing walkway on ocean side, regrade site to natural contours, plant as needed to stabilize |
| WOSI | T-8 | 4 | 5 | 31 | 9 | 1 | B,E | Create new salt marsh in the area located to the west of the existing parking lot by lowering elevations of upland areas, making a cut in the bay shoreline to introduce tidal flow, and planting native salt marsh species |
| Seatuck Refuge | T-23 | 2 | 9 | 44 | 14 | 1 | E | Excavate site as needed to reconfigure existing tidal channels, control *Phragmites* with herbicides |
| Atlantique to Corneille Estates | T-25 | 1 | 38 | 37 | 16 | 1 | B,E | Deposit sediment and regrade area to create bayside sand bar |
| Islip Meadows | T-22 | 1 | 36 | 21 | 27 | 1 | B,E | Restore hydrologic connection by excavating to remove sediment, install two flap gates to manage tidal flow |
| East Inlet Island | T-10 | 1 | 22 | 8 | 21 | 1 | U,R | Regrade portions of dunegrass to remove *Phragmites* and dense vegetation and create conditions more favorable for shorebird nesting |
| Seatuck Refuge | T-23 | 3 | 12 | 34 | 4 | 1 | B,E | Remove bulkhead along small inlet, regrade shoreline, stabilize shoreline using coir log bio-engineering, and restore marsh through plantings |
| New Made Island | T-15 | 1 | 51 | 33 | 23 | 1 | U,R | Fill existing *Phragmites*-dominated baybeach to control *Phragmites* and create open dune habitat favorable for shorebird nesting, regrade a portion of shoreline to promote wildlife access |
| Islip Meadows | T-22 | 3 | 37 | 14 | 17 | 1 | B,E | Plug ditches and create tidal pools, excavate site as needed to achieve desired elevations of pool and obtain plug material, *Phragmites* control using herbicides |
| John Boyle Island | T-11 | 1 | 27 | 5 | 29 | 1 | U,R | Regrade portions of the dunegrass community to remove dense vegetation to create shorebird nesting habitat, control *Phragmites* throughout site |
| Atlantique to Corneille Estates | T-25 | 2 | 33 | 17 | 41 | 1 | B,E | Create new salt marsh by regrading upland areas and bay shoreline, plant native salt marsh species |
| East Inlet Island | T-10 | 2 | 14 | 2 | 38 | 1 | E | Control *Phragmites* throughout island using herbicides |
| Atlantique to Corneille Estates | T-25 | 3 | 28 | 28 | 37 | 1 | D,U | Enhance upper beach/dune slope, height, and width throughout site, reduce human disturbance by closing off some access roads/trails, add topsoil to facilitate upland creation in disturbed areas, plant site as needed to stabilize |

| Site Name | HEP Transect ID | Alternative Number | RANK-Net Gain in AAHU | RANK-CE/ICA Rank | RANK - Matrix | HEP Prioritization Exercise | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|---|---|
| Reagan Property | T-3 | 2 | 32 | 30 | 47 | 1 | D,U | Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes to create a dune walkover and restore dune at cuts |
| Fair Harbor | T-29 | 1 | 54 | 45 | 40 | 2 | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Islip Meadows | T-22 | 2 | 41 | 51 | 20 | 2 | E | Excavate marsh to reconfigure existing tidal channels |
| Fair Harbor | T-29 | 2 | 48 | 55 | 10 | 2 | L,D | Reduce disturbance through buyouts and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| New Made Island | T-15 | 2 | 53 | 26 | 49 | 2 | U,R | Add topsoil to existing dunegrass community to create tree covered upland habitat for heron |
| New Made Island | T-15 | 3 | 56 | 25 | 52 | 2 | U | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |
| John Boyle | T-11 | 2 | 34 | 15 | 53 | 2 | U,R | Grade and add topsoil to convert portions of dunegrass to tree covered upland habitat for heron species, regrade a portion of shoreline to promote wildlife access, plant as needed to stabilize |
| East Inlet Island | T-10 | 3 | 11 | 16 | 54 | 2 | U | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| John Boyle | T-11 | 3 | 26 | 11 | 55 | 2 | U | Regrade and stabilize shoreline with vegetated gabion basket bio-engineering and plantings |
| Kismet | T-26 | 2 | 40 | 54 | 5 | u | D,L | Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Kismet | T-26 | 3 | 42 | 50 | 19 | u | D,L | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Davis Park | T-24 | 1 | 18 | 6 | 39 | u | D | Add sand fill to restore dune and beach at large vehicle access cut, plant as needed to stabilize |
| Davis Park | T-24 | 2 | 13 | 36 | 44 | u | D | Enhance upper beach/dune slope, width, and height throughout the site, raise existing walkovers, plant as needed to stabilize |

| Site Name | HEP Transect ID | Alternative Number | RANK-Net Gain in AAHU | RANK-CE/ICA Rank | RANK - Matrix | HEP Prioritization Exercise | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|---|---|
| Davis Park | T-24 | 3 | 17 | 35 | 18 | u | D,L,U | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas, restore portions of disturbed upland surrounding marina, plant disturbed areas. |
| Great Gunn | T-5 | 4 | 15 | 32 | 8 | u | B,E | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with coir log bio-engineering and plantings |
| Georgica Pond | T-9 | 3 | 1 | 27 | 31 | u | D,L,E | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, replacing the dune at the open cut, removing all groins, and installing a tide gate to manage tidal flow |
| Ocean Beach | T-14 | 1 | 7 | 47 | 11 | u | D,L | Remove groins and relocate water supply well, regrade as needed to stabilize |
| Sunken Forest | T-2 | 4 | 19 | 41 | 15 | u | B,E | Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, add fill as needed, stabilize with coir log bio-engineering and plantings |
| Kismet | T-26 | 1 | 44 | 40 | 25 | u | D | Enhance upper beach/dune slope, width, and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points |
| Ocean Beach | T-14 | 2 | 47 | 42 | 28 | u | D | Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, raising boardwalks above dunes and restoring dune, plant as needed to stabilize |
| Ocean Beach | T-14 | 3 | 43 | 52 | 1 | u | D,L | Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas |
| Sunken Forest | T-2 | 1 | 31 | 24 | 48 | u | B,E | Remove bulkhead adjacent to marina, regrade shoreline and stabilize using bio-engineering, control *Phragmites* |
| Reagan Property | T-3 | 1 | 39 | 19 | 45 | u | B,E | Regrade eroding bayside shoreline and stabilize using bio-engineering (vegetated gabions) |
| Reagan Property | T-3 | 3 | 35 | 23 | 36 | u | B,E | Bury bulkhead, regrade shoreline and create intertidal area, add fill as needed, stabilize shoreline using bio-engineering |
| Atlantique | T-28 | 3 | 50 | 57 | 13 | 3 | D,L | Reduce disturbance through buy-outs and removal of structures within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |

| Site Name | HEP Transect ID | Alternative Number | RANK-Net Gain in AAHU | RANK-CE/ICA Rank | RANK - Matrix | HEP Prioritization Exercise | Process Targeted[1] | Restoration Target |
|---|---|---|---|---|---|---|---|---|
| Fair Harbor | T-29 | 3 | 45 | 56 | 12 | 3 | D,L | Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas |
| Sunken Forest | T-2 | 3 | 20 | 39 | 51 | 3 | D,U | Restore interior upland and dune areas of the site to more natural conditions by removing most hard structures, boardwalks and dune walk overs, and closing off and regrading many of the existing disturbed areas/roads/trails (except one to provide access from marina) |
| Sunken Forest | T-2 | 2 | 29 | 29 | 57 | 3 | D | Enhance upper beach/dune width/slope/height, reduce disturbance by raising the existing boardwalks to create a dune walkover, and restoring dune at cuts |
| Warner Island East | T-27 | 1 | 52 | 48 | 26 | 3 | U,R | Enlarge island size and create shorebird nesting habitat by filling baybeach areas and planting |
| Warner Island East | T-27 | 2 | 46 | 46 | 46 | 3 | U,R | Enlarge island size and create heron nesting habitat by filling baybeach areas, add topsoil and plant as needed |
| Warner Island East | T-27 | 3 | 57 | 49 | 50 | 3 | U | Regrade and stabilize shoreline with vegetated gabion bio-engineering and plantings |
| Georgica Pond | T-9 | 1 | 2 | 38 | 43 | 3 | E | Control *Phragmites* in Georgica Pond by manually removing *Phrag.* and lowering elevations along the shoreline to improve tidal flow, and spot planting of native marsh species |
| Georgica Pond | T-9 | 2 | 3 | 22 | 42 | 3 | E | Control *Phragmites* in coves adjacent to Georgica Pond by manually removing Phrag and lowering elevations along the shoreline to improve tidal flow and spot planting native salt marsh species in excavated areas |

[1]B = Bayside Process, C = Cross Island Transport, D = Dune Growth and Evolution, E = Estuarine Processes, L = Longshore Transport, R = Rare Species, U = Upland

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# ATTACHMENT I

## DESCRIPTION OF RESTORATION SITES AND ALTERNATIVES

**CONTENTS:**

**Description of Fire Island to Montauk Point (FIMP) Storm Damage Reduction Project (Project) Potential Restoration Alternatives**

The Habitat Evaluation Procedures (HEP) advisory team (HEP Team) identified the following conceptual restoration alternatives for the 18 potential sites. The options include habitat enhancements, which would change HSI scores but not effect acreages as well as habitat conversions of one HEP community to another, or disturbed areas (non-HEP communities) into a HEP community. Descriptions of sites and photographs (when available) are based on the site conditions observed/documented during 2004 field visits.

The objective in evaluating conceptual restoration designs with HEP was to assess a broad spectrum of conceptual ideas that could be carried out at locations across the barrier island, to evaluate extremes of alternatives (e.g., full restoration versus reduced area), and to present a range of possible options, costs, etc. Although attempts were made to include at least one restoration option at each site that would meet goals and objective of each Team member's affiliation, all members of the Team do not necessarily support all of the site locations and alternatives presented herein. The proposed options may or may not be feasible and would be further evaluated during subsequent phases of this Project. In addition, the USACE has not predetermined that any restoration should take place on any given site, but is evaluating a suite of locations and alternatives that have been identified by the Team and outside sources.

In this evaluation, it is assumed that any maintenance events needed to ensure the habitat conditions at a site following restoration are maintained over the 50-year life of the project (i.e., vegetation removal, invasive species control, minimization of human impacts, etc.) and that they would occur. It is recognized that should maintenance activities not occur, a general decrease in habitat quality would likely occur over time and these conditions are not accounted for in the HEP method. Although management will be necessary to ensure long-term sustainability of restored sites, it is assumed that management activities will be funded by project sponsors or funded under separate USACE authority.

For HEP analysis, six barrier island communities have been identified and include UPLAND, DUNEGRASS, VEGBEACH, OCEANBEACH, BAYBEACH and BAYSUBSAV. Community definitions were based upon cover types as determined by data collection at representative transects (see Appendix F for example data sheets). In general, habitats representative of each of these communities are found along each of the 18 potential restoration areas selected for HEP and their general locations on the barrier island are shown in Appendix A, Figure 2. The exception are sites located along the mainland and on islands, in which case the OCEANBEACH and VEGBEACH communities are not applicable, and in areas where natural or manmade disturbance has eliminated a community. In general, the following descriptions of habitats are applicable to the six communities when present in a restoration area unless otherwise noted in the description of the restoration site.

## OCEANBEACH

This community includes the nearshore zone of the ocean and the beach intertidal zone extending from 30 ft (10 m) depth in the ocean landward to the average daily high tide line (i.e., wrack line). Unvegetated areas dominated by sand characterize the community.

**VEGBEACH**
This community includes the upper beach zone extending from the average daily high tide line (i.e., wrack line) landward to the toe of the primary (i.e., fore) dune. The community comprises bare or sparsely vegetated areas dominated by sand. Vegetation, when present, is dominated by beachgrass (*Ammophila breviguluta*), but also includes beach pea (*Lathyrus maritimus*), seaside goldenrod (*Solidago sempervirens)*, beach heather (*Hudsonia* to*men*to*sa*), running dune grass (*Panicum amarum*), and dune bean (*Strophyostyles helvola*). Scattered species from the open sandy dune areas can also be found on the primary dunes, but only in low densities.

**DUNEGRASS**
The DUNEGRASS community includes the face of the primary dune (i.e., foredune), dunes, interdunes, and swales that are dominated by sand or herbaceous cover. In general, this community is found in areas extending from the seaward toe of the primary dune landward to the bayside storm high water mark, or landward to the seaward edge of upland community. Dune grass is typically the dominant species, but the community often also includes a significant component of vine species. Shrubs, when present, are typically stunted and cover less than 20% of this community. This community is well interspersed throughout the island from ocean to bay. The dominant vegetation is American beachgrass, but beach plum (*Prunus maritima*), sand bur (*Cenchrus tribulides*), seaside goldenrod, beach heather, switch grass (*Panicum virgatum*), and vines/shrubs such as poison ivy (To*xicodendron radicans*), multiflora rose (*Rosa multiflora*), bayberry (*Myrica pennsylvanica*), and wax myrtle (*Myrica cyrifera*) also are found in this community type. Areas of the secondary dune with shrub densities > 20% are included in the UPLAND community type.

**UPLAND**
The UPLAND community occurs behind the primary dunes and includes shrub-dominated areas of the secondary dunes and stunted maritime forest that occur behind secondary dunes. Generally, this community is found in areas extending from the crest of the primary dune landward to the bayside storm high water mark. Vegetation is characterized by > 20% cover of non-wetland shrubs or trees. Herbs and/or vines are also common components of this community, but do not dominate (i.e., < 20% cover). Dominant species in this community include pitch pine (*Pinus rigida*), post oak (*Quercus stellata*), red cedar (*Juniperus virginiana*), American holly (*Ilex opaca*), sassafras (*Sassafras albidum)*, and cherry (*Prunus virginiana*). Dominant shrub/vine species include poison ivy, greenbriar (*Smilax rotundifolia*), serviceberry (*Amelanchier canadensis)*, multiflora rose, bayberry, and wax myrtle.

**BAYBEACH**
The BAYBEACH community includes bay intertidal areas and the bay side upper shore zone and extends from the bay LLW (low-low water) line landward to the point where the upland or dunegrass (i.e., non-wetland) community is encountered. This community may be dominated by sand, mud, or vegetated with wetland herb and/or wetland shrub communities and includes wetland and beach areas that are hydrologically connected to the bay and are not permanently inundated. Often, the invasive species common reed (*Phragmites australis*) dominates these wetland areas. However, these wetlands can be very diverse in terms of species composition and depending on hydrologic regime include the following species: salt marsh cordgrass (*Spartina*

*alterniflora),* salt meadow hay *(Spartina patens),* seashore saltgrass *(Distichlis spicata),* black grass *(Juncus gerardii),* sea lavender *(Limonium carolinianum),* seabeach orach *(Atriplex arenaria),* glasswort *(Salicornia spp.),* cattail *(Typha spp.),* American three-square (*Schoenoplectus pungens*), salt marsh bulrush *(Schoenoplectus robustus*), salt marsh fleabane *(Pluchea odorata),* saltmarsh aster *(Aster novae-angliae),* and shrubs such as blueberry (*Vaccinium corymbosum),* arrowwood (*Viburnum dentatum*), inkberry (*Ilex glabra*), marsh elder *(Iva frutescens)* and groundsel tree *(Baccharis halimifolia).*

**BAYSUBSAV**

The BAYSUBSAV community includes permanently inundated areas from the bay LLW line bay ward to 500 feet from the shoreline and includes permanently inundated impounded areas (i.e., ponds). The 500-foot distance is arbitrary and was selected to facilitate HEP analysis of the BAYSUBSAV community, which could extend for several thousand feet in some areas of the study area. The BAYSUBSAV community is typically not vegetated and is dominated by bare sand substrate. However, submergent aquatic vegetation (SAV) beds, dominated by eelgrass (*Zostera marina*), are found in some areas of the BAYSUBSAV community.

### T-2 SUNKEN FOREST

The Sunken Forest site includes all six HEP community model types. The most notable restoration needs at this location are the severely eroding and steep bayside shoreline banks, a bulkhead, and scattered invasive common reed (*Phragmites australis),* also referred to as *Phragmites,* along the bayside shoreline. In addition, an active public marina and numerous buildings and recreational facilities associated with the National Park Service are also located on approximately 25 percent of the site. The site is dominated by maritime upland forest. Sand trails and wooden boardwalks traverse much of the site and provide access to the beach.

Recreational use of the area is high. Trash was noted along the bay and ocean shorelines and evidence of vehicle use of the beach was documented. Vehicle access to the beach is provided via open cuts in the dune located beyond the area surveyed for the restoration site. In general, bayside shoreline and estuarine processes have been negatively impacted in this area and appear to be most effected by hard structures such as a marina, bulk heading, buildings and various human activities along the shoreline and in aquatic and intertidal areas. Additionally, the dune development and evolution and cross-island sediment transport processes have also been negatively effected by placements of buildings and walkways within upland and dune areas and overall direct human use of the area. The negative impacts to cross-island transport may be somewhat offset by man-made cuts in the primary dune that allow for vehicle access to beach areas.

**Restoration Alternative T-2-1, Eroding Bayside Shoreline**

The goal of T-2-1 is to enhance the eroding bayside shoreline and intertidal zone and remove bulkhead material located west of the marina. Components include:

- Remove 210 lf (1 ac) of bulkhead;
- Regrade 900 lf (4.3 ac) of shoreline;
- Add 2.2 ac of sand fill material to restore the intertidal zone along 900 lf of shoreline;
- Remove 0.25 ac of debris from shoreline;
- Manually remove 0.5 ac of *Phragmites;*
- Stabilize 900 lf (4.3 ac) of shoreline with coir log bioengineering measures; and,
- Plant 2.2 ac of the 900 lf shoreline; allow other disturbed areas to revegetate naturally.

Specific activities would include regrading approximately 900 lf of the shoreline to a slope < 2:1 and Place sand material over approximately a 2.2-acre (ac) area to enhance the interidal zone and provide bay sediment. Approximately 2.2 ac of fill material will be used to restore the shoreline grade; of this, potentially 1.1 ac can be taken from the area of the existing bulkhead. Dredge material would be used onsite for additional gradient alterations and would support dredge material management activities. The bulkhead and other debris along the shoreline would be removed and disposed of in a suitable location. Coir logs and plantings would be utilized to stabilize the 900 lf of shoreline and minimize further erosion and loss of habitat (assuming that velocities and slope or conducive to this stabilization measure). Approximately 0.5 ac of *Phragmites* and 0.25 ac of debris would be removed manually as part of shoreline modification efforts. Desirable vegetation and faunal species are expected to recolonize communities of the site naturally once suitable habitat conditions are established.

Restoration measures are expected to enhance the existing BAYBEACH community and result in some improvements to the BAYBEACH HSI variables for invasive species, species richness, erosion, shoreline modifications, and barriers to wildlife, as shown in Appendix G. The grade of the existing BAYBEACH community will be modified, but the overall width/size would not. There will be no changes in acreages of community types with this alternative.

By stabilizing the bay side shoreline and restoring the intertidal zone and intertidal vegetation, this alternative is expected to positively affect the bayside shoreline and estuarine coastal processes.

**Restoration Alternative T-2-2, Upper Beach and Dune**

The goal of T-2-2 is to enhance the existing beach and dune system. Components of T-2-2 include:

- Regrade 1,800 lf (8.6 ac) of the dune face and slope;
- Add additional 8.6 ac of fill material to restore dune, and area beneath walkway and at cuts;
- Plant 3.2 acres of dune grass along 1,800 lf of ocean shoreline and in disturbed areas at cuts; and,
- Raise and restore a 300 ft wooden boardwalk.

Specific tasks would be to improve the slope of approximately 1,800 feet of the existing dune face to approximately 20 to 25% slope, plant the dune face with approximately 40% cover of vegetation, widen the VEGBEACH community to 120 feet, and plant the upper 40 feet of the VEGBEACH community with dune grass species such as beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass. Measures would also include raising the existing beach access boardwalk and restoring the dune/upland beneath it to a slope and width matching the adjacent dunes and replanting as needed to stabilize the area. Approximately 8.6 ac of sand material will be needed for regrading dunes and dune replacement. In addition, open cuts through the dune to the beach would be restored and planted to stabilize, and the overall area of disturbance would be reduced by restricting access to these areas and planting an additional 1 ac of dune grass. Structures associated with the NPS service and recreational facilities would remain, as would boardwalks and the sand road oriented east-west through the center of the site. Alternative natural materials such as rock, logs, etc., would be used to restrict access where feasible.

Restoration measures are expected to enhance the existing DUNEGRASS and VEGBEACH communities and would result in some improvements to the HSI variables for percent cover of vegetation, slope, and minor improvements to impacts from human disturbance and shoreline modifications, as shown in Appendix G. Width would be increased, however the HSI score for this variable was already at maximum score (1.0) prior to restoration and would not be changed. The size of each of these communities and the OCEANBEACH community is expected to change slightly and this change is reflected in HEP HU calculations. There will be no changes in acreages of community types with this alternative.

This alternative would make dunes more stable (i.e., by improving dune slope), restore the dune in access areas, and widen the beach and is expected to positively affect the longshore sediment transport and dune development and evolution processes. However, the activity would also have a negative effect on dune development and evolution by artificially modifying the dune structure and would negatively affect the cross-island transport process by closing off the areas most susceptible to overwashing. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**Restoration Alternative T-2-3, Upland and Interior Dune Areas**

The goal of T-2-3 is to restore upland and dune areas of the site to natural conditions. Components of T-2-3 include:

- Remove 4.1 ac of hard structures such as buildings, boardwalks, parking lots, paved areas; and,
- Close off and regrade 4.1 ac of disturbed areas and trails (except one sand trail to provide access from marina to beach).

The effort includes the removal of several man-made structures on the site (covering approximately 4.1 ac), which includes 1,200 lf of wooden boardwalks, approximately 1,900 feet of linear paved areas, three large buildings, three maintenance buildings, and a bathhouse associated with recreational facilities. This measure includes regrading 4.1 ac of disturbed areas and allowing the site to return to conditions of natural barrier island communities such as dune and upland. Disturbed areas would be left to revegetate naturally. Access via one existing sand trail would be permitted on site to provide access to the Marina.

Restoration measures are expected to improve HSI scores for the UPLAND, DUNEGRASS, and VEGBEACH communities. Hard structures will be removed from existing disturbed areas but otherwise the site is expected to revert to natural conditions naturally. Improvements to the HSI variables include species richness, percent cover of vegetation, percent cover of trees and shrubs, and barriers to wildlife, although increases will be relatively minor because the site overall scores relatively high in these areas prior to restoration (Appendix G). All communities will see some improvement in the HSI variables for magnitude of human impacts because fewer disturbances from humans is expected on site due to the removal of some facilities and public access ways and boardwalks. The DUNEGRASS community would increase by 0.3 ac, UPLAND would increase by 3.8 ac, and disturbed would decrease by 4.1 ac; and this change is reflected in HEP HU calculations.

This alternative is expected to somewhat positively affect the cross-island transport process by removing hard structures that might impede overwashing of some portions of the site. However, overwashing is not likely in this area due to existing dune height, island width and presence of well-established upland communities.

**Restoration Alternative T-2-4, Marina**

The goal of T-2-4 is to remove the marina and hard structures directly attached to the marina to restore the intertidal zone and shoreline within the marina footprint. Components of T-2-4 include:

- Remove 2,300 lf (11 ac) of bulkhead material associated with marina and associated hard structures;
- Remove 2 ac of fill and rock material associated with marina;
- Remove 1 ac of debris and rubbish;
- Regrade 750 lf (3.6 ac) of shoreline/disturbed area within marina footprint;
- Replant 1 ac of disturbed shoreline to stabilize; and,
- Use coir log bioengineering measures to stabilize 900 lf of shoreline.

The effort includes the removal of the marina and hard structures directly attached to the marina on the site (covering approximately 2 ac). Approximately 1 ac of the 2 ac of sand material removed from the existing marina may be reused on site to regrade the shoreline and disturbed areas. Coir log stabilization measures would be used, and the site would be replanted to facilitate stabilization along 750 lf of shoreline. One (1) ac of wetland shrubs and emergent vegetation will be planted to restore the shoreline within the marina footprint.

Restoration measures are expected to improve HSI scores for the BAYBEACH and BAYSUBSAV communities. Improvements to the HSI variables include, slight improvements to erosion, barriers to wildlife, species richness, and shoreline modification, as shown in Appendix G. In addition, the HSI variables for all communities will increase slightly for magnitude of human impacts and percent vegetative cover because fewer disturbances from humans are expected on site due to the removal of the marina. Approximately 1.9 acres of disturbed area will be converted to intertidal and submergent aquatic habitats as a result of this alternative and this change is reflected in HEP HU calculations.

This alternative is expected to positively effect the bayside shoreline and estuarine coastal processes by removing a hard structure that is directly impacting the bay shoreline and is believed to be contributing to disruption of natural hydrologic flow and sediment distribution in the bay.

## T-3 REAGAN PROPERTY

The Reagan site is similar to the Sunken forest in that a predominant restoration need at the site is the severely eroding bayside shoreline banks as well as scattered invasive *Phragmites* along the bayside shoreline. In addition, a significant portion of the site includes the highly developed community of Fire Island Pines. The entire bayside shoreline along this community is bulkheaded and as a result lacks a bayside intertidal zone. Vehicle cuts, pathways, sand fence, hard structures, and walkways from residential areas, heavily impact dunes along the ocean side of the site.

Upland areas adjacent to the residential community include sandy roads and trails, a power station, a helipad, and sand fence. Recreational use of the area is high and evidence of trash and vehicle use of the beach was documented. Access to the beach through the dune is via one wooden boardwalk, several small sand trails, and a major vehicle access point that connects the beach, residential area, and helipad.

Similar to the Sunken Forest site, the bayside shoreline and estuarine processes at the Reagan site have been negatively impacted and appear to be most effected by hard structures such as extensive bulk heading, boat slips, buildings and various human activities in the area, particularly those associated with the highly developed community of Fire Island Pines. Impacts have directly and indirectly affected the shoreline, intertidal, and aquatic areas of the site. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, residential housing, and other hard structures within upland and dune areas, and overall direct human use of the area. The negative impacts to cross-island transport may be somewhat offset by man-made cuts in the primary dune that allow for vehicle access to beach areas.

**Restoration Alternative T-3-1, Eroding Bayside Shoreline**

The goal of T-3-1 is to enhance the eroding bayside shoreline and intertidal zone. Components of T-3-1 include:

- Regrade slope of 1,00 lf (4.8 ac) of bay shoreline and upland;
- Add 2.2 ac of sand fill to enhance/restore shoreline;
- Install coir log bioengineering structures along 1,000 lf of shoreline; and,
- Plant 1.2 ac of shoreline to stabilize.

Specific measures would be to regrade the upland edge/shoreline to a slope < 2:1 and place sand material over approximately a 2.2 ac area to enhance the interidal zone and provide bay sediment. Dredge material may be utilized to restore grade in support of dredge material management activities. Soft bioengineering structures such as coir logs (or other) bioengineering measures and plantings would be installed to stabilize 1,000 feet of the shoreline. However, due to the velocity of water flow in this area, vegetated gabion bioengineering structures may be necessary to ensure the long-term stability of the site and protection of upland habitat. The shoreline would be planted with 2.2 ac of wetlands shrub and emergent vegetation to facilitate stabilization.

Restoration measures are expected to enhance the existing BAYBEACH community and would result in some improvements to the BAYBEACH HSI variables for invasive species, species richness, erosion, shoreline modifications, and barriers to wildlife, as shown in Appendix G. The grade of the existing BAYBEACH community will be modified, but the overall width/size would not.

By stabilizing the bay side shoreline and recreating the intertidal zone and vegetation, this activity is expected to result in positive impacts to the bayside shoreline and estuarine coastal processes.

**Restoration Alternative T-3-2, Upper Beach and Dune**
The goal of T-3-2 is to enhance the existing beach and dune system and improve conditions within upland areas of the site. Components of T-3-2 include:

- Remove 400 lf (2 ac) of sand fence on dunes;
- Regrade 1,300 lf (6.2 ac) of dune to improve slope, height, width;
- Add 6.5 ac of fill material to enhance dune and close or reduce roads, trails, and dune cuts; and,
- Raise and restore one 300 ft wooden walkway over dune.

Specific tasks would be to remove sand fence from dunes, improve the slope of the existing dune face to approximately 20 to 25% slope and 50 foot width (i.e., foredune characteristics), plant the dune face with approximately 40% cover of vegetation, and widen the VEGBEACH community to 120 feet and planting the upper 40 feet (from the toe of dune slope toward the ocean) with dune vegetation. Several existing sand roads and trails would be closed off or reduced in width. Approximately 6.5 acres of sand fill material would be needed for dune restoration and to minimize sand roads and trails. Structures and access roads associated with the residential area, power station, and helipad would remain on site. One existing walkway from the residential area to the beach would be raised and the dune would be restored to a slope and width matching the adjacent dunes and replanted as needed to stabilize the area.

Restoration measures are expected to enhance the existing DUNEGRASS, and VEGBEACH communities and would result in some improvements to the HSI variables for percent cover of vegetation, slope, and minor improvements to impacts from human disturbance and shoreline modifications, as shown in Appendix G. Width would be increased for the dune face, however, the HSI score for this variable was already at maximum score (1.0) prior to restoration and would not be changed as a result. The size of each of these communities and the

OCEANBEACH community is expected to change slightly and this change is reflected in HEP HU calculations. There will be no changes in acreages of community types with this alternative.

This alternative would make dunes more stable (i.e., by improving dune slope), restore the dune in access areas, and widen the beach and is expected to positively affect the longshore sediment transport and dune development and evolution processes. However, the activity would also have a negative effect on dune development and evolution by artificially modifying the dune structure and would negatively affect the cross-island transport process by closing off the areas most susceptible to overwashing. Although a relatively large cut in the dune would remain to provide access to residential areas and the helipad. Components of this alternative (i.e., dune enhancement) would support storm damage reduction project objectives.

**Restoration Alternative T-3-3, Bury Bulkhead and Restore Shoreline**
The goal of T-3-3 is to bury the existing bulkhead along Fire Island Pines, regrade the shoreline to restore the intertidal zone, and to stabilize the area using bioengineering. Components of T-3-3 include:

- Regrade 2.9 ac area;
- Add 5 ac of sand fill to bury bulkhead and extend shoreline;
- Apply coir log bioengineering methods to stabilize 300 lf of shoreline;
- Plant 1 ac of shoreline to stabilize; and,
- Extend intertidal zone along 600 lf of shoreline.

Bioengineering structures such as coir logs and plantings would be installed to stabilize the toe of the 300-foot section of sand that is placed over the bulkhead. However, due to the velocity of water flow in this area, vegetated gabion (or other) bioengineering structures may be necessary to ensure the long-term stability of the site and protection of upland habitat. The intertidal zone will be extended over approximately 600 feet of the site and 1 ac of it will be planted with salt marsh species to stabilize the site. Dredge material would be utilized to restore grade in support of dredge material management activities. Approximately 5 ac of fill would be needed to bury the bulkhead, rebuild the shoreline, and extend the intertidal zone.

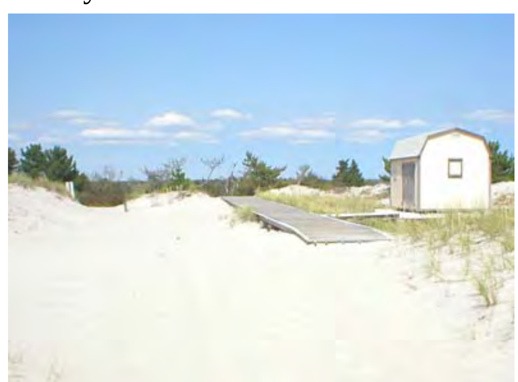
Restoration measures are expected to restore/enhance the existing BAYBEACH community and would result in some improvements to the BAYBEACH HSI variables for invasive species, species richness, shoreline modifications, erosion, and barriers to wildlife, as shown in Appendix G. The size of the BAYBEACH and BAYSUBSAV communities are not expected to change and this change is reflected in HEP HU calculations.

Removal of hard structures and the recreation of intertidal areas and salt marsh along the bay shoreline are expected to positively affect the bayside shoreline and estuarine coastal processes.

## T-5 GREAT GUN

Great Gun recreational use area includes a major boat dock, helipad, wooden boardwalk, and several structures associated with the recreational area (i.e., outhouses, picnic tables, storage sheds). Numerous sand roads and trails are found throughout the site and numerous access roads and trails cut through the dune. The site also is characterized by a tidal marsh system comprised of an inundated saltwater pond and saltmarsh. However, due to tidal restrictions the tidal pond associated with this marsh is relatively stagnant and a significant component of the upper zones of the high marsh is dominated by invasive *Phragmites*.

This area is a public recreational facility, and use of the area is high. Vegetation loss and substrate disturbance from pedestrian and vehicle use of uplands and dune areas is significant throughout the site. Despite the recreational uses of the area, the dunes and beach are of relatively high quality in terms of vegetation, slope and width. The bayside shoreline and estuarine processes at the site have been negatively impacted and appear to be most effected by hard structures such as extensive bulk heading, boat slips, buildings, a playground/recreational area, and general impact from various human uses the area. Impacts have directly and indirectly affected the shoreline, intertidal, and aquatic areas of the site and in particular have altered hydrologic connection to a relatively large salt marsh community on site.



Evidence of erosion is present on the bayside shoreline, but is not as severe as other sites such as Reagan and Sunken Forest. The dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, other hard structures within upland and dune areas, and overall direct human use of the area. However, the negative impacts to cross-island transport may be somewhat offset by man-made cuts in the primary dune that allow for vehicle access to beach areas.

**Restoration Alternative T-5-1, Existing Salt Marsh**

The goal of T-5-1 is to restore the 1.14-acre degraded salt marsh and tidal pond at Great Gun. Components of T-5-1 include:

- Install a 48-inch culvert to reestablish hydrologic connection to the existing marsh;
- Excavate 0.2 ac of the area to achieve suitable elevations for culvert installation;
- Add 0.3 ac of sand fill over culvert to raise and restore sand road; and,
- Plant excavated areas (0.2 ac) with salt marsh species.

Specifically, a 48-inch metal culvert would be placed beneath a sand road to connect the existing marsh located on the western portion of the site with the degraded marsh located in the center and eastern portion of the site. Some excavation may be required on 0.2 acres of the site to achieve desirable elevations for culvert installation and tidal flow. Approximately 0.3 ac of fill will be added above culvert to raise and replace sand access road. Some of excavated material may be reused on site. Planting is not proposed with this alternative since the increase in tidal flow is expected to create conditions favorable for desirable salt marsh species currently found on site to flourish, and to reduce the presence of *Phragmites*. However, areas disturbed during construction would be replanted. The existing sand road and boardwalk, which bisect the marsh system, would remain.

Restoration measures are expected to enhance the existing BAYBEACH community and would result in some improvements to the BAYBEACH HSI variables for percent cover of vegetation, invasive species, species richness, and some reduction in the magnitude of impacts from human disturbance to the marsh (road will be raised) as shown in Appendix G. The size of the BAYBEACH community would increase by 1.14 ac and UPLAND would decrease slightly as flooding is expected to result in the conversion of some fringe upland areas along the marsh to wetland shrub.

The enhancement of the existing degraded salt marsh is expected to positively affect the estuarine coastal process.

**Restoration Alternative T-5-2, Upper Beach and Dune**

The goal of T-5-2 is to enhance the existing beach and dune system reduce disturbance in uplands. Components of T-5-2 include:

- Regrade and improve the dune face and slope along a 200 lf (1 ac) area at dune cuts;
- Plant 0.25 ac of dunegrass at restored dune;
- Remove 1 ac of sand fence;
- Raise and restore one 500 ft wooden boardwalk; and,
- Close off and regrade several dune trails (not primary access points), no plantings.

This measure focuses on reducing disturbance on site by removing hard structures, minimizing road widths and some roads and access points. Structures associated with the recreational area, including the primary boardwalk and sand roads that provide vehicle access between the beach, helipad, and marina, would not be removed. To reduce disturbance on site, vehicle traffic would be restricted to a single access road and the road would parallel the existing boardwalk at the cut through the dune. Access would be restricted on the remaining sandy roads and trails using natural objects such as large rocks. Disturbed areas are expected to revegetate naturally, but dune faces would be replanted. Dune restoration would focus on disturbed areas (i.e., dune cuts and roads), which cover approximately 200 lf (1 ac) of the 1,100-foot foredune and upper beach area. Within this area the dune face would be restored to approximately 20 to 25% slope, and 0.25 ac planted with approximately 40% cover of vegetation. The VEGBEACH community would be widened to 120 feet, and the upper 40 feet planted with dune grass species such as beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass.

Restoration measures are expected to enhance the existing BAYBEACH and DUNEGRASS communities and improve the HSI variables for percent cover of vegetation, barriers to wildlife. Although some roads and trails will be closed, the overall impacts from human disturbance are not expected to decrease significantly throughout the area because primary access routes will remain. VEGBEACH and UPLAND restoration would generally mimic conditions of adjacent areas. Thus, other than improving the human magnitude variable, HSI scores for these communities will not change. The restoration of 4.07 ac of disturbed areas would result in an additional 3.11 ac of upland and 0.97 ac of dune grass with this alternative.

As with Alternative 1, the enhancement of the existing degraded salt marsh is expected to positively affect the estuarine coastal process. In addition, this alternative is expected to have a slight positive effect on the dune development and evolution processes by restoring disturbed access areas in the dune, but would negatively effect the cross-island transport process, by closing off the location most susceptible to cross-island overwashing. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**Restoration Alternative T-5-3, Upland and Interior Dune**

The goal of T-5-3 is to restore upland and dune areas of the site to natural conditions by removing most of the hard structures on the site and deterring access. Components of T-5-3 include:

- Remove hard structures such as buildings, boardwalks and eliminate trails covering 4.7 ac;
- Regrade and restore 1 ac of dune at cuts (no boardwalk replacement);
- Add 1 ac of sand fill to restore cuts;
- Plant 0.25 ac of restored dune at cuts with dune grass;
- Remove 1,300 lf of wooden boardwalks throughout the site; and,
- Regrade and restrict access on 4.7 ac of the site (one sand trail would remain to provide access from marina to beach).

The effort includes the removal of man-made structures on the site, which include 1,300 lf of wooden boardwalks, a latrine, three sheds, and allowing the disturbed areas, such as roads, trails, boardwalks, and building sites, to return to barrier island communities. This measure includes regrading disturbed areas and allowing the site to return to conditions of natural barrier island communities. Incipient dunes (dunes much smaller and less established than foredunes) would be placed in areas of dune cuts (1 ac) and planted with low-density dune grass species (i.e., beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass) to stabilize the area. Other disturbed areas would be left to revegetate naturally.

Restoration measures are expected to improve HSI scores for the UPLAND, DUNEGRASS, and VEGBEACH communities. Hard structures will be removed from existing disturbed areas but otherwise the site is expected to revert to natural conditions naturally. Improvements to the HSI variables include, percent cover of vegetation, percent cover of trees and shrubs, species richness, and barriers to wildlife, as shown in Appendix G. Human factors/magnitude of human impacts are expected to decrease somewhat in most communities due to elimination of facilities and restriction of public access. The restoration of 4.75 ac of disturbed habitat would result in an additional 2.3 ac of dune grass, 2.3 ac of upland, and 0.15 ac of intertidal habitat.

This alternative is expected to somewhat positively affect the cross-island transport process by removing hard structures that might impede overwashing of some portions of the site.

**Restoration Alternative T-5-4, Marina**
The goal of T-5-4 is to remove the marina (covering approximately 1.5 ac) and restore approximately 200 lf of the intertidal zone to conditions similar to the adjacent shoreline. Specific components of T-5-4 include:

- Remove 950 lf (4.6 ac) of marina (i.e., bulkhead and pier) and associated hard structures;
- Regrade 150 lf (0.72 ac) of shoreline at marina;
- Remove 1.2 ac of sand fill and rock; and,
- Plant 0.2 ac of restored shoreline.

The effort includes the removal of 950 lf of the marina and hard structures directly attached to the marina on the site (covering approximately 1.2 ac) and would also require removal of approximately 1.2 ac of sand fill from the site. Some sand material from the existing marina would be reused on site to regrade the shoreline and disturbed areas. No shoreline stabilization measures would be used, but the site would be replanted to facilitate stabilization.

Restoration measures are expected to improve HSI scores for the BAYBEACH and BAYSUBSAV communities. Improvements to the HSI variables include percent cover of vegetation, shoreline modification, and barriers to wildlife, as shown in Appendix G. In addition, all communities will see some slight improvement in the HSI variables for magnitude of human impacts and percent vegetative cover because fewer disturbances from humans are expected on site due to the removal of the marina. The restoration of 1.2 ac of disturbed area on site would result in 0.25 acres of dune grass, 0.18 ac of upland, and 0.76 ac of intertidal habitat.

This alternative is expected to positively effect the bayside shoreline and estuarine coastal processes by removing a hard structure that is directly impacting the bay shoreline and is believed to be contributing to disruption of natural hydrologic flow and sediment distribution in the bay.

## T-7 TIANA

The Tiana restoration site currently provides parking and access to the beach for recreational activities. The site is at a relatively narrow portion of the barrier island, however, the dunes and beach in this area are relatively wide and stable. On the bayside, the salt marsh is of relatively high quality overall. However, a portion of the site has been degraded due to flooding and runoff from the paved road, and use of the area as a boat launch point. Recreational use of the area is high and includes vehicle access to the beach. Access to the beach is provided by a large cut in the dune that extends from the end of the asphalt parking area.

The bayside shoreline and estuarine processes at the site generally appear to be functioning naturally, considering the overall setting of the site. However, a small portion of the salt marsh and bay shoreline has been directly impacted by vehicles accessing the area to launch watercraft and from runoff from the adjacent road surface. The dune development and evolution process is affected by vehicle traffic on the upper beach and beach maintenance activities (i.e., sand deposition and dune building). This activity mimics sand accretion, which may or may not be the "natural trend in this area". Cross-island sediment transport processes have been negatively affected by beach maintenance activities and other hard structures (i.e., asphalt parking lot and roads) within upland and dune areas. The negative impacts to cross-island transport may be somewhat offset by man-made cuts in the primary dune that allow for vehicle access to beach areas.

**Restoration Alternative T-7-1, Bayside Shoreline, Salt Marsh, and Upper Beach and Dune**
The goal of T-7-1 is to restore salt marsh by removing fill material, regrading and replanting to area, restoring the dune at an oceanside access cut and providing access via a dune walkover, and restoring dunegrass/upland in those areas. Specific components of T-7-1 include:

- Remove 0.2 ac of fill bayside;
- Regrade 0.2 ac area;
- Plant 0.1 ac of regraded bayside shoreline;
- Regrade and restore 200 foot wide vehicle access cut in the dune to slope and width of adjacent dune;
- Fill cut with 1 ac of sand;
- Plant 0.25 ac of restored dune with dune grass; and,
- Install one 300 ft wooden dune walkover.

On the bayside, approximately 0.2 ac of gravel, asphalt, and fill material, would be removed from the salt marsh and upland community. This portion of the site would be regraded and planted as needed to restore salt marsh and a narrow upland community along the road edge. On the oceanside, approximately a 200 foot-wide area of the dune and upper beach located at the vehicle cut would be restored to foredune conditions such that approximately 200 feet of the existing dune face would be regraded to a slope of approximately 20 to 25%, planting the dune face with approximately 40% cover of vegetation, widening the VEGBEACH community to 120 feet, and planting the upper 40 feet of the VEGBEACH community with dune grass species that include beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass. One walkover would be installed to provide pedestrian access to the beach.

Restoration measures are expected to enhance, and in some cases restore, four of the six HEP communities (OCEANBEACH and BAYSUBSAV excluded), and would result in some improvements to the HSI variables for percent cover of vegetation, percent cover of trees and shrubs, species richness, erosion, shoreline modification, barriers to wildlife, and human factors/magnitude of human impacts, as shown in Appendix G. However, due to the small size of upland and salt marsh creation in disturbed areas, this alternative is expected to have an overall low change in habitat quality (HSI scores) for these habitats. This measure is expected to convert 0.38 of disturbed area to intertidal area (0.04), salt marsh vegetation (0.05), and dune grass (0.29)

The removal of fill and restoration of salt marsh in intertidal areas is expected to have a positive effect on the bayside shoreline and estuarine coastal processes. On one hand, dune development and evolution processes would be positively affected by restoring the dune in the open cut area. But, this would also negatively affect the cross-island transport process by closing off the areas most susceptible to overwashing. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**Restoration Alternative T-7-2, Upland and Interior Dune**

The goals of T-7-2 would be to remove impervious surface from the interior areas of the site to allow the site to revert to more natural conditions. Specific components include:

- Remove 0.2 ac asphalt lot to eliminate impervious surface;
- Regrade area; and,
- Plant 0.1 ac of disturbed area with dune grass.

Specifically, the 2-ac asphalt lot would be removed entirely to eliminate impervious surface within the dune/upland area. Parking would still be allowed on site, but within a reduced area on sand substrate. The primary asphalt road through the site and the large dune cut to the ocean would remain.

Restoration measures are expected to convert existing disturbed areas to DUNEGRASS, and would result in improvements to the HSI variables for percent cover of vegetation, species richness, barriers to wildlife, and human factors/magnitude of human impacts, as shown in Appendix G. HSI scores for magnitude of impacts from humans and percent vegetation will also improve for most communities as less human activity is expected on site due to parking lot removal.  This measure would convert 0.4 ac of disturbed area to dune grass.

The removal of the parking lot would positively affect the cross-island transport process by replacing disturbed area with natural habitat, particularly since the large dune cut would be left open under this scenario.

**Restoration Alternative T-7-3, Bay Submergent**
The goals of T-7-3 are to enhance conditions of the BAYSUBSAV community by:

- Plant 1 ac of submergent aquatic vegetation.

Restoration measures are expected to enhance the existing BAYSUBSAV community and would result in improvements to the following BAYSUBSAV HSI variables, percent cover of eelgrass and species richness, as shown in Appendix G.  The community would be enhanced through this action, but the size of the BAYSUBSAV community would not change.

This alternative is expected to positively effect estuarine coastal processes by increasing the amount of desirable submergent aquatic vegetation in the area.

## T-8 WEST OF SHINNECOCK INLET (WOSI)

The WOSI restoration site currently provides parking and access to the beach for recreational activities. The site is at a relatively narrow portion of the barrier island, however, the dunes and beach in this area are relatively wide and stable due to beach renourishment activities that were recently completed for the site. The dune currently has a wooden walkover that provides access for pedestrians to the beach. However, washouts have been occurring through the dune at this location and the foundation of the walkover is located within, rather than above, the dune.

Bayside, the site is characterized by an asphalt parking lot, relatively steep bayside dunes, and impacts to bayside dunes caused by pedestrian access from the parking lot to the bay shoreline. A relatively high quality salt marsh is located in the northeastern portion of the site, however the marsh does contain invasive *Phragmites*.

Recreational use of the bay and ocean shorelines areas is high. No vehicle access points are located within the restoration site, but vehicle access is provided elsewhere along the beach and tire ruts have been documented on the beach. The state and Federally-listed seabeach amaranth and piping plover have been documented in the VEGBEACH community in the vicinity of this location.

The bayside shoreline and estuarine processes at the site generally appear to be functioning naturally, considering the overall setting of the site. A small portion of the salt marsh and bay shoreline has been directly impacted by human use of the area for recreation, but impacts overall are relatively minor. The dune development and evolution process is affected by vehicle traffic on the upper beach, hard structures (i.e., boardwalk), and beach maintenance activities (i.e., sand deposition and dune building). This activity mimics sand accretion, which may or may not be the "natural trend in this area". Cross-island sediment transport processes have been negatively affected by beach maintenance activities and other hard structures (i.e., asphalt parking lot, boardwalk, and roads) within upland and dune areas.

**Restoration Alternative T-8-1, *Phragmites* Control**

The goal of T-8-1 is to use herbicides to control *Phragmites* in the existing 5-ac salt marsh and 4 ac of adjacent upland shrub communities. Specific components include:

- Apply herbicides to 9-ac area to control *Phragmites.*

Restoration measures are expected to enhance the existing BAYBEACH community by removing the invasive species *Phragmites* from the site and making conditions more favorable for establishment of desirable native species. Restoration is expected to result in some improvements to the BAYBEACH HSI variables for invasive species, barriers to wildlife, and species richness, as shown in Appendix G. The size of the HEP communities would not change as a result of this measure.

The removal of *Phragmites* in the existing marsh is expected to positively affect the estuarine coastal process.

**Restoration Alternative T-8-2, Bayside Shoreline and Upper Beach and Dune**
The goals of T-8-2 are to restore the dunes and shoreline at pedestrian access points currently located on the bay and ocean shorelines, install/raise pedestrian access walkovers, and reshape and stabilize the bayside shoreline to reduce erosion and improve wildlife access. Specific components of T-8-2 include:

- Regrade 1,400 lf (6.7 ac) of bayside shoreline slope to improve stability and intertidal zone and 0.2 ac of Oceanside shoreline to restore dune cut;
- Add 0.1 ac of fill bayside to fill opening in bay shoreline and 0.5 ac of fill oceanside to fill dune cut;
- Install a 30 lf wooden walkway to the bay;
- Raise existing 200 lf walkway on the ocean side; and,
- Plant 0.1 ac of dune oceanside with dune grass, and 1.7 ac of bay shoreline with emergents and shrubs to stabilize.

Bayside restoration measures include restoring a 0.2 ac pedestrian access area at the northern end of the parking lot and regrading approximately 1,400 feet of the bay side shoreline to a slope < 2:1, and placing approximately 3.4 ac of sand material to enhance the intertidal zone and provide bay sediment. Dredge material may be utilized to restore grade in support of dredge material management activities. A wooden walkway would be installed above the restored bayside dune to provide pedestrian access from the lot to the bay shoreline. Oceanside, the existing walkway would be raised above the dune and 0.5 ac of the dune would be restored to a slope and width matching the adjacent dunes and replanted as needed to stabilize the area. HSI scores for DUNEGRASS and VEGBEACH slope, height, and width are not expected to change due to the small size (< 10’ wide cut) of the effected area. This measure would result in conversion on 0.19 ac of disturbed habitat to dune grass habitat.

Restoration measures are expected to enhance four of the six HEP communities (OCEANBEACH and BAYSUBSAV excluded), and would result in improvements to the HSI variables for percent cover of vegetation, species richness, erosion, shoreline modification, barriers to wildlife, and magnitude of human impacts, as shown in Appendix G. Approximately 0.19 ac of disturbed area would be converted to dune habitat with this alternative and this change is reflected in HEP HU calculations.

Regrading the bayside shoreline slope and increasing the shoreline intertidal areas is expected to have a positive effect on the bayside shoreline and estuarine coastal processes. Dune development and evolution processes would be positively affected by restoring the dune in the area of the existing boardwalk. But, this would also negatively affect the cross-island transport process by closing off the areas most susceptible to overwashing. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**Restoration Alternative T-8-3, Removal of Hard Structures on Site**
The goal of T-8-3 is to remove manmade structures from the site and allow portions of the site to revert to natural conditions. Specific components include:

- Remove 0.4 ac asphalt parking lot and regrade area;
- Removal of walkway on oceanside; and,
- Plant 0.25 ac of upland plant species in part of disturbed area.

Specifically, the 0.40-acre asphalt lot would be removed entirely to eliminate impervious surface within the dune/upland area. Parking would still be allowed on site, but within a reduced area on sand substrate. The primary asphalt road through the site would remain. A portion of the disturbed area would be replanted with 0.25 ac of upland species. No measures would be taken to regrade the bayside shoreline. The area beneath the walkway through the dune would be restored to conditions similar to adjacent dunes and the walkway would be removed. Due to the small size of impact from the walkover, the overall HSI scores for the slope, height and width of the DUNEGRASS and VEGBEACH communities are not expected to change as a result of this action. The primary asphalt road through the site would remain.

Restoration measures are expected to enhance dune and upland habitats on the site and would result in improvements to the HSI variables for percent cover of vegetation, percent cover of trees and shrubs, species richness, erosion, shoreline modification, barriers to wildlife, and human factors/magnitude of human impacts, as shown in Appendix G. The conversion of disturbed area would result in 0.13 additional acres of dunegrass and 0.27 acres of upland. Other HEP communities would also see some slight improvements due to the reduction of human activity in the area as a result of removing public access and parking.

The removal of the parking lot would somewhat positively affect the cross-island transport process by replacing disturbed area with natural habitat. Although the cut in the dune would not be restored under this scenario, the elevation and condition of the dune at this location is likely not conducive to breaching.

**Restoration Alternative T-8-4, Salt Marsh Creation**
The goal of T-8-4 is to create new, high-quality salt marsh within a marginally productive upland/dune area. Specific components include:

- Regrade 11 ac of upland to create saltmarsh;
- Regrade and reduce slope of 200 lf (1 ac) of shoreline to facilitate tidal flushing;
- Plant 11 ac of salt marsh species; and,
- Remove 25 ac of fill material from the site.

Elevations of the dune and upland communities located to the northeast of the site would be lowered to create conditions similar to the existing marsh on site. Native salt marsh species, including 8 ac of emergent wetland species such as salt marsh cordgrass, salt meadow hay, seashore saltgrass, and black grass, and 3 ac of wetland shrubs such as marsh elder, blueberry, bayberry, and groundsel tree would be planted to facilitate establishment of the marsh. The slope of approximately 200 ft of the existing shoreline would be lowered to an elevation adequate facilitate tidal flushing of the created marsh.

Restoration measures are expected to enhance the existing BAYBEACH community and would result in some improvements to the BAYBEACH HSI variables for species richness, wildlife barriers, and erosion, as shown in Appendix G. Approximately 3.1 ac of salt marsh would be created through the conversion of 1.8 ac of dune grass and 1.3 ac of upland habitat.

The creation of additional salt marsh is expected to positively affect the bayside shoreline and estuarine coastal processes by improving the bayside shoreline stability, tidal flow, and creating additional high quality salt marsh in the area.

## T-9 Georgica Pond

Georgica Pond is characterized by a large tidal pond system that is surrounded by highly developed residential areas. Tidal flushing in the pond is sporadic and is at times manually controlled as part of local pond management activities. The pond supports a diversity of vegetation and aquatic fauna and serves as a significant foraging area for shorebirds, particularly during draw down (low tide) conditions. However, intertidal areas along most of the perimeter of the pond and adjoining coves are dominated by > 90% coverage of the invasive species *Phragmites*.

The width of the *Phragmites* along the perimeter ranges from 1 to 40 feet with an average height of 15 feet. Desirable marsh vegetation is more common at the northern end of the site, where freshwater input is higher. Species include a diversity of sedges, rushes, jewelweed (*Impatiens capensis*), blue flag (*Iris versicolor*), marsh elder, sweet gale, and arrowood, but also includes potentially invasive species that are tolerant of freshwater conditions such as cattail (*Typha* spp) and purple loosestrife (*Lythrum salicaria*).

South of the pond (i.e., oceanside), there is a large wide cut in the dune that allows for occasional overflow from the ocean into the pond under extreme storm events. Flow into the pond is otherwise manually controlled via a tide gate. Dunes to either side of the pond have been restored to foredune height and widths, and replanted with beachgrass. Sand fence, holiday trees, and other wood debris is scattered throughout the dune area. The upper beach community is very narrow and includes a groin field as shown in the photo above. The beach is in general not accessible to the public and use of the area by local residents is moderate.

Surrounding development influences the bayside shoreline and estuarine processes at the site and the flow of saline water from the ocean into the tidal pond is unnaturally controlled via a tide gate. As a result, the shoreline fringe of the tidal pond is dominated by *Phragmites*. Despite this, desirable plant and wildlife communities are flourishing in area. Except for the low-lying area at the tide gate, the dune development and evolution process and cross-island transport processes are negatively effected by residential development close to the foredune areas, sand fence, vehicle traffic on the upper beach, and beach maintenance activities (i.e., sand deposition and dune building). This activity mimics sand accretion, which may or may not be the natural trend in this area. The long shore transport process is affected by the presence of several groins in the area.

**Restoration Alternative T-9-1, *Phragmites* Control Within Georgica Pond**

The objective of T-9-1 is to control invasive *Phragmites* in Georgica Pond to restore the 122 acres of intertidal area of Georgica Pond. Specific components of T-9-1 include:

- Mow, cut, and excavate 50 ac of shoreline to enhance tidal flushing to control *Phragmites;*
- Remove 30 ac of material from site; and,
- Plant 17 ac of shoreline with salt marsh species.

Efforts will focus on approximately 50 acres of the BAYSUBSAV community where *Phragmites* is most problematic. Herbicide use is recommended, but not supported by local communities. Therefore control measures will include the manual removal of *Phragmites* and associated rhizomes through mowing/cutting and excavation to reduce thatch material and lower the shoreline elevation. The resulting reintroduction of regular tidal flushing is expected to increase salinity levels and promote conditions for desirable species. This effort will focus on 122 acres of Georgica Pond proper. The alternative will also include some spot planting of desirable salt marsh species on approximately 1/3 of the excavated area (17 ac) as needed to stabilize the site. Species would include emergent wetland species such as salt marsh cordgrass, salt meadow hay, seashore saltgrass, and black grass, and wetland shrubs such as marsh elder, blueberry, bayberry, and groundsel tree.

Restoration measures are expected to enhance conditions of the BAYBEACH community through the removal of *Phragmites*. Improvements to HSI variables include percent cover of vegetation, invasive species, species richness, and barriers to wildlife, as shown in Appendix G. Because this is a relatively closed system, improvements to the species richness variable are also expected in the BAYSUBSAV community through improvements to the shoreline of the pond. The grade of the existing BAYBEACH community will be modified, but the overall width/size would not.

This alternative would positively effect the estuarine coastal processes by removing invasive *Phragmites*, improving tidal flushing of the site, and enhancing the tidal marsh shoreline through restoration of grades that would support natural vegetation.

**Restoration Alternative T-9-2, *Phragmites* Control in Cove**

The goal of T-9-2 would focus on the restoration of intertidal area located within the cove in the eastern portion of the study site and hydrologically connected to Georgica Pond. Specific components for T-9-2 include:

- Mow, cut, and excavate 10 ac of shoreline to enhance tidal flushing to control *Phragmites;*
- Remove 8 ac of material from site; and,
- Plant 3 ac of shoreline with salt marsh species.

Proposed control measures are the same as with Alternative 1, and efforts will focus on an additional 10 acres of the shoreline within the cove. The alternative would also include spot planting of desirable salt marsh species on approximately 1/3 of the site (3 ac) to stabilize excavated areas.

Restoration measures are expected to enhance conditions of the BAYBEACH community through the removal of *Phragmites*. Improvements to HSI variables include percent cover of vegetation, invasive species, species richness, and barriers to wildlife, as shown in Appendix G. Because this is a relatively closed system, slight improvements to the species richness variable are also expected in the BAYSUBSAV community through improvements to the shoreline of the cove. The grade and species composition of the existing BAYBEACH community will be enhanced, but the overall width/size would not.

This alternative would positively effect the estuarine coastal processes by removing invasive *Phragmites*, improving tidal flushing of the site, and enhancing the tidal marsh shoreline through restoration of grades that would support natural vegetation.

**Restoration Alternative T-9-3, Groin Removal and Dune Restoration**

The goal of T-9-3 is to remove three groins and restore habitat on the beach and dunes. Components of T-9-3 include:

- Remove three stone groins;
- Add 35 ac of sand fill to restore dune at 1,750 lf wide cut, and 26 ac to enhance existing dune;
- Grade 8.3 ac new dune and regrade 5,500 lf (26 ac) of enhanced dune;
- Plant 2 ac of dune grass on new dune and 7 ac of dune grass on enhanced dunes;
- Install a tidal gate for Georgica Pond; and,
- Remove 2,000 lf (9.5 ac) of fence.

Approximately 2 ac of the OCEANBEACH and VEGBEACH communities will be restored beneath the groins and at a cut located directly in a front of Georgica Pond. Efforts would also include enhancing 1,750 feet of existing dune area that surrounds the cut, and 5,500 lf of dune in front of developed areas to either side of Georgica Pond. Dunes would be restored to foredune height, slope, width, and planted with dunegrass cover such as American beachgrass, beach plum, seaside goldenrod, and beach heather. A gate system would be installed to allow for manual control of tidal flushing in the pond. Sand fence and similar sand retention structures would be removed from approximately 2,000 feet of the existing dune areas. The VEGBEACH community would be increased in width to 120 feet and the upper 40 feet of the VEGBEACH community along 7,500 feet of the shoreline would planted as needed to stabilize the community.

Restoration measures are expected to enhance the existing DUNEGRASS, VEGBEACH, and OCEANBEACH communities and would result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The HSI variable for shoreline modification for the baybeach community would decrease as a result of installation of a tide gate in the shoreline of Georgica Pond under this alternative. Approximately 11.61 ac of OCEANBEACH and 3.3 ac of

BAYBEACH would be converted to 7.5 ac of VEGBEACH and 7.5 ac of DUNEGRASS habitat with this alternative; these changes are reflected in HEP HU calculations.

Because this alternative includes the removal of groins, removal of structures within the existing dunes, restoring the dune at a large cut, and beach widening, it is expected to positively affect the longshore sediment transport and dune development and evolution processes. Improved tidal flushing and the ability to monitor and manage this flushing using a tide gate is also expected to result in positive impacts to the estuarine coastal process. However, cross-island transport would be negatively affected from closing and increasing elevation of the low-lying areas of the dune, and the dune development and evolution processes may also be negatively affected by unnatural deposition of sand when enhancing existing dunes and beaches. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**T-10 EAST INLET ISLAND**

As with most man-made dredge islands in the study area, the restoration site at East Inlet Island (T-10) is characterized by habitats representative of four of the six HEP communities that are characteristic of a bayside island community. These habitats comprise sandy upland and dune areas surrounded by intertidal communities dominated by *Phragmites*. Dense *Phragmites* and steep slopes along some of the island perimeter pose significant obstacles to access for some wildlife species.

The areas of most recent dredge deposition are sparsely vegetated. But, there is evidence of previous restoration planting efforts on this site, which includes about 5% cover of planted beachgrass and salt marsh goldenrod, as well as about 25% cover of *Phragmites*, sea rocket and beach pea. *Phragmites* composition increases moving down slope from the highest part of the island to nearly 95% cover in the intertidal areas. Upland areas include species such as rose, poison ivy, milkweed, raspberries, and several mulberry trees that at the time of the survey had black-crowned night herons roosting in them. The substrate in upland areas is currently dominated by silty material and is of low-suitability for nesting shorebird species.

The northwest and western side of the island is experiencing significant erosion. Shoreline banks in these areas are up to 10 feet in height with nearly sheer slope faces. Sediment from the eroding island is being transported along the island perimeter and much of it has been deposited to the southeast of the island, forming a direct connection between the island and the mainland. This sand spit is exposed at low tide and provides foraging and loafing habitat for shorebirds. The primary focus of restoration activities on this dredge island is to make the island substrate suitable for nesting target species, stabilize the island shoreline, maintain vegetation to support shorebird nesting, and managing the island for long-term breeding and nesting habitat for shorebirds.

Although, located within bays, bay islands have communities representative of those found on the barrier island and are affected by similar coastal processes. Except for the long-shore transport process, all other processes are applicable to bay island communities. Generally, the cross-island process is actively occurring on East Inlet Island as sand from the dune face of the island is washed over and around the island to form productive tidal flats and low-lying areas that support intertidal vegetation. However, boat traffic and currents negatively affect the dune development process as the relatively unstable dunes are being scarped at an accelerated rate and sand is being moving away from the dune face. No new natural input of sand is occurring on the islands and new dunes are not being formed as a result of the dune erosion. Bayside shorelines and estuarine processes are also somewhat negatively affected by wave action and currents in the bay as the wave action erodes shorelines at an accelerated rate and prohibits establishment of salt marsh communities. However, although portions of East Inlet Island are negatively effected, a large, diverse salt marsh community and tidal flat have formed in protected areas on the southeast side of the island.

**Restoration Alternative T-10-1, Shorebird Nesting Habitat**

The goal of T-10-1 is to create shorebird-nesting habitat by regrading/removing vegetation on existing DUNEGRASS areas and to add sandy fill material to improve nesting substrate to promote use of the areas by breeding/nesting shorebirds. Specific components include:

- Regrade 5 acres of densely vegetated DUNEGRASS;
- Add several feet of sandy material suitable for nesting shorebirds; and,
- Remove 2 ac of rubbish/excess vegetation from site.

To create conditions more favorable for shorebird nesting, restoration measures would include the regrading of approximately 5 acres of the 11 acres of existing DUNEGRASS to remove *Phragmites* and other dense vegetation, and adding several feet of sandy fill material that is of a size/texture suitable for nesting shorebirds. Sand material would likely need to be at least 3 feet in depth to adequately cover the existing silt material. Modifications would also include regrading of some areas of the shoreline to provide access points for wildlife to move between upper island areas and the shoreline.

Restoration measures are expected to enhance conditions of the existing DUNEGRASS community by regrading and removing high densities of vegetation. Improvements to HSI variables include percent cover of vegetation, species richness, invasives, slope, barriers to wildlife, and slight improvement to width, as shown in Appendix G. No changes in community types are anticipated.

Alternative T-10-1 would improve upland conditions by removing invasive *Phragmites* and would provide habitat for state and Federally-listed species.

**Restoration Alternative T-10-2, *Phragmites* Control**

The goal of T-10-2 is to enhance the existing BAYBEACH community by using herbicides to control *Phragmites*. Specific components include:

- Herbicide control of *Phragmites* across approximately 16 acres.

Restoration measures would include removal of *Phragmites* from 16 acres of the existing BAYBEACH community.

Restoration measures are expected to enhance conditions of the BAYBEACH community through the removal of *Phragmites*. Improvements to HSI variables include, invasive species, species richness, and barriers to wildlife, as shown in Appendix G. None of the existing communities will gain or lose acreage as a result of this alternative.

This alternative would improve estuarine processes by removing invasive species from the existing salt marsh.

**Restoration Alternative T-10-3, Shoreline Stabilization**

The goal of T-10-3 is to use bio-engineering measures to stabilize eroding island shoreline and reduce further loss of material from the island. Specific components include:

- Regrade 3,700 feet (18 ac) of shoreline;
- Place 3,700 lf of vegetated gabion basket along the shoreline; and,
- Plant 13 ac of salt marsh shrubs in gabion structures and along shoreline.

Regrading of the entire shoreline would be required, and deposition of material into some intertidal areas of the island would be necessary in order to reshape and stabilize the island, however no conversion of community type is expected. Vegetated gabions (a bioengineering measure) will be used to stabilize the eroding shoreline where flow velocities are believed to exceed 6 ft/sec. Bioengineering measures such as vegetated gabions combine live plant materials with structural engineering techniques to stabilize slopes and stream banks (see attached figure). These techniques provide a more cost-effective, aesthetically pleasing, and environmentally acceptable stabilization measure than the once widely accepted concrete and riprap stabilization measures.

This alternative is likely to impact the BAYSUBSAV, BAYBEACH and DUNEGRASS communities as regrading and bioengineering is used to stabilize these areas, but overall there would be no change in acres for these community types. Improvements to HSI variables include percent cover of vegetation, species richness, barriers to wildlife, slope, and in addition would halt further erosion of the shoreline and these communities, as shown in Appendix G. Upland areas would also see a slight improvement to percent vegetation over time, as the stabilization measure will reduce loss of this habitat. However, there would be some negative impact to the shoreline modification variable due to the Place a permanent man-made structure on site.

This alternative would improve bayside and estuarine processes by creating a relatively stable, vegetated shoreline, with appropriate slope to support salt marsh species.

## T-11 JOHN BOYLE ISLAND

As with most dredge islands in the study area, steep eroding banks, sparsely vegetated sandy uplands and dunes, and a predominance of the invasive species *Phragmites* characterize John Boyle Island. A well-established gull colony has colonized the sparely vegetated open sandy areas of the site. These birds can be extremely aggressive and deter use of the site by other species. Seaside goldenrod, *Phragmites*, sea rocket, and beachgrass cover about 20% of the upland and dune area.

Dense *Phragmites* and steep slopes along some of the island perimeter pose significant obstacles to access for some wildlife species. Upland areas include a few scattered sumac and poplar trees. No birds were observed roosting in these areas during site visits. Steep scarping banks were on average 4 feet in height. Sediment from the eroding island is being transported along the island perimeter and much of it has been deposited to the east and southeast of the island. This sand spit is exposed at low tide and provides foraging and loafing habitat for shorebirds.

Sand from the dune face of the island is washed over and around the island to form productive tidal flats and low-lying intertidal areas that support the cross-island process on John Boyle Island. However, boat traffic and currents negatively affect the dune development process as the relatively unstable dunes are being scarped at an accelerated rate and sand is being moving away from the dune face. As with other dredge islands in the area, no new natural input of sand is occurring on the islands and new dunes are not being formed as a result of the dune erosion. Bayside shorelines and estuarine processes are also somewhat negatively affected by wave action and currents in the bay as the wave action erodes shorelines at an accelerated rate and prohibits establishment of salt marsh communities. Despite this, a relatively small *Phragmites*-dominated salt marsh, and intertidal zone have formed on the east side of the island.

### Restoration Alternative T-11-1, Shorebird Nesting Habitat

Similar to efforts for East Inlet Island, the goal of T-11-1 is to create shorebird nesting habitat by regrading/removing vegetation on existing DUNEGRASS areas to promote use of the areas by breeding/nesting shorebirds, and using herbicide to control *Phragmites*. Specific components of T-11-1 include:

- Regrade 2.9 ac of dunegrass;
- Remove 1 ac of rubbish/undesirable plant material from site; and,
- Apply herbicides to 4-ac area to control *Phragmites.*

Activities include regrading of the DUNEGRASS community as needed to create vegetation densities more favorable for shorebird nesting and to provide shoreline access points for wildlife, the removal of *Phragmites* from 4 ac of upland, dune, and BAYBEACH intertidal areas.

Restoration measures would be designed to enhance conditions of the UPLAND, DUNEGRASS and BAYBEACH community. Improvements to HSI variables include percent cover of vegetation, invasive species, and species richness, and barriers to wildlife, as shown in Appendix G. Communities may be regraded and enhanced through vegetation changes, but acreages would not change.

This alternative would improve upland conditions by removing invasive *Phragmites*, and would provide habitat for state and Federally-listed species.

**Restoration Alternative T-11-2, Create Upland Habitat**
The goal of T-11-2 is to convert existing DUNEGRASS to UPLAND habitats to promote use of the area by breeding and nesting heron species. Specific components of T-11-2 include:

- Regrade 1.7 ac of dunegrass and 0.1 ac of steep shoreline;
- Remove 0.25 ac of rubbish/undesirable vegetation form site;
- Add 1.7 ac of topsoil; and,
- Plant 1.7 ac of upland with trees and shrubs.

Measures would include adding approximately 6 ac of sand and regrading the DUNEGRASS community as needed to create appropriate elevations, and the addition of 3 ac of topsoil to improve growing substrate for trees/shrubs. Modifications would also include regrading and vegetation removal in 0.1 ac to provide shoreline access for wildlife.

Restoration measures are expected to enhance conditions of the UPLAND community and would convert 1.7 ac of existing DUNEGRASS to UPLAND. Improvements to HSI variables include percent cover of vegetation, invasive species, species richness, and barriers to wildlife, as shown in Appendix G.

This alternative would improve upland conditions and would provide habitat for species of special concern.

**Restoration Alternative T-11-3, Stabilize Shoreline**

The goal of T-11-3 is to use bio-engineering measures to stabilize approximately 1,500 feet of eroding island shoreline. Specific components include:

- Regrade 1,500 ft (7.2 ac) of shoreline;
- Place 1,500 lf of vegetated gabion basket along the shoreline; and,
- Plant 5 ac of salt marsh shrub vegetation in gabion structures and along shoreline.

Regrading of the entire shoreline would be required, and deposition of material into some intertidal areas of the island would be necessary in order to reshape and stabilize the island, however no conversion of community type is expected. Vegetated gabions (described in alternative T-10-3) will be used to stabilize 1,500 feet of the existing shoreline. The remaining shoreline would be regraded as needed, but bio-engineering measures would not be used in these areas to preserve the existing shorebird forging mudflat area.

This alternative is likely to impact the BAYSUBSAV, BAYBEACH and DUNEGRASS communities as regrading and bioengineering is used to stabilize these areas, but overall there would be no change in acres for these community types. Improvements to HSI variables include percent cover of vegetation, species richness, barriers to wildlife, slope, and in addition would halt further erosion of the shoreline and these communities, as shown in Appendix G. Upland areas would also see a slight improvement to percent vegetation over time as the stabilization measure will reduce loss of this habitat. However, there would be some negative impact to the shoreline modification variable due to the Place a permanent man-made structure on site.

This alternative would improve bayside and estuarine processes by creating a relatively stable, vegetated shoreline, with appropriate slope to support salt marsh species.

## T-14 OCEAN BEACH

Ocean Beach (T-14) is a typical highly developed barrier island community. Bayside intertidal areas are limited due to residential and commercial development, bulkheading, marinas, and boat slips that currently dominate the bay side shoreline. Despite this, eelgrass beds are flourishing in permanently innundated areas just off the shoreline, an unusual situation in subtidal habitats in close proximity to dense development. Residential housing, commercial development, and paved roads and trails dominate interior upland and dune areas. Hard structures, sand fence, debris, makeshift sand stabilizers, and pedestrian walkways and access cuts have impacted dunes.

Deteriorated groins occupy the beach and near ocean areas. Groins are notched and are almost completely covered by sand. Portions of the beach are narrow (< 50 feet from toe of dune to average high water line) and the beach is experiencing significant seasonal scarping at the high water line as documented in the above photograph. Recreational use of the beach by pedestrians is high and there is use of vehicles on the beach. In protected areas of the dune (i.e., behind sand fences) dunes overall are well-vegetated with 50% cover of beachgrass.

The bayside shoreline and estuarine processes at the Ocean Beach site have been negatively impacted and appear to be most effected by hard structures such as extensive bulk heading, boat slips, buildings and various human activities in the area, particularly those associated with the highly developed community of Ocean Beach. Impacts have directly and indirectly affected the shoreline, intertidal, and aquatic areas of the site. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, residential housing, and other hard structures within upland and dune areas, and overall direct human use of the area.

**Restoration Alternative T-14-1, Hard Structures on Beach**
The goal of T-14-1 is to enhance and restore the dune beach by removing groins and wells. Specific components of T-14-1 include:

- Remove two groins;
- Relocate the Ocean Beach water supply well and all associated structures, which are currently located in the dune area in the vicinity of the easternmost groin; and,
- Regrade 0.23-ac area.

Restoration measures are expected to convert approximately 0.50 ac of disturbed area to an additional 0.13 ac of OCEANBEACH, 0.10 ac of VEGBEACH, and 0.23 ac of DUNEGRASS and would result in improvements to the HSI variables for these communities which include shoreline modifications and impacts from human disturbance as shown in Appendix G.

Because this alternative includes the removal of groins, and removal of well structures within the existing dunes, it is expected to positively affect the longshore sediment transport and dune development and evolution processes.

**Restoration Alternative T-14-2, Upper Beach and Dunes**

The goal for T-14-2 includes enhancing the upper beach/dune width/slope/height, reducing disturbance by removing sand fence, raising boardwalks above dunes, and restoring the dune at walkways/cuts. Specific components of T-14-2 include:

- Remove 1,200 lf of sand fence;
- Raise walkways above dunes;
- Regrade 1,600 lf (7.6 ac) of dune face to enhance slope, height, and width and restore dune cuts;
- Use 7.6 ac of sand fill to enhance dunes and fill cuts; and,
- Plant 2 ac of dune with dunegrass.

Specifically, T-14-2 would include removing sand fence within approximately 1,200 feet of the existing dune, raising and replacing seven walkways and restoring the dune beneath them. Approximately 1,600 feet of the existing dune face would be regraded to a slope of approximately 20 to 25%, planting the dune face with approximately 40% cover of vegetation, widening the VEGBEACH community to 120 feet, and the upper 40 feet of the VEGBEACH community would be replanted with dune grass species such as beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass.

Restoration measures are expected to enhance the existing DUNEGRASS, VEGBEACH, and OCEANBEACH communities and would result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to be minor, because public access and high use of the beach is expected to continue. Approximately 2.4 ac of OCEANBEACH and 0.2 ac of disturbed habitat would be converted to 2.2 ac of VEGBEACH and 0.4 ac of DUNEGRASS with this alternative.

Alternative T-14-2 includes improving groin and well removal, and significant improvements to dune slope and vegetation, restoring dune areas at access cuts, and beach widening. Accordingly, it is expected to positively affect the longshore sediment transport and dune development and evolution processes. Negative impacts to the cross-island transport process might be expected due to closing off dune cuts. However, overwashing at any location along this area is unlikely due to the significant development in the area. Therefore, no negative effects to processes are expected. In addition, components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

**Restoration Alternative T-14-3, Buyouts**

The goal of T-14-3 is to reduce disturbance through buy-outs and removal of structures within the Coastal Environmental Hazard Zone (CEHA), and the restoration of upper beach/dune width/slope/height in these disturbed areas. Specific components of T-14-3 include:

- Buy-out eight homes;
- Regrade and restore 1,000 lf (4.8 ac) of dunes and disturbed areas;
- Use 4.8 ac of fill to restore sites and create insipient dunes; and,
- Plant 3 ac of dunegrass in dune areas.

Specifically, this alternative will include the buy-out and removal of eight homes currently located oceanward of the CEHA line and within the foredune area. The disturbed area within the structure footprint (1.3 ac) will be restored to DUNEGRASS habitat through regrading and planting, and insipient dunes (slope 5 to 0%, vegetation 20%, and width 25 ft) would be restored in areas of direct dune impact.

Restoration measures are expected to enhance the existing DUNEGRASS, VEGBEACH, and OCEANBEACH communities and would result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to slightly higher than the previous alternative, however, changes are still small because public access and high use of the beach is expected to continue. This measure would result in the conversion of 1.3 ac of disturbed area to DUNEGRASS.

Similar to T-14-2 this alternative is expected to positively affect the longshore sediment transport and dune development and evolution processes. Effects are expected to be greater for the dune development process under this alternative, because the structures being removed have a larger impact on the dune system. Components of this alternative (i.e., dune enhancement and replacement) would support storm damage reduction project objectives.

## T-15 NEW MADE ISLAND

Overall, sparsely vegetated upland and dune portions of New Made Island are limited. At the highest elevation on the island there is a small sandy area characterized by approximately 35% cover of seaside goldenrod, salt marsh aster, *Phragmites*, milkweed, poison ivy, and rose. Densities of the desirable species quickly diminishes downslope of this area for most of the island, and vegetated areas become dominated by > 95% cover of invasive *Phragmites*, which occurs in high density even in upland areas. Upland shrubs/trees were limited and included junipers < 10 feet in height. Protected, regularly flooded areas, along the southern edge of the island are dominated by desirable salt marsh species that include *Spartina* spp., black grass, salt marsh aster, glasswort, and shrubs that include marsh elder and groundsel tree.

As with most islands in the study area, dense *Phragmites* and steep slopes along the northern shoreline of New Made Island pose significant obstacles to access for some wildlife species. However, diamond back terrapin were observed nesting in the open sandy portion of the island and tracks on the scarp indicate that access to the site was via the scarped bank. Restoration alternatives will avoid disturbance to the existing DUNEGRASS community and will limit activities within the adjacent upland to *Phragmites* control only in order to protect the terrapin nesting area.

As with other dredge islands in the area, sand from the dune face of New Made Island is washed over and around the island to form productive tidal flats and low-lying intertidal areas that support the cross-island process. However, boat traffic and currents negatively affect the dune development process. Relatively unstable dunes are being scarped at an accelerated rate and sand is being moving away from the dune face. As a result, no new natural input of sand is occurring on the island and new dunes are not being formed as a result of the dune erosion. Bayside shorelines and estuarine processes are also somewhat negatively affected by wave action and currents in the bay as the wave action erodes shorelines at an accelerated rate and prohibits establishment of salt marsh communities. Despite this, a relatively large, *Phragmites*-dominated salt marsh, and itertidal zone have formed within protected low-lying areas of the island and around much of the island perimeter.

**Restoration Alternative T-15-1, Shorebird Nesting Habitat**

The goal of T-15-1 is to convert existing *Phragmites*-dominated intertidal areas to habitat suitable for shorebird breeding and nesting. Components of T-15-1 include:

- Regrade 1.1 ac area to manually control *Phragmites;*

- Remove 0.75 ac of rubbish/undesirable vegetation from site;
- Place 4 ac of sand fill over 1.1 ac of *Phragmites*-dominated BAYBEACH; and,
- Regrade 0.1 ac of steep shoreline bank.

Specifically, sand would be deposited on the island to elevate the grade of the BAYBEACH community to create an open, sandy DUNEGRASS community. Restoration would focus on 1.2-ac area of *Phragmites*-dominated salt marsh (i.e., areas with > 75% cover) and would avoid the approximately 0.5-ac salt marsh area that is currently dominated by suitable salt marsh vegetation such as that shown in the figure above (located on the southern end of the island). Activities would minimize disturbance to existing DUNEGRASS and UPLAND areas to avoid impacts to terrapin nesting areas. Steep banks within a 0.1-acre area would be regraded to improve wildlife accessibility to the site.

Restoration measures are expected to convert *Phragmites*-dominated BAYBEACH to DUNEGRASS. Because *Phragmites* will be manually removed/covered, improvements to HSI variables for the remaining BAYBEACH community are expected to improve somewhat and include percent cover of vegetation, invasive species, and species richness, and barriers to wildlife, as shown in Appendix G. The HSI Scores for the newly created DUNEGRASS would be improved as shown in Appendix G. Under this scenario, the BAYBEACH community would be reduced in size and DUNEGRASS would increase.

Alternative T-15-1 would provide habitat for state and Federally-listed species.

**Restoration Alternative T-15-2, Heron Nesting Habitat**
The goal of T-15-2 is to add fill/topsoil to the existing DUNEGRASS community to create UPLAND habitat suitable for nesting heron. Specific components of T-15-2 include:

- Regrade 0.6 ac DUNEGRASS community;
- Remove 0.2 ac of rubbish/undesirable vegetation from site;
- Add 2 ac of topsoil to graded DUNEGRASS community; and,
- Plant 2 ac of site with trees and shrubs.

Restoration measures are expected to create UPLAND habitat by converting 0.6 acres of DUNEGRASS community to upland. Improvements to HSI variables include percent cover of vegetation, invasive species, species richness, and barriers to wildlife, as shown in Appendix G.

Alternative T-15-2 would provide habitat for species of concern.

**Restoration Alternative T-15-3, Stabilize Shoreline**
The goal of T-15-3 is to use bio-engineering measures to stabilize the eroding island shoreline. Specific components include:

- Regrade 1,400 feet (6.7 ac) of shoreline;
- Place 1,000 lf of vegetated gabion basket along the shoreline; and,
- Plant 4.8 ac of salt marsh vegetation in gabion structures and along shoreline.

Regrading of the entire 1,400 feet of shoreline would be required, and deposition of material into some intertidal areas of the island would be necessary in order to reshape and stabilize the island, however no conversion of community type is expected. Vegetated gabions (described in alternative T-10-3) will be used to stabilize 1,000 ft of the existing shoreline. The remaining shoreline would be regraded as needed, but bio-engineering measures would not be used in these areas to preserve the existing shorebird foraging mudflat area.

Approximately 400 lf of shoreline to the south end of the island will not be stabilized in order to preserve tidal flushing in the existing salt marsh community in the area. Regrading of the shoreline would be required to achieve desired slope (20%), and relocation of sand material into some intertidal areas will be necessary in order to stabilize the island, however, the overall width/size of the BAYBEACH community is not expected to change under this alternative. Dredge material from the island or other sources may be used and may be included as part of dredge material management.

This alternative is likely to impact the BAYSUBSAV, BAYBEACH and DUNEGRASS communities as regrading and bioengineering is used to stabilize these areas, but overall there would be no change in acres for these community types. Improvements to HSI variables include percent cover of vegetation, species richness, barriers to wildlife, slope, and in addition would halt further erosion of the shoreline and these communities, as shown in Appendix G. Upland areas would also see a slight improvement to percent vegetation over time, as the stabilization measure will reduce loss of this habitat. However, there would be some negative impact to the shoreline modification variable due to the Place a permanent man-made structure on site.
This alternative would improve bayside and estuarine processes by creating a relatively stable, vegetated shoreline, with appropriate slope to support salt marsh species.

**T-22 ISLIP MEADOWS (no photos available)**

The Islip Meadows site (part of the county nature preserve) is characterized by a large salt marsh surrounded on two sides by residential development and recreational areas and surrounded on the remaining sides by the Great South Bay and associated manmade channels. The marsh includes numerous linear ditches that were placed in the marsh to drain portions of the marsh surface as a form of mosquito control. Hydrologic connections between the Great South Bay and the marsh are further restricted at various locations along the shoreline where inlets have filled in with sediment. These inlets are associated with a manmade channel and pool located in the eastern section of the site. Tidal flow in the channels and pool is sporadic due to inlet blockage and other hydrologic restrictions on the marsh surface.

Desirable salt marsh species can be found throughout the marsh and include *Spartina* species, black grass, glasswort, sedges, rushes, salt marsh aster, marsh elder, bayberry, arrowwood, as well as a diversity of upland species on higher elevations within the study site. However, portions of the marsh (particularly in the northern and northwestern portion of the site) are dominated by monocultures of *Phragmites* with > 95% cover.

**Restoration Alternative T-22-1, Improve Hydrology**
The goal of T-22-1 is to restore and maintain regular hydrological connection between the marsh and Great South Bay via stabilized inlets. Two inlets are currently located along the bay shoreline but have filled in with sediment. Specific components of T-22-1 include:

- Excavate and remove 0.5 ac of sediment from inlet channels; and,
- Install two 48" aluminum flap gates at inlets to maintain tidal flow.

This alternative requires excavation of approximately 0.5 ac to remove sediment, and maintenance measures to ensure the long-term hydrologic connection. The installation of two flap gates is proposed to achieve and maintain adequate tidal flow and allow for management of hydrology on the marsh surface. A more natural hydrologic regime on the marsh surface is expected to improve the suitability of the marsh for desirable species.

Restoration measures are expected to enhance conditions of the existing salt marsh (BAYBEACH) community. Improvements to HSI variables include percent cover of vegetation, and some improvement to invasive species, and species richness, as shown in Appendix G. However, the HSI score for shoreline modification will be reduced due to installation of culverts or tide gates on site. Under this scenario, there would be no changes to acreages.

Alternative T-22-1 would positively affect estuarine coastal process by improving tidal flushing and flow throughout the marsh and making the site more favorable for desirable salt marsh species.

**Restoration Alternative T-22-2, Reconfigure Tidal Channels**
The goal of T-22-2 is to create tidal channels with a more natural (i.e., sinuous) configuration. Specific components of T-22-2 include:

- Excavate and remove 2,600 lf (12.5 ac) of marsh to create a more sinuous (natural) channel configuration.

Specifically, marsh areas surrounding the relatively linear man-made channel associated with the pond at this site will be modified to create a more sinuous channel configuration. Some excavated material would be reused on site as part of reconfiguring the existing channel, but most will be removed from the site

This alternative is not expected to result in changes to HSI scores in addition to the changes anticipated from Alternative 1. However, under this scenario there would be a gain in acreage of BAYSUBSAV and a loss for BAYBEACH as some salt marsh areas would be converted to create a sinuous permanently flooded channel.

Similar to alternative T-22-1, this alternative would positively affect estuarine coastal process by improving tidal flushing and flow throughout the marsh and making the site more favorable for desirable salt marsh species. Positive effects from this alternative are expected to be greater than with alternative T-22-1.

**Restoration Alternative T-22-3 Create Saltmarsh Pools, Control *Phragmites***
The goal of T-22-3 would be to create pool habitat and control *Phragmites* throughout the site. Specific components of T-22-3 include:

- Plug 10 ditches;
- Excavate 0.5 acres in high marsh areas to create pool habitat; and,
- Apply herbicide to 45 ac to control *Phragmites.*

The purpose of the ditch plugging would be to increase the hydroperiod on the marsh surface. Excavation of approximately 0.5 ac in high marsh areas would be intended to create pool habitat. Herbicide control of *Phragmites* would occur throughout the approximately 45-ac site, particularly in the northern portion of the marsh where the invasive species has formed dense monocultures. *Phragmites* removal methods will include herbicide application and flooding. It is assumed that excavated material from created pool areas would be reused on site to plug ditches.

Restoration measures are expected to enhance conditions of the existing salt marsh (BAYBEACH) and create additional permanently flooded areas (BAYSUBSAV) within the marsh system. As a result there would be some improvements to HSI variables include reducing invasive species, and improving species richness, as shown in Appendix G. This measure is expected to do a better job at invasive species control than alternative 1 and this is reflected in HSI scores. Under this scenario there would be a gain in acreage of BAYSUBSAV and a loss for BAYBEACH as some salt marsh areas would be converted to permanently flooded pools.

This alternative would also positively affect estuarine coastal process by improving tidal flushing and flow throughout the marsh and making the site more favorable for desirable salt marsh species. Positive effects from this alternative are expected to be greater than with alternative T-22-1 and T-22-2.

## T-23 SEATUCK REFUGE (no photos available)

The Seatuck site (part of the U.S. Fish and Wildlife Service's Wildlife Refuge) is characterized by a relatively large salt marsh surrounded on two sides by residential development and surrounded on the remaining sides by the Great South Bay and Champlain Creek. The marsh includes numerous linear ditches that were placed in the marsh to drain portions of the marsh surface as a form of mosquito control, and several disturbed areas associated with dredge/fill deposition sites. Three culverts located along the south shore of the site were intended to provide hydrologic connections between the Great South Bay and the marsh. However, culverts are undersized and/or degraded and as a result hydrologic flow to the marsh is restricted at these locations. Various areas of shoreline along Champlain Creek have been bulkheaded and as a result have minimal to no intertidal zone.

Desirable salt marsh species can be found throughout the marsh and include *Spartina* species, black grass, glasswort, sedges, rushes, salt marsh aster, marsh elder, bayberry, arrowwood, as well as a diversity of upland species on higher elevations within the study site. However, portions of the marsh (particularly in the southern and southeastern portion of the site) are dominated by monocultures of *Phragmites* with > 95% cover.

### Restoration Alternative T-23-1, Improve Hydrology

The goal of T-23-1 is to convert approximately 6 ac of disturbed area to salt marsh and restore and maintain regular hydrological connection between the marsh and Great South Bay via stabilized inlets or culverts. Specific components of T-23-1 include:

- Remove and replace three existing culverts with 48" diameter pipe;
- Remove 6 ac of undesirable fill material to create wetlands; and,
- Plant 6 ac of salt marsh vegetation.

Three culverts are currently located along the bay shoreline but do not provide adequate hydrologic flow into the marsh. As a result, the lower portion of the marsh is dominated by *Phragmites*. T-23-1 includes measures to replace existing culverts with three 48-inch culverts of adequate size to restore and maintain long-term hydrologic connection. A more natural hydrologic regime on the marsh surface is expected to improve the suitability of the marsh for desirable species and reduce the coverage of some of the *Phragmites* currently found on the marsh. In addition dredge/fill deposition sites will be excavated to a depth appropriate for establishment of a brackish wetland shrub community and the sites will be replanted with native shrub species including 4 ac of emergent wetland species such as salt marsh cordgrass, salt meadow hay, seashore saltgrass, and black grass, and 2 ac of wetland shrubs such as marsh elder, blueberry, bayberry, and groundsel tree to facilitate establishment of the marsh. .

Restoration measures are expected to convert disturbed dredge/fill sites to salt marsh and to enhance conditions of the existing salt marsh (BAYBEACH) community by restoring hydrology to the marsh surface. Improvements to HSI variables include percent cover of vegetation, invasive species, and species richness, as shown in Appendix G. HSI score for Shoreline modification is lowered due to installation of culverts or tide gates on site. Under this scenario there would be an increase in acreage for BAYBEACH.

T-23-1 would positively effect estuarine coastal process by improving tidal flow, removing invasive species and fill material and making the estuarine system more favorable overall to desirable species.

**Restoration Alternative T-23-2, Saltmarsh and *Phragmites***

The goal of T-23-2 is to reconfigure existing tidal channels to a more natural state and control *Phragmites* with herbicides, particularly in the southern portion of the marsh where the invasive species has formed dense monocultures. Specific components of T-23-2 include:

- Excavate and remove 2,500 lf (12 ac) of marsh to create a more sinuous (natural) channel configuration; and,
- Apply herbicides to 90 ac to control *Phragmites.*

Specifically, marsh areas surrounding the relatively linear man-made channel that bisects the site from east to west will be modified to create a 2,500 lf sinuous channel. Excavated material would be reused on site as part of reconfiguring the existing channel. *Phragmites* control measures will be implemented throughout the 90-ac site and will include herbicide application and flooding.

Restoration measures will serve to control *Phragmites* on the marsh, and improvements to HSI variables include percent cover of vegetation, invasive species, and species richness, as shown in Appendix G. Under this scenario there would be a gain in acreage of BAYSUBSAV and a loss for BAYBEACH, as some salt marsh areas would be converted to create a sinuous permanently flooded channel. The size of each of these communities is expected to change slightly, and this change is reflected in HEP HU calculations.

Similar to alternative T-23-1, this alternative would positively affect estuarine coastal process by improving tidal flushing and flow throughout the marsh and the removal of *Phragmites*, thus making the site more favorable for desirable salt marsh species. Positive effects from this alternative are expected to be greater than with alternative T-23-1.

**Restoration Alternative T-23-3, Remove Bulkhead, Create Salt Marsh**

The goal of T-23-3 would remove the existing bulkhead along the western shoreline of Champlain Creek to restore the intertidal zone and create salt marsh habitat. Specific aspects of T-23-3 would include:

- Remove 1,700 lf (8.1 ac) of bulkhead;
- Regrade 1,700 lf of shoreline;
- Use 2 ac of fill to restore shoreline grade;
- Plant 2 ac of salt marsh vegetation; and,
- Install coir logs to stabilize 1,700 lf of shoreline.

The 1,700 lf area would be regraded as needed to create a suitable transition from low marsh into upland, and techniques such as coir-logs or geo-textile tube would be used to stabilize 1,700 lf of shoreline bank (assuming that velocities and slope or conducive to this stabilization measure). Intertidal areas would be replanted with approximately 2 ac of native salt marsh species including 1.5 ac of emergent wetland species such as salt marsh cordgrass, salt meadow hay, seashore saltgrass, and black grass, and 0.5 ac of wetland shrubs such as marsh elder, blueberry, bayberry, and groundsel tree to facilitate establishment of the marsh. Dredge material may be utilized to restore grade in support of dredge material management activities.

Restoration measures are expected to convert disturbed (bulkheaded) areas to BAYBEACH. Improvements to HSI variables include percent cover of vegetation, invasive species, and species richness, as shown in Appendix G. The size of each of these communities is expected to change slightly and this change is reflected in HEP HU calculations.

This alternative would positively affect estuarine coastal and bayside shoreline processes by returning the shoreline to a more natural vegetated state and increasing the salt marsh in the area.

## T-24 DAVIS PARK (no photos available)

Similar to other barrier island residential communities, Davis Park is characterized by commercial development, bulkheading, marinas, and boat slips that dominate the bayside shoreline, and residential housing, commercial development, paved roads and trails that dominate upland and dune areas. Dunes at this site have been significantly impacted by the Place hard structures within foredunes, sand fence, debris, pedestrian walkways, and a large 500-foot vehicle access cut. Portions of the beach are narrow (< 70 feet from toe of dune to average high water line) and the beach is experiencing significant seasonal scarping at the high water line. In the center of Davis Park there is approximately a 1000-ft section where the dune is essentially absent or very low. The low dune is the result of anthropogenic actions for recreational benefit and not natural processes. Public access to the beach throughout Davis Park is via cuts in the dune, rather than boardwalks that cross above the dunes and thus interfere with dune development and evolution. In addition, there is a dune cut for vehicle access in the approximately 1,000 ft low dune area. Recreational use of the beach by pedestrians is high and vehicles are permitted on the beach. The driving regulations, developed under NPS negotiated rule making, call for the relocation of all driving from the beach to the interior road.

As with other highly-developed areas of the barrier island, the bayside shoreline and estuarine processes at Davis Park have been negatively impacted and appear to be most effected by hard structures such as extensive bulk heading, boat slips, buildings and various human activities in the area, particularly those associated with the highly developed community. Impacts have directly and indirectly affected the shoreline, intertidal, and aquatic areas of the site. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, residential housing, and other hard structures within upland and dune areas, and overall direct human use of the area. The negative impacts to the cross-island process could be somewhat offset by a large cut in the dune that allows for vehicle access to the beach. However, even if an overwash were to occur at the dune cut, significant alterations and hard structures bayside would severely inhibit environmental benefits that would normally be expected from an overwash event.

**Restoration Alternative T-24-1, Create Dune**

The goal of T-24-1 is to restore the dune by closing off a 500 foot wide area of dune cut (1 ac) located at the vehicle access cut and convert the disturbed area to DUNEGRASS. Specific components of T-24-1 include:

- Regrade and restore insipient dune at 500 lf (2.4 ac) access cut;
- Add 1.2 ac of sand fill material to close of the vehicle access cut; and,
- Plant 0.6 ac of dune grass.

The restored dune would have characteristics similar to incipient dunes (i.e., DUNEGRASS slope 5 to 10%, vegetation 20%, and width 25 ft) rather than large foredunes (i.e., slope 20 to 25%, and width 50 ft). Planting would be conducted as needed to stabilize the area. The incipient dune would close an existing vehicle cut. However, there are dune cuts at Watch Hill and Blue Point Beach located on either side of Davis Park, thus this cut is not essential to provide for the direction of traffic from the beach to the interior road.

Restoration measures would convert disturbed habitat to DUNEGRASS. Human disturbance and human impact HSI variable scores for the new dune will improve as a result of this activity because a large access point for vehicles will be closed off. However, because the site is small relative to the beach and dune found it the overall area, the activity will not result in any significant changes tot eh HSI score for the overall site.

T-24-1 is expected to result in somewhat positive effects on the dune development and evolution process and a slightly negative effect on the cross-island transport process due to creation of a dune in the area most susceptible to overwashing. This effect is only slightly negative due to the insipient nature of the dune. Components of this alternative (i.e., dune enhancement and Place insipient dunes at existing cuts) would support storm damage reduction project objectives.

**Restoration Alternative T-24-2, Upper Beach and Dune**

The goal of T-24-2 is to enhance approximately 4,700 lf of existing dune to create conditions similar to a young insipient dune, and convert disturbed dunes areas to dune. Specific components of T-24-2 include:

- Raise 16 walkways;
- Remove 2,700 lf (13 ac) of sand fence;
- Regrade and enhance dune slope, width and height along 3,500 lf (16.8 ac) of shoreline;
- Use 8.4 ac of fill material to enhance dune areas; and,
- Plant 4.2 ac of dune grass.

Sixteen (16) walkways from residential areas will be replaced at elevations above the dune, and insipient dunes (slope 5 to 10%, vegetation 20%, and width 25 ft) will be restored beneath them. Sand fence and similar sand retention structures would be removed from approximately 3,500 lf of dune. Enhanced and created dunes would have characteristics similar to insipient dunes (slope 5 to 10%, vegetation 20%, and width 25 ft) rather than large foredunes.

Restoration measures would convert disturbed habitat to DUNEGRASS and would enhance conditions of existing dune areas. Because Alternative 2 would affect the overall dune area and beach area of the site, some improvements to HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to be minor, because public access and high use of the beach is expected to continue. These changes will reflect insipient dune conditions.

T-24-2 is expected to result in a positive effect on the dune development and evolution process and a slightly negative effect on the cross-island transport process due to creation of a dune in the area most susceptible to overwashing. This effect is only slightly negative due to the insipient nature of the dune. Components of this alternative (i.e., dune enhancement and Place insipient dunes at existing cuts) would support storm damage reduction project objectives.

**Restoration Alternative T-24-3, Buyouts**

The goals of T-24-3 are to reduce disturbance in the CEHA zone through buy-outs and structure removal, the restoration of upper beach/dune width/slope/height in these areas, and restoration of portions of disturbed upland surrounding marina (no marina removal). Specific components of T-24-3 include:

- Remove the Casino Restaurant and hard structures directly associates with this establishment;
- Regrade and convert 2.1 ac of disturbed habitat within structure footprints to DUNEGRASS; and,
- Plant 2.1 ac of dune vegetation within footprint.

Removal of the Casino Restaurant would allow for future migration of the dune at Davis Park and would contribute to dune development and evolution as well as storm damage protection. This alternative would also include the conversion of 2.1 ac of disturbed area adjacent to the marina to upland habitat by restricting vehicle access and replanting the site with 2 ac of upland species such as post oak, sassafras, cherry, and serviceberry. Sandy-loam dredge material would be added to improve suitability of substrate for upland species.

The conversion of 2.9 ac of disturbed area would result in an increase in 0.8 ac of DUNEGRASS and 2.1 ac of UPLAND. HSI scores for percent cover and magnitude of human impact would also improve slightly through plantings and restrictions to access to this area.

T-24-3 is expected to result in positive effects on the dune development and evolution process and a negative effect on the cross-island transport process due to restoration of the upland and dunegrass communities.

### T-25 ATLANTIQUE TO CORNEILLE (no photos available)

The area from Atlantique to Corneille (T-25) includes habitat representative of the six HEP community model types. The site is similar to the Reagan site in that well-vegetated upland and dune areas characterize the site and these communities are located adjacent to densely populated residential communities. Bayside portions of the shoreline are bulkheaded and include boat docks and commercial development. Other areas of the shoreline are experiencing accelerated rates of erosion, which is severe in some areas. Vehicle cuts and pathways are interspersed throughout the upland and dune communities and cuts in the dune provide access to the beach. Overall the dunes and beach in the area are of moderate size and width and experience moderate recreational use. Several buildings have been built within the foredune area and appear to extend into the upper beach zone. The highly developed communities of Atlantiqe (to the west) and Corneille Estates (to the east) abut the site.

This site closely resembles the Reagan site. Bayside shoreline and estuarine processes have been negatively impacted and appear to be most effected by hard structures such as extensive bulk heading, boat slips, buildings and various human activities in the area, particularly those associated with the highly developed community of Fire Island Pines. Impacts have resulted in accelerated shoreline erosion in unprotected areas and direct loss of shoreline and intertidal areas. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, residential housing, and other hard structures within upland and dune areas, and overall direct human use of the area. However, some of the negative impacts to processes from the development may be somewhat offset by the presence of large undeveloped upland and dune areas within the site. These low-lying areas are relatively natural and likely have a positive effect on the five coastal processes.

**Restoration Alternative T-25-1, Create Bayside Sand Lobe**

The goal of T-25-1 is to simulate cross-island overwashing without disturbing existing upland and dune communities by creating a sand lobe on the bayside shoreline of the site to provide sand input for bayside processes. Specific components of T-25-1 include:

- Deposit 15 ac of sand fill material bayside; and,
- Regrade shoreline and lobe to appropriate elevations and grade.

Restoration measures would include the deposition of approximately 15 ac of sand material up to 100 feet from the existing 1,900-ft shoreline and located between the eastern boundaries of the Village of Atlantique to the western boundary of Corneille Estates. Dredge material may be utilized to restore grade in support dredge material management activities. Efforts would be made to create sand spit habitat that would provide habitat for foraging shorebirds. Under this scenario, there would be an initial sand deposition event and no additional deposition throughout the 50-year project life. No plantings are proposed.

T-25-1 would result in the conversion of 2.35 ac of BAYSUBSAV to BAYBEACH, thus acreages will change. This activity supports a key bay process, but will not affect HSI scores because variables in the models do not account for the habitat changes anticipated from this alternative. This alternative is expected to result in a positive effect on the cross-island and bay shoreline processes by simulating a breach event.

**Restoration Alternative T-25-2, Salt Marsh Creation**

The goal of T-25-2 is to create new salt marsh by excavating and regrading upland areas and bay shoreline, and planting native salt marsh species. Specific components of T-25-2 include:

- Excavate 1.22 ac of upland along the bay shoreline to create salt marsh habitat;
- Regrade 1.22 ac area; and,
- Plant 1.22 ac of salt marsh vegetation.

Approximately 1.22 ac of upland and bay shoreline would be excavated and planted with native salt marsh species such as cordgrass, salt meadow hay, black grass, and marsh elder shrub to promote salt marsh in this area.

Restoration measures are expected to restore/enhance the existing BAYBEACH community and would result in some improvements to the BAYBEACH HSI variables for invasive species, species richness, shoreline modifications, and barriers to wildlife, as shown in Appendix G. Approximately 1.22 ac of upland area would be converted to intertidal salt marsh habitat.

The creation of salt marsh along the bay shoreline is expected to positively affect the bayside shoreline and estuarine coastal processes.

**Restoration Alternative T-25-3, Upper Beach and Dune**

The goal of T-25-3 is to restore and enhance upland, dune, and upper beach habitats. Specific components of T-25-3 include:

- Regrade and enhance 2,000 lf (9.6 ac) of dune width, slope, and height and regrade 3.6 ac of disturbed area;
- Plant 2.4 ac of dune species on foredune, and 3.6 ac of upland and dune species in areas of former roads/trails;
- Add 9 ac of fill to enhance dune; and,
- Add 1.5 ac of topsoil to facilitate upland plantings.

Specifically, the slope and width of 2,000 lf of the existing dune would be enhanced to replicate foredune (i.e., slope of approximately 20 to 25%, 50 foot wide, 40% cover of vegetation), and the VEGBEACH community would be widened to 120 feet and the upper 40 feet would be planted with 2.4 ac of dune grass species (i.e., beachgrass, beach plum, seaside goldenrod, and beach heather, and switch grass). Approximately 3.6 ac of sand roads and trails would be eliminated and the disturbed areas converted to 0.8 ac of UPLAND and 2.8 ac of DUNEGRASS using plantings and soil amendments. One road will remain to provide access between Atlantique and Cornielle Estates.

Restoration measures would convert 1.9 ac of disturbed area and 3.1 ac of OCEANBEACH to 1.4 ac of VEGBEACH, 2.8 ac of DUNEGRASS, and 0.8 ac of UPLAND. This alternative would result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G.

T-25-3 is expected to result in a positive effect on the dune development and evolution process and a slightly negative impact on the cross-island process due to restoration of foredunes, and presence of dense upland forest, in areas most susceptible to over washing.  Components of this alternative (i.e., dune enhancement) would support storm damage reduction project objectives.

### T-26 KISMET (no photos available)

Areas included in this restoration site closely resemble those found at Ocean Beach and are typical of a highly developed barrier island community. Bayside intertidal areas are limited due to commercial development, bulkheading, marinas, and boat slips that currently dominate the bay side shoreline. Residential housing, commercial development, and paved roads and trails dominate interior upland and dune areas. Hard structures, sand fence, debris, makeshift sand stabilizers, and pedestrian walkways and access cuts have impacted dunes and the upper beach. Portions of the beach are narrow (< 50 feet from toe of dune to average high water line) and the beach is experiencing significant seasonal scarping at the high water line in some areas. Recreational use of the beach by pedestrians is moderate and use of vehicles is permitted on the beach.

Similar to all other highly-developed areas of the barrier island, the bayside shoreline and estuarine processes at these sites have been negatively impacted by hard structures such as extensive bulk heading, boat slips, marinas, buildings and various human activities in the area. These structures and activities have negatively affected the shoreline, intertidal, and aquatic areas of the site. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively affected by placements of boardwalks, sand fence, residential housing and other hard structures within upland and dune areas, and overall direct human use of the area.

**Restoration Alternative T-26-1, Upper Beach and Dune**
The goal of T-26-1 is to restore the dune and upper beach along 1,200 lf of shoreline in front of the highly developed community of Kismet. Specific components of T-26-1 include:

- Raise and rebuild five pedestrian walkways
- Regrade and enhance dune slope, height and width along 1,200 lf
- Add 5.7 ac of fill to enhance dune
- Plant 1.4 ac of dune grass

Specifically, this alternative will include rebuilding five existing pedestrian walkways and restoring the dune beneath them to foredune height, width, and vegetative composition. The slope and width of the dune throughout the area will be improved to foredune width (50 feet) and slope (20 to 25%), and dunes will be revegetated to 40% cover of dune species. The width of the upper beach (VEGBEACH) community will be extended to an average width of 120 feet and the upper 40 feet will be planted to stabilize.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, some OCEANBEACH to VEGBEACH and to enhance the existing DUNEGRASS and VEGBEACH communities. The activity is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to be minor, because public access and high use of the beach is expected to continue. Approximately 2.1 ac of OCEANBEACH and 0.1 ac of disturbed would be converted to 2.1 ac of VEGBEACH and 0,1 ac of DUNEGRASS with this measure. This change is reflected in HEP HU calculations.

T-26-1 includes increasing dune slope and restoring the dune beneath a walkway in front of a highly developed community. As a result, it expected to have a positive effect on the longshore sediment transport. Although foredune replacement tends to negatively affect the cross-island process by blocking potential overwash areas, it will not do so in this case because overwash potential in this area is very low due to the presence of the residential community behind the dune. Components of this alternative (i.e., dune enhancement) would support storm damage reduction project objectives.

**Restoration Alternative T-26-2, Buyouts – Oceanward Edge**
The goal of T-26-2 is to buy out and remove five homes currently located along the oceanward edge of the Kismet residential area and within the CEHA zone. Specific components of T-26-1 include:

- Buy out and remove five buildings and associated structures;
- Add 1.1 ac of fill to enhance disturbed area; and,
- Regrade and replant 1.1 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of five homes currently located oceanward of the CEHA zone and along the leading oceanward edge. That is, this measure targets those structures most susceptible to storm damage. The disturbed area within the structure footprint (1.1 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert 1.1 ac of disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes through the removal of hard structures currently located within the dune system. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

**Restoration Alternative T-26-3, Buyouts – Interior to Oceanward Edge of Residential Area**
The goal of T-26-3 is to buy out and remove three homes currently located on, or within, the CEHA zone, but not on the most oceanward edge of the residential community. This measure targets homes that fall within the CEHA zone, but are not addressed by Alternative 2. Specific components of T-26-3 include:

- Buy out and remove 3 structures;
- Add 0.4 ac of fill to enhance disturbed area; and,

- Regrade and replant 0.42 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of three homes currently located within the foredune area. The disturbed area within the structure footprint (0.42 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert 0.42 ac of disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes only if combined with Alternative 2. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

## T-27 WARNER ISLAND EAST (no photos available)

Warner Island East is a former "island" that is essentially now a sandy spit that is exposed only during low tide conditions. Severe erosion has resulted in the loss of most of the original dredge material from the site and currently only two of the six HEP communities are represented at this location (BAYBEACH and BAYSUBSAV). When exposed, the site served as loafing/resting area for shorebirds, waterbirds, and gulls. However, there is potential to restore the site to habitat conditions that would support shorebird or heron nesting activities.

Erosive forces have negatively disrupted all coastal processes at Warner's Island East.

**Restoration Alternative T-27-1, Shorebird Nesting Habitat**
The goal of T-27-1 is to create additional DUNEGRASS habitat. Specific components of this alternative include:

- Add 25 ac of sand fill to an 8.3 ac area of unvegetated BAYBEACH intertidal community to create 5.8 ac of DUNEGRASS habitat and 2.5 ac of BAYBEACH;
- Regrade 8.3 ac of site and shoreline to create BAYBEACH zone; and,
- Plant low densities (1 ac) of dune species and 1.5 ac of wetland shrubs (along shoreline) as needed to stabilize site.

Material would be added to the site and planted as needed to create 3 ac of DUNEGRASS habitat that would support breeding/nesting shorebirds (i.e., sparsely vegetated dune habitat). DUNEGRASS species would include American beachgrass, beach plum, seaside goldenrod, and beach heather. Dredge material may be utilized to restore grade in support of dredge material management activities.

Restoration measures would result in the conversion 8.3 ac of BAYBEACH community to DUNEGRASS and BAYBEACH. The HSI scores for the DUNEGRASS community would represent conditions suitable for shorebird nesting (i.e., lack of invasive species, appropriate dune vegetative cover, and lack of hard structures and human disturbance, etc.).

T-27-1 is expected to positively affect the bayside shoreline process by reducing the sediment loading in the bay system from the dredge island and would provide habitat for state and/or Federally-listed species.

**Restoration Alternative T-27-2, Heron Nesting Habitat**
The goal of T-27-2 is to create a heron rookery. Specific components of T-27-2 include:

- Add 20 ac of sand fill (3 ft depth) to unvegetated BAYBEACH intertidal areas to create 5.4 ac of UPLAND habitat and 1.1 ac BAYBEACH habitat;
- Add 6.5 ac of topsoil (1 ft depth);
- Regrade 6.5 ac site and shoreline to create BAYBEACH zone; and,
- Plant 5.4 ac of upland shrubs and trees and 0.75 ac of salt marsh vegetation.

Material would be added to the site to raise elevations to appropriate height for upland communities (3 ft assumed), which would then be planted as needed to create 6.5 ac of UPLAND habitat that would support breeding/nesting herons (i.e., tall shrubs and trees). UPLAND species would include cherry, holly, post oak, and sasafrass. The shoreline would be planted with marsh shrubs and emergents to stabilize. Dredge material may be utilized to restore grade in support of dredge material management activities.

Restoration measures would result in the conversion of 6.5 ac of BAYBEACH community to 5.4 ac of UPLAND and 1.13 ac of BAYBEACH. The HSI scores for the UPLAND community would represent conditions suitable for heron nesting (i.e., lack of invasive species, appropriate tree and shrub vegetative structure and cover, and lack of hard structures and human disturbance).

T-27-2 is expected to positively affect the bayside shoreline process by reducing the sediment loading in the bay system from the dredge island and create habitat for species of concern.

**Restoration Alternative T-27-3, Shoreline Stabilization**

The goal of T-27-3 is to use bio-engineering measures to stabilize approximately 1,560 feet of eroding island shoreline. It is assumed that there would be some utility to adding this feature to retain sediment and reduce continued erosion of this area regardless if other alternatives are implemented at this site. Specific components include:

- Place vegetated gabion basket along 1,560 lf (7.5 ac) of the shoreline;
- Add 15 ac of fill (at tidal elevations) to stabilize gabion system; and,
- Plant 6 ac of gabion basket and fill with salt marsh vegetation.

Regrading of the entire 1,560 ft of shoreline would be required, and deposition of material into some intertidal areas of the island would be necessary in order to achieve desired slope (20%), and stabilize the island. However no conversion of community type is expected. Vegetated gabions (described in alternative T-10-3) will be used to stabilize 1,560 ft of the existing shoreline. Dredge material from the island or other sources may be used and may be included as part of dredge material management. This alternative may only be feasible if used in conjunction with Alt 1 and/or Alt 2. However, there may be some ecological benefit in creating in front if the existing sand spit currently found in this location.

This alternative is likely to impact the BAYSUBSAV, BAYBEACH and DUNEGRASS communities as regrading and bioengineering is used to stabilize these areas, but overall there would be no change in community type. Improvements to HSI variables include percent cover of vegetation, barriers to wildlife, and in addition would halt further erosion of the shoreline, as shown in Appendix G.

This alternative would improve bayside and estuarine processes by creating a relatively stable, vegetated shoreline, with appropriate slope to support salt marsh species.

**T-28 ATLANTIQUE (no photos available)**

Similar to Kismet and Fair Harbor, Atlantique is typical of a highly developed barrier island community in that bayside intertidal areas are limited due to development and bulkheading and hard structures, sand fence, debris, makeshift sand stabilizers, and pedestrian walkways and access cuts have impacted dunes and the upper beach. The area overall has been significantly affected by human use of the area. Portions of the beach are narrow and the beach is experiencing significant seasonal scarping at the high water line in some areas. Recreational use of the beach by pedestrians is moderate and use of vehicles is permitted on the beach. These factors have negatively impacted bayside shoreline, estuarine, dune development and evolution and the cross-island sediment transport processes.

**Restoration Alternative T-28-1, Upper Beach and Dune**

The goal of T-28-1 is to restore the dune and upper beach along 850 lf of shoreline in front of the highly developed community of Atlantique. Specific components of T-28-1 include:

- Raise and rebuild four walkways;
- Regrade and enhance 850 lf (4.1 ac) of dune slope, height, width;
- Use 4.1 ac of sand fill to enhance dune; and,
- Plant 1 ac of dune grass.

Specifically, this alternative will include rebuilding four existing pedestrian walkways and restoring the dune beneath them to foredune height, width, and vegetative composition. The slope and width of the dune throughout the area will be improved to foredune width (50 feet) and slope (20 to 25%), and dunes will be revegetated to 40% cover of dune species. The width of the upper beach (VEGBEACH) community will be extended to an average width of 120 feet and the upper 40 feet will be planted to stabilize.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, some OCEANBEACH to VEGBEACH and to enhance the existing DUNEGRASS and VEGBEACH communities. The activity is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to be minor, because public access and high use of the beach is expected to continue.

This alternative would result in the conversion of approximately 1 ac of OCEANBEACH and 0.1 ac of disturbed habitat to 1 ac of VEGBEACH and 0.1 ac of DUNEGRASS.

T-28-1 includes increasing dune slope and restoring the dune beneath a walkway in front of a highly developed community. As a result, it expected to have a positive effect on the longshore sediment transport. Although foredune replacement tends to negatively affect the cross-island process by blocking potential overwash areas. It will not do so in this case because overwash potential in this area is very low due to the presence of the residential community behind the dune. Components of this alternative (i.e., dune enhancement) would support storm damage reduction project objectives.

**Restoration Alternative T-28-2, Buyouts – Oceanward Edge**

The goal of T-28-2 is to buy out and remove four homes currently located along the oceanward edge of the Atlantique residential area within the CEHA zone. Specific components of T-28-2 include:

- Buy out and remove four buildings and associated structures;
- Add 0.37 ac of fill to enhance disturbed area; and,
- Regrade and replant 0.37 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of four homes currently located within the foredune area. The disturbed area within the structure footprint (0.37 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue. This restoration measure is expected to convert 0.37 ac of disturbed areas to DUNEGRASS.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes through the removal of hard structures currently located within the dune system. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

**Restoration Alternative T-28-3, Buyouts – Interior to Oceanward Edge of Residential Area**

The goal of T-28-3 is to buy out and remove two homes currently located on or within the CEHA zone, but are not on the most oceanward edge of the residential community. This measure targets homes that fall within the CEHA zone, but are not addressed by Alternative 2. Specific components of T-28-3 include:

- Buy out and remove two structures; and,
- Regrade and replant 0.26 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of two homes currently located within the foredune area. The disturbed area within the structure footprint (0.26 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue. This restoration measure is expected to convert 0.26 ac of disturbed areas to DUNEGRASS.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes only if combined with Alternative 2. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

**T-29 FAIR HARBOR (no photos available)**

Fair Harbor characterizes another typical highly developed barrier island community with significant residential and commercial development, bulkheading, marinas, boat and access roads and trail throughout. Hard structures, sand fence, debris, makeshift sand stabilizers, and pedestrian walkways and access cuts have impacted dunes and the upper beach. Recreational use of the beach by pedestrians is moderate and use of vehicles is permitted on the beach.

The bayside shoreline and estuarine processes at these sites have been negatively impacted by hard structures such as extensive bulk heading, boat slips, marinas, buildings and various human activities in the area. Impacts have negatively affected the shoreline, intertidal, and aquatic areas of the site. Additionally, the dune development and evolution and cross-island sediment transport processes have also been significantly negatively effected by placements of boardwalks, sand fence, residential housing and other hard structures within upland and dune areas, and overall direct human use of the area.

**Restoration Alternative T-29-1, Upper Beach and Dune**

The goal of T-29-1 is to restore the dune and upper beach along 950 lf of shoreline in front of the highly developed community of Fair Harbor. Specific components of T-29-1 include:

- Raise and rebuild five walkways;
- Regrade and enhance 950 lf (4.5 ac) of dune slope, height, width;
- Use 4.1 ac of sand fill to enhance dune; and,
- Plant 1.1 ac of dune grass.

Specifically, this alternative will include rebuilding five existing pedestrian walkways and restoring the dune beneath them to foredune height, width, and vegetative composition. The slope and width of the dune throughout the area will be improved to foredune width (50 feet) and slope (20 to 25%), and dunes will be revegetated to 40% cover of dune species. The width of the upper beach (VEGBEACH) community will be extended to an average width of 120 feet and the upper 40 feet will be planted to stabilize.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, some OCEANBEACH to VEGBEACH and to enhance the existing DUNEGRASS and VEGBEACH communities. The activity is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. Changes to variables relating to human disturbance and barriers to wildlife are expected to be minor, because public access and high use of the beach is expected to continue. This alternative would convert 0.6 ac of OCEANBEACH to VEGBEACH.

T-28-1 includes increasing dune slope and restoring the dune beneath a walkway in front of a highly developed community. As a result, it expected to have a positive effect on the longshore sediment transport. Although foredune replacement tends to negatively affect the cross-island process by blocking potential overwash areas. It will not do so in this case because overwash potential in this area is very low due to the presence of the residential community behind the dune. Components of this alternative (i.e., dune enhancement) would support storm damage reduction project objectives.

**Restoration Alternative T-29-2, Buyouts – Oceanward Edge**

The goal of T-29-2 is to buy out and remove homes currently located along the oceanward edge of the Fair Harbor residential area and within the CEHA zone. Specific components of T-29-1 include:

- Buy out and remove seven buildings and associated structures;
- Add 0.8 ac of fill to enhance disturbed area; and,
- Regrade and replant 0.8 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of homes currently located within the foredune area. The disturbed area within the structure footprint (0.8 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue. Approximately 0.8 ac of disturbed area would be converted to DUNEGRASS with this alternative.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes through the removal of hard structures currently located within the dune system. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

**Restoration Alternative T-29-3, Buyouts – Interior to Oceanward Edge of Residential Area**

The goal of T-29-3 is to buy out and remove homes currently located on or within the CEHA zone, but are not on the most oceanward edge of the residential community. This measure targets homes that fall within the CEHA zone, but are not addressed by Alternative 2. Specific components of T-29-3 include:

- Buy out and remove 15 buildings and associated structures;
- Add 1.65 ac of fill to enhance disturbed area; and,
- Regrade and replant 1.65 ac of disturbed areas within structure footprints.

Specifically, this alternative will include the buy-out and removal of homes currently located within the foredune area. The disturbed area within the structure footprint (1.65 acres) will be restored to DUNEGRASS habitat through regrading and planting.

Restoration measures are expected to convert some disturbed areas to DUNEGRASS, and is expected to result in some improvements to the HSI variables for percent cover of vegetation, impacts from human disturbance, shoreline modifications, slope, and width, as shown in

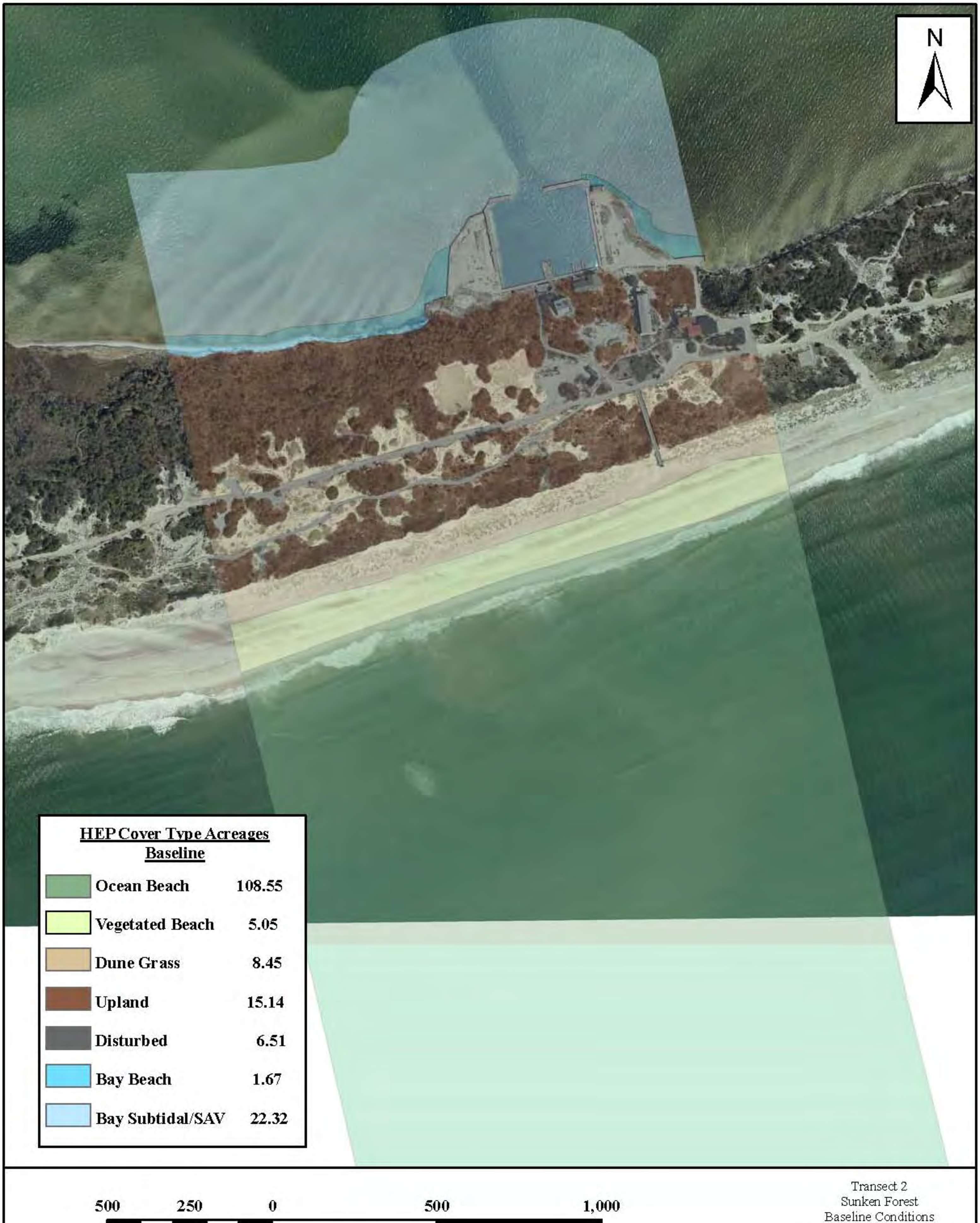
Appendix G. The magnitude of human impact is expected to decline, but only slightly since public access and use of the beach is expected to continue. Approximately 1.7 ac of disturbed area would be converted to DUNEGRASS with this alternative.

This alternative is expected to have a positive effect on the longshore sediment transport and dune enhancement and evolution processes only if combined with Alternative 2. Cross-island process would not be affected because the overwash potential in this area would still remain very low due to the presence of additional hard structures behind the dune.

# ATTACHMENT II

## CONCEPTUAL RESTORATION DESIGNS

**CONTENTS:**

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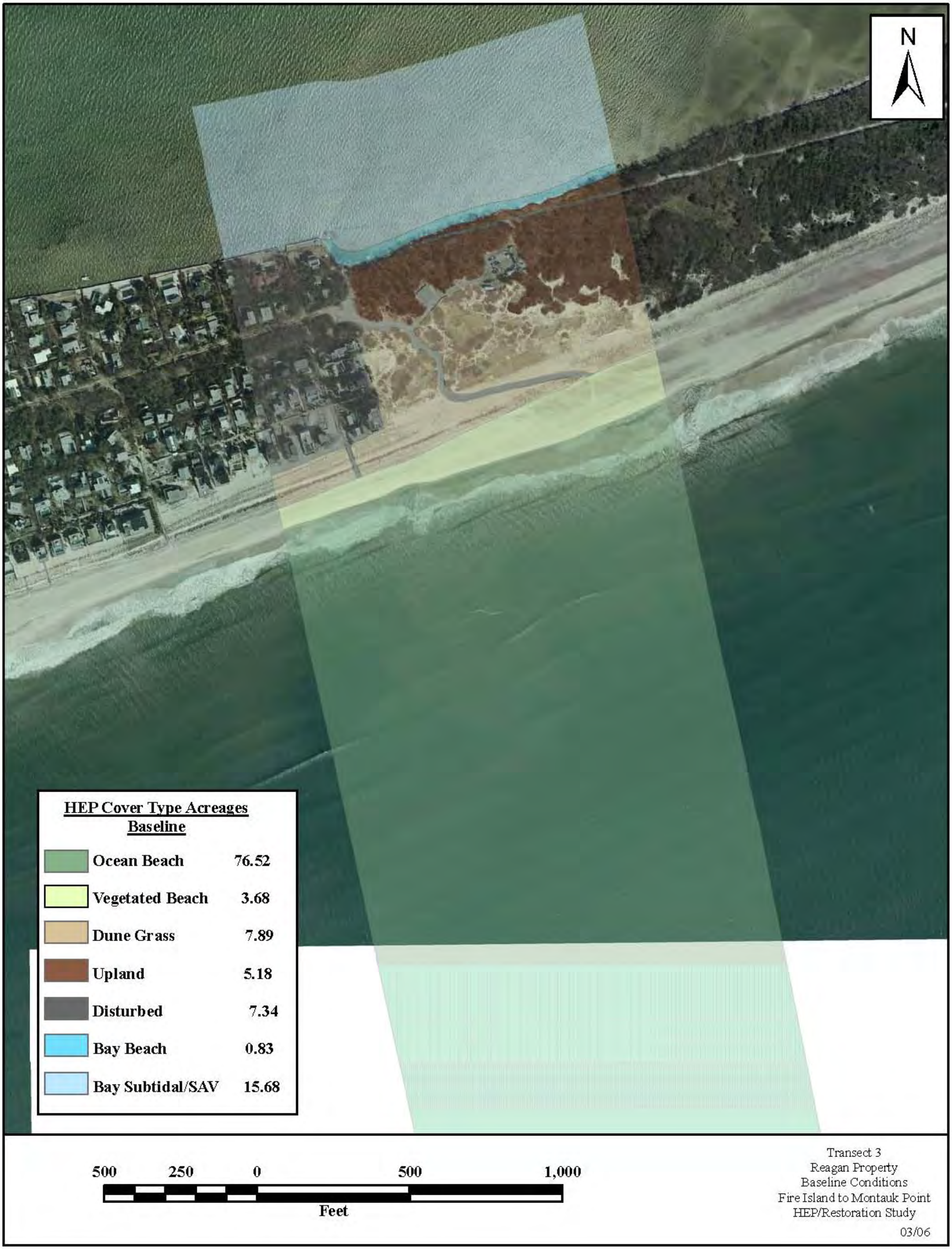
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06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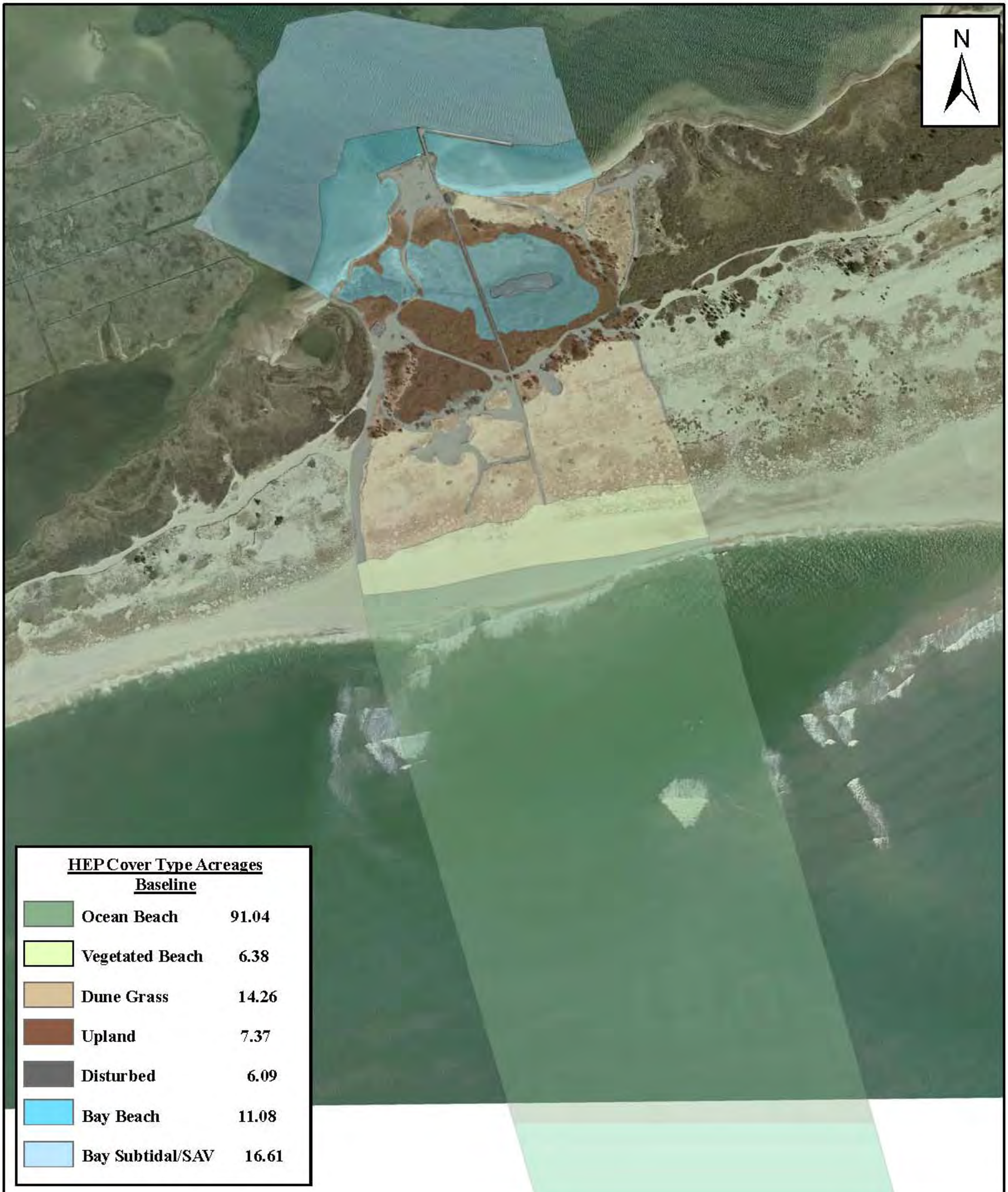
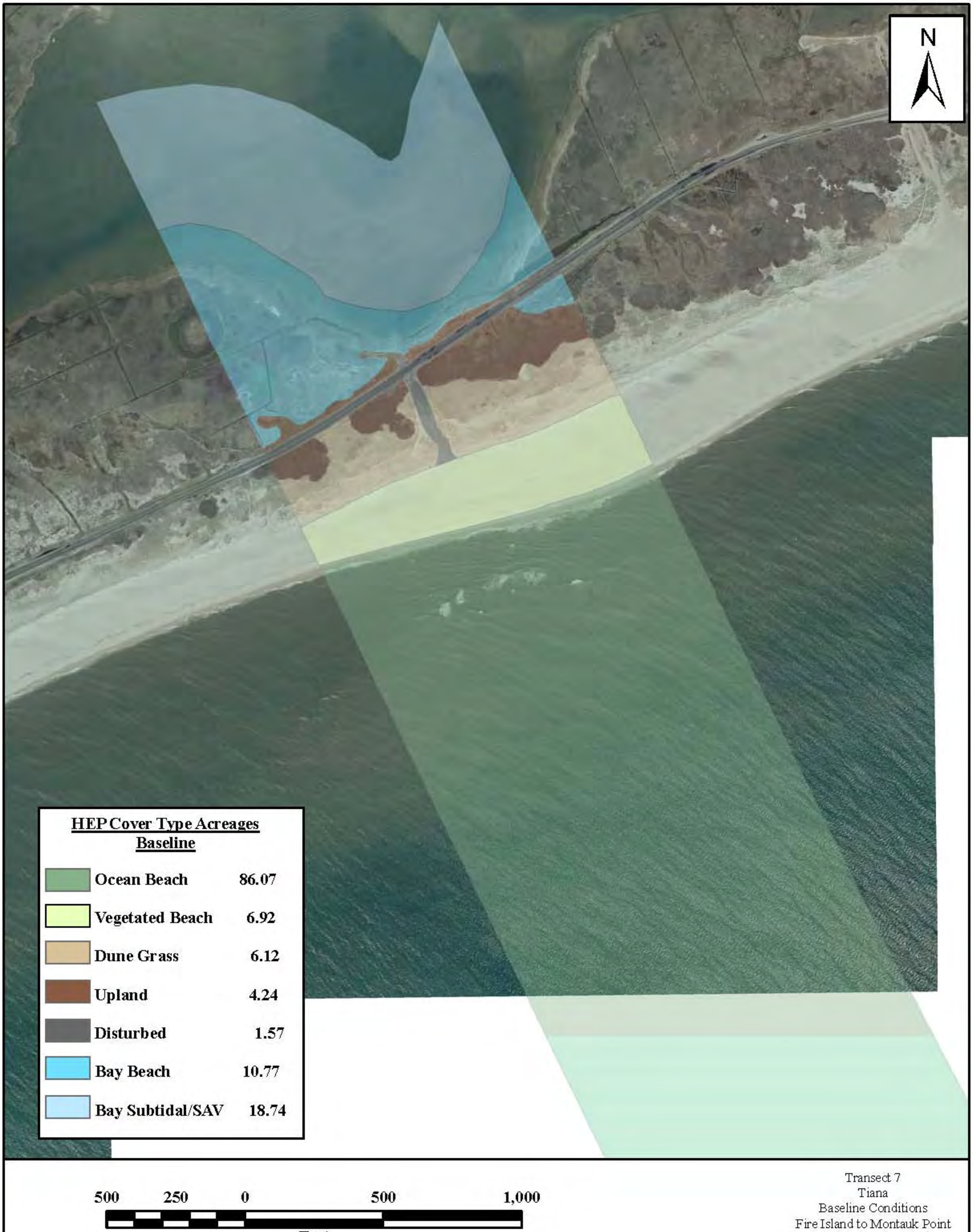
Baseline
Ocean Beach 76.52
Vegetated Beach 3.68
Dune Grass 7.89
Upland 5.18
Disturbed 7.34
Bay Beach 0.83
Bay Subtidal/SAV 15.68
500 250 0 500 1,000
Feet
Transect 3
Reagan Property
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06




500 250 0 500 1,000
Feet

Transect 5
Great Gun
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06




Transect 7
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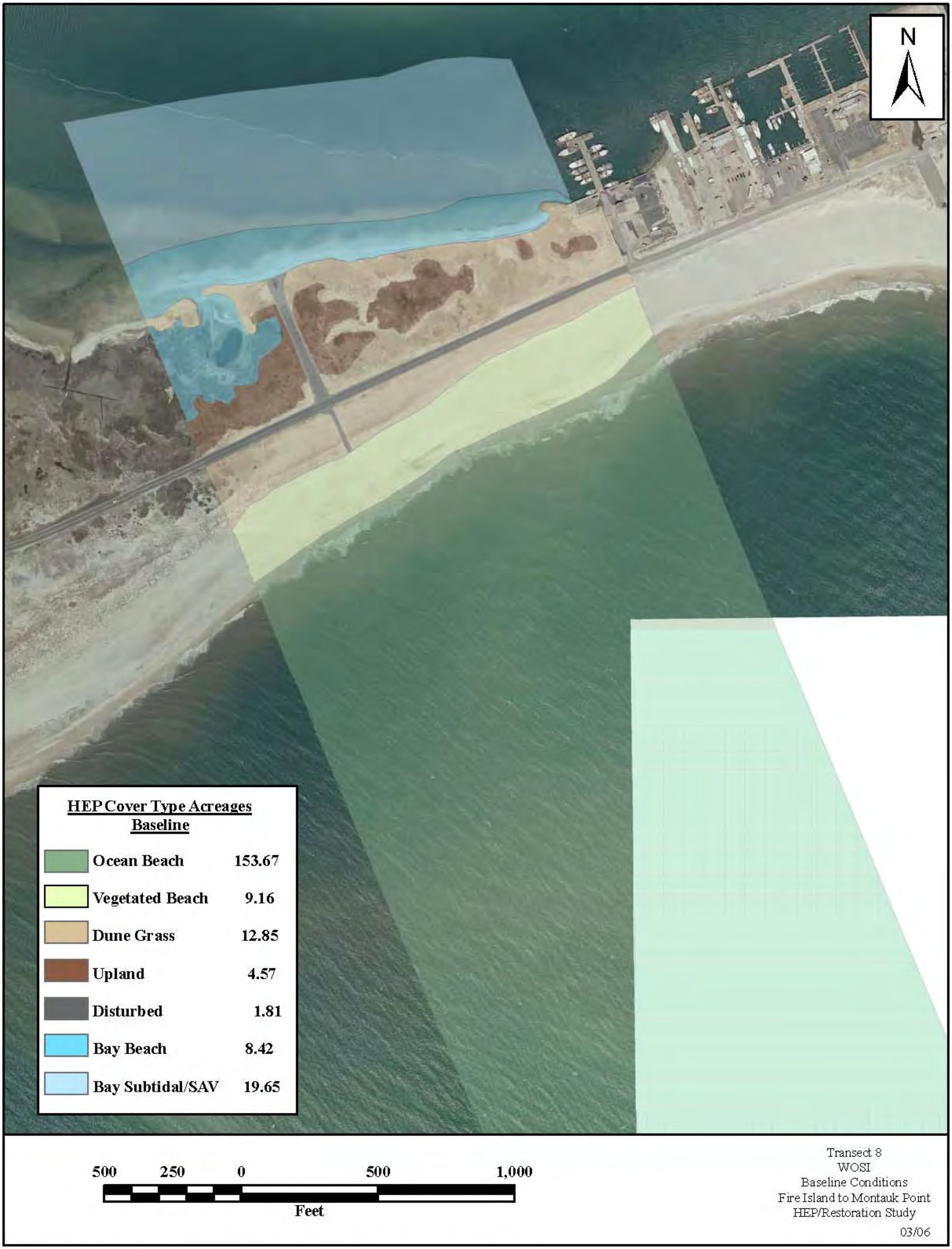
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06

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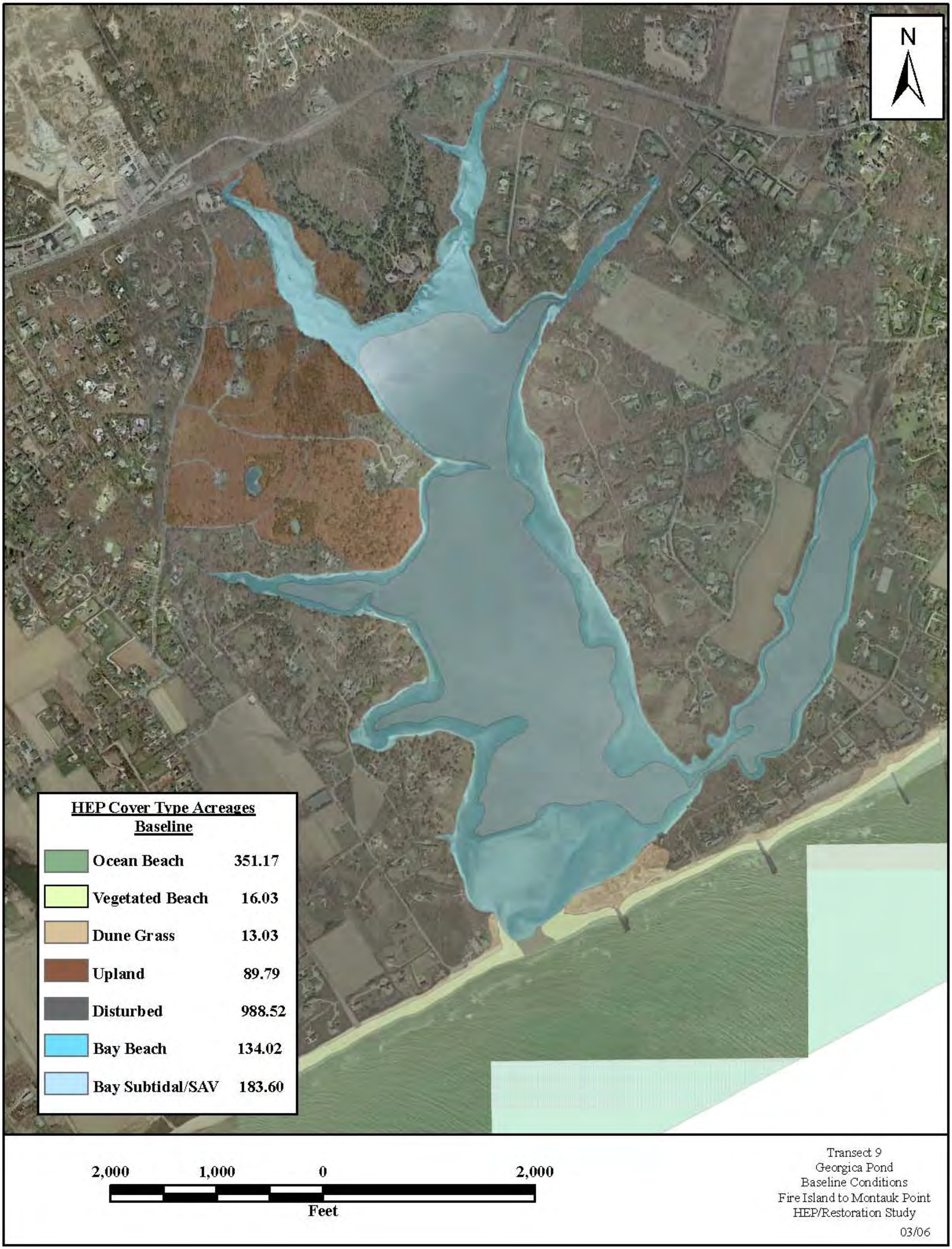
HEP/Restoration Study
03/06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HEP Cover Type Acreages
Baseline
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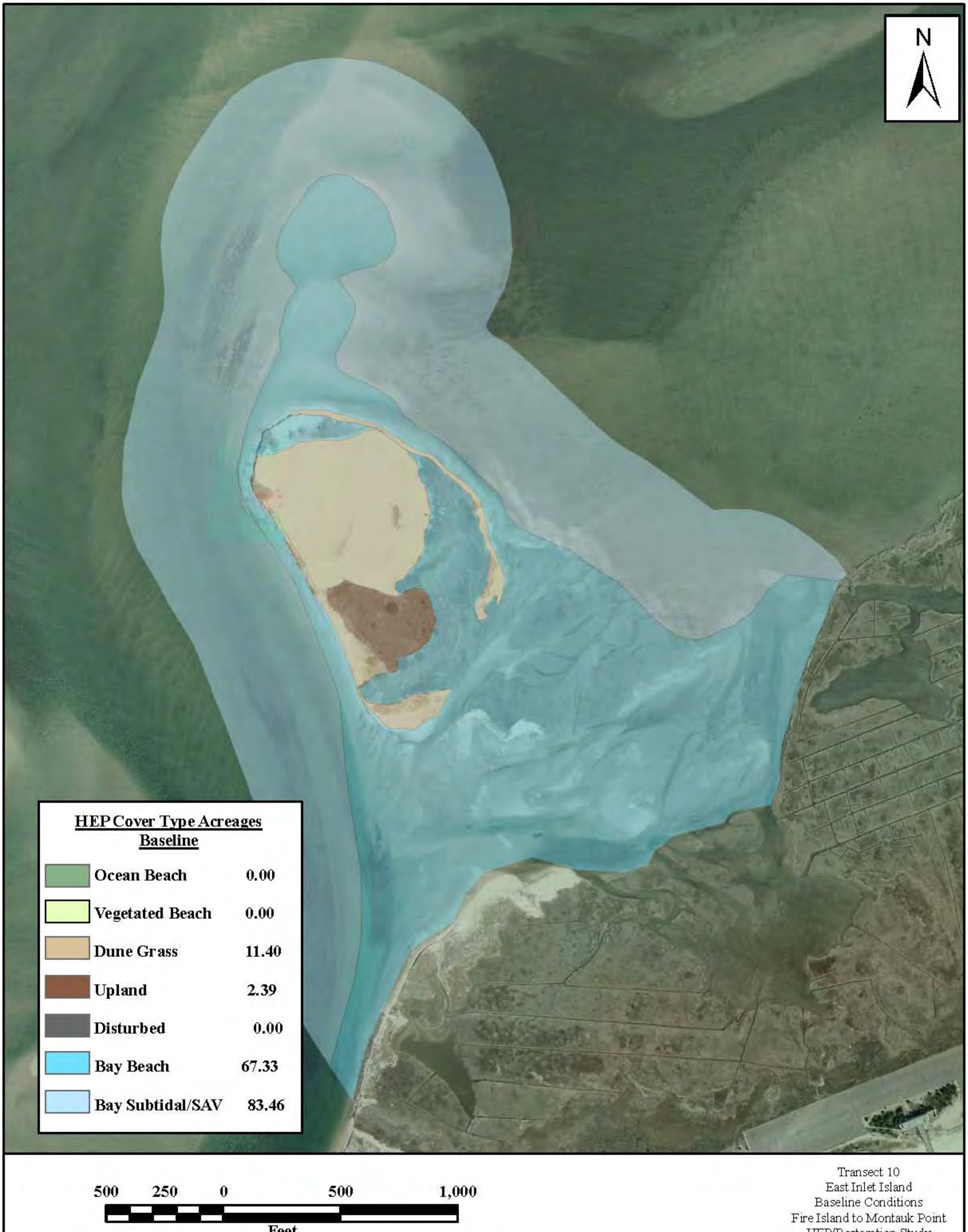
Vegetated Beach 16.03
Dune Grass 13.03
Upland 89.79
Disturbed 988.52
Bay Beach 134.02
Bay Subtidal/SAV 183.60
2,000 1,000 0 2,000
Feet
Transect 9
Georgica Pond
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06

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Baseline Conditions
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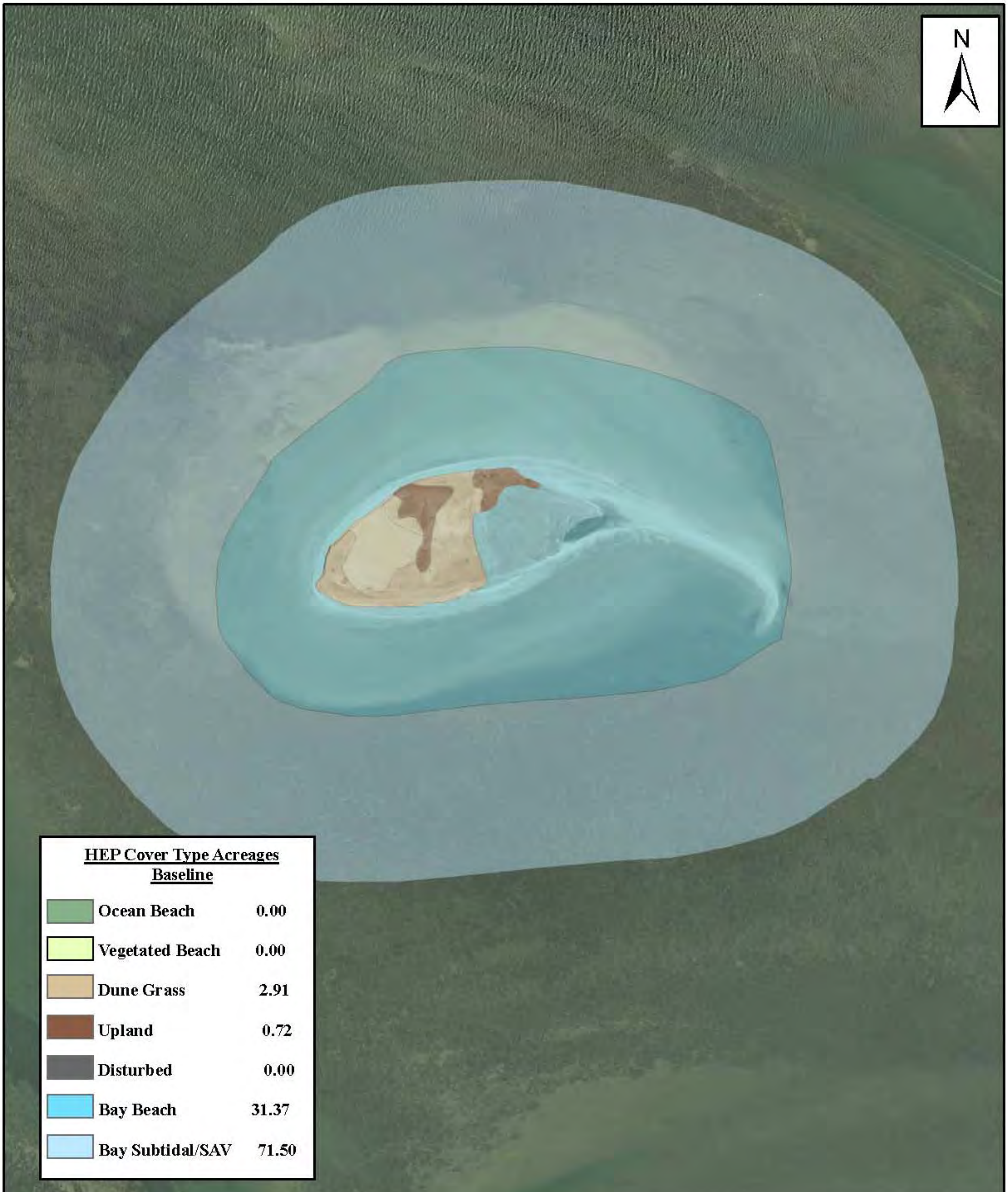
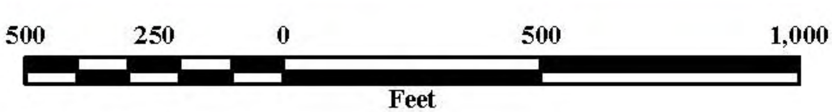
HEP/Restoration Study
02/06

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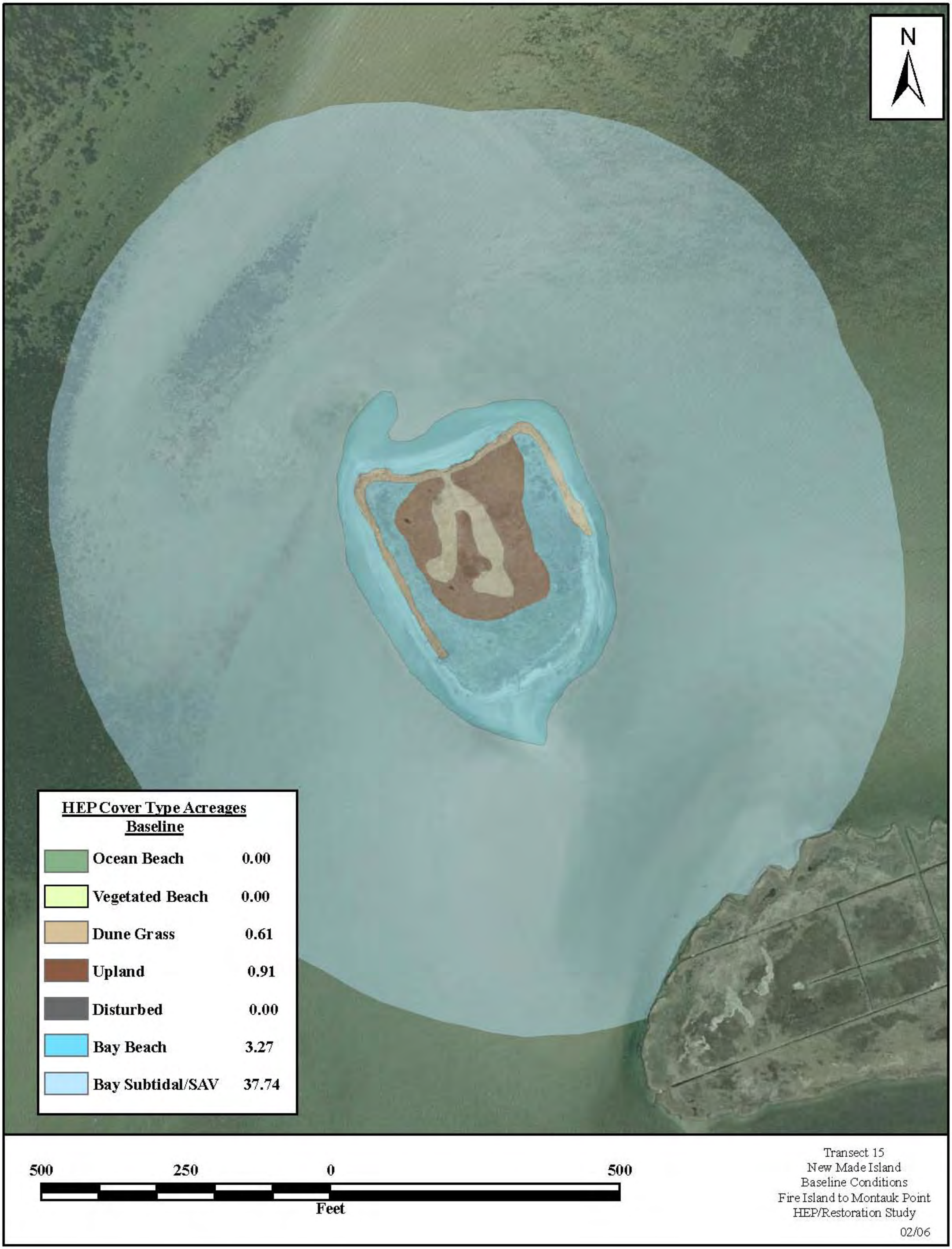
John Boyle Island
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
02/06


Transcect 14
Ocean Beach
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06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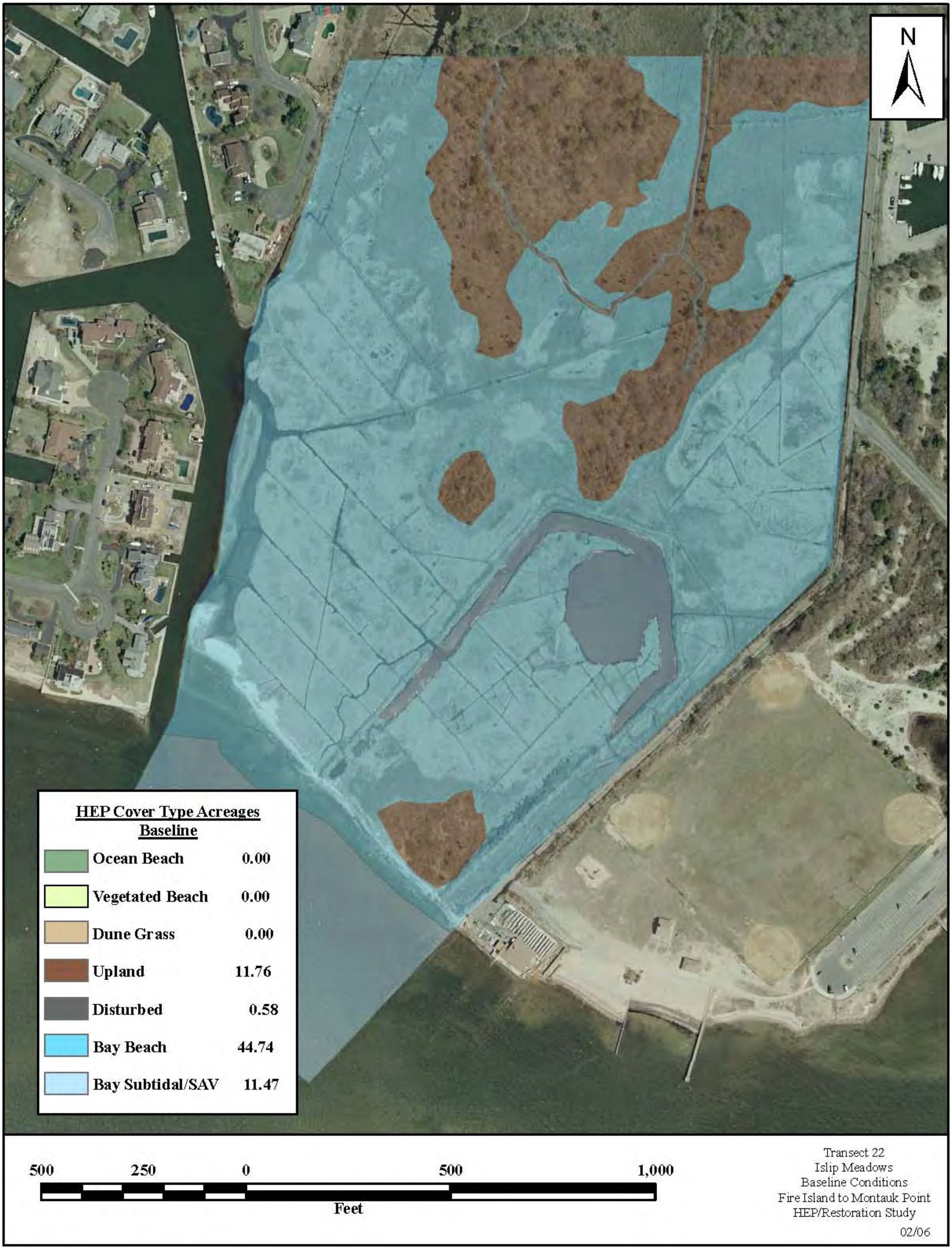
Baseline
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.61
Upland 0.91
Disturbed 0.00
Bay Beach 3.27
Bay Subtidal/SAV 37.74
500 250 0 500
Feet
Transect 15
New Made Island
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
02/06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HEP Cover Type Acreages
Baseline
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.00
Upland 11.76
Disturbed 0.58
Bay Beach 44.74
Bay Subtidal/SAV 11.47
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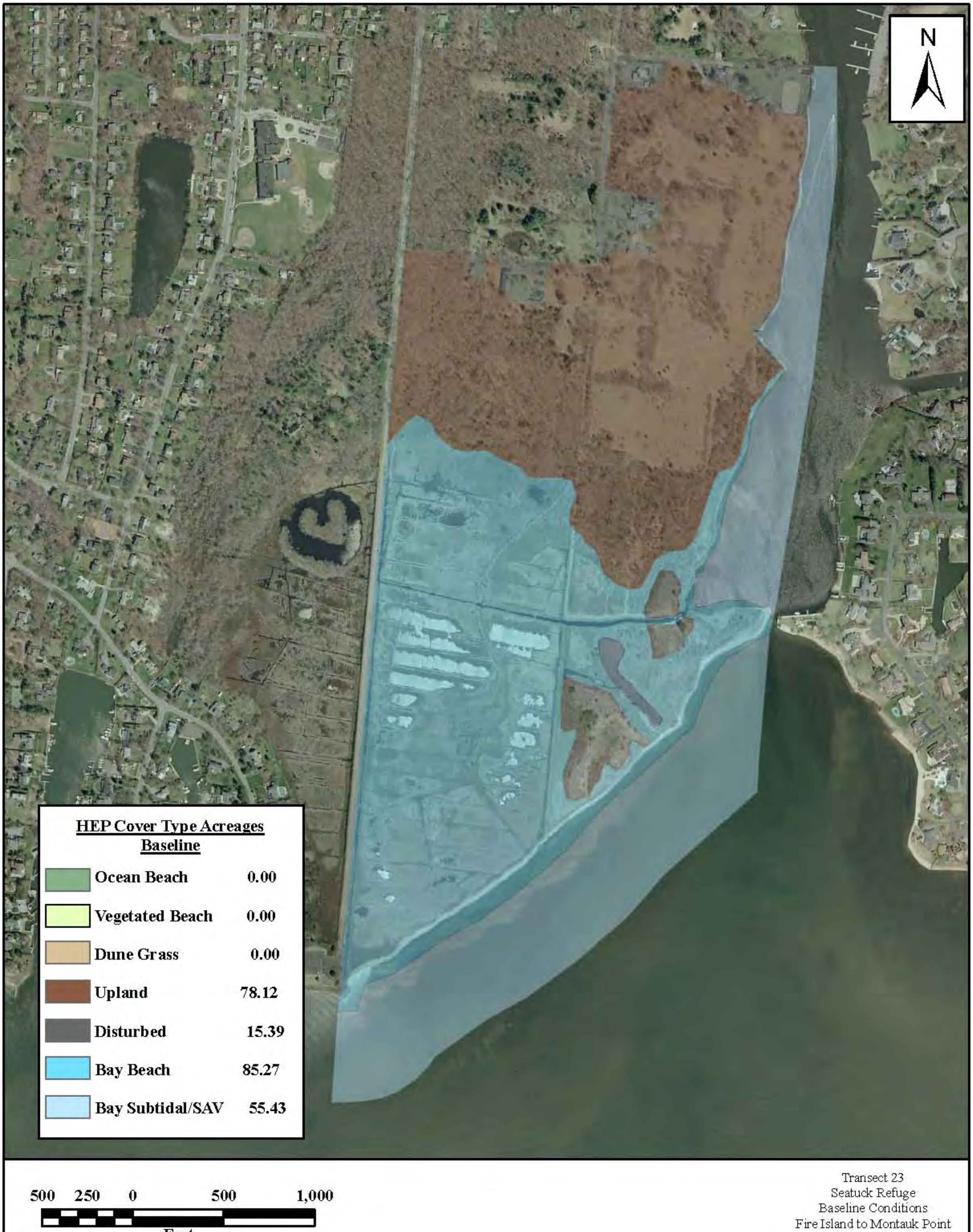
Feet
Transect 22
Islip Meadows
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
02/06

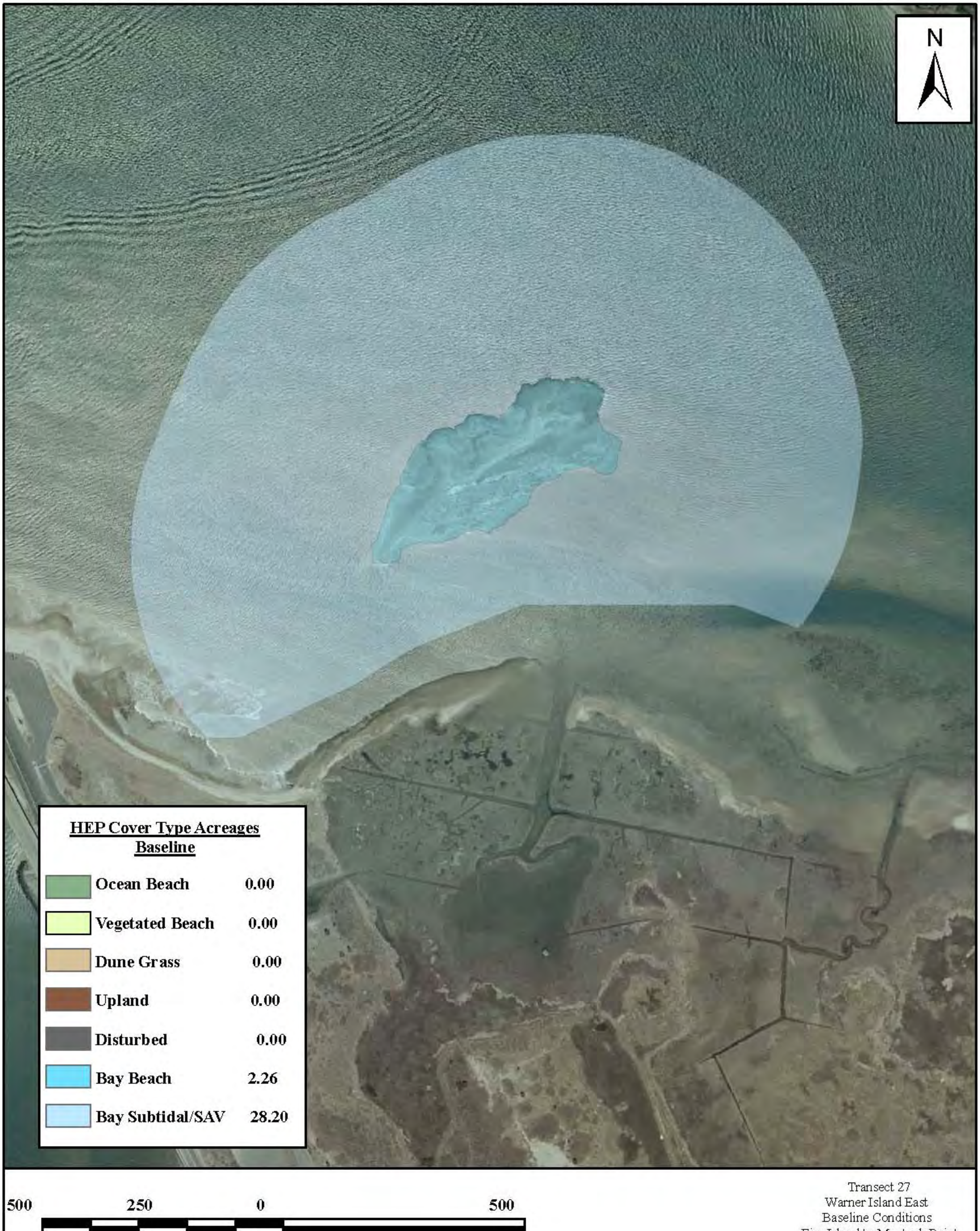



Transect 23
Seatuck Refuge
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
02/06


N
HEP Cover Type Acreages
Baseline
Ocean Beach 261.43
Vegetated Beach 9.77
Dune Grass 4.80
Upland 0.81
Disturbed 62.81
Bay Beach 7.59
Bay Subtidal/SAV 58.47
500 250 0 500 1,000
Feet
Transect 24
Davis Park
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06


Transect 25
Atlantique to Corneille
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06


N
HEP Cover Type Acreages
Baseline
Ocean Beach 64.74
Vegetated Beach 2.06
Dune Grass 2.32
Upland 6.01
Disturbed 36.97
Bay Beach 1.00
Bay Subtidal/SAV 15.05
500 250 0 500 1,000
Feet
Transect 26
Kismet
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06

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HEP/Restoration Study
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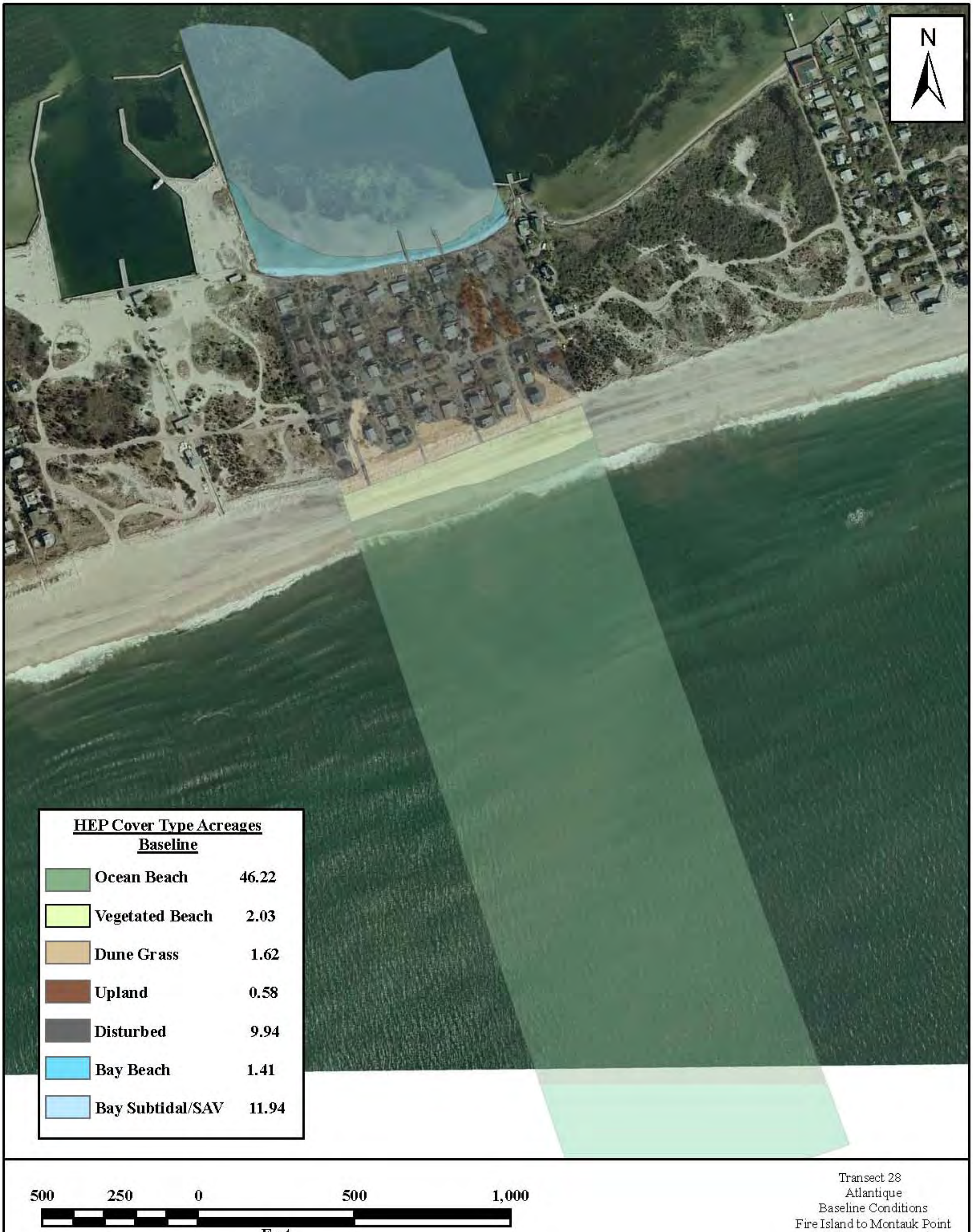



Transect 28
Atlantique
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06


500 250 0 500 1,000

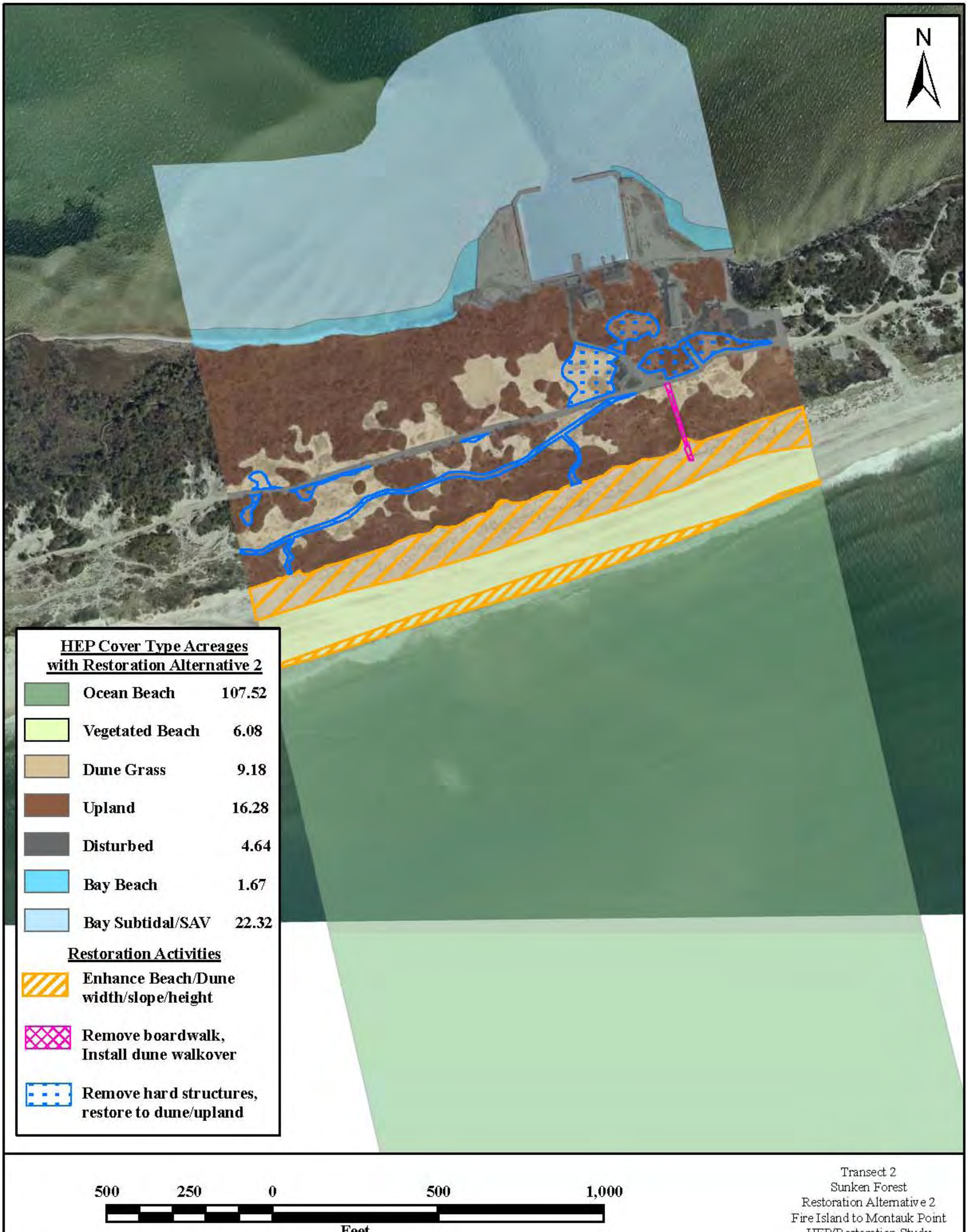
Feet

Transect 29
Fair Harbor
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
03/06


500 250 0 500

Feet

Transect 2
Sunken Forest
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

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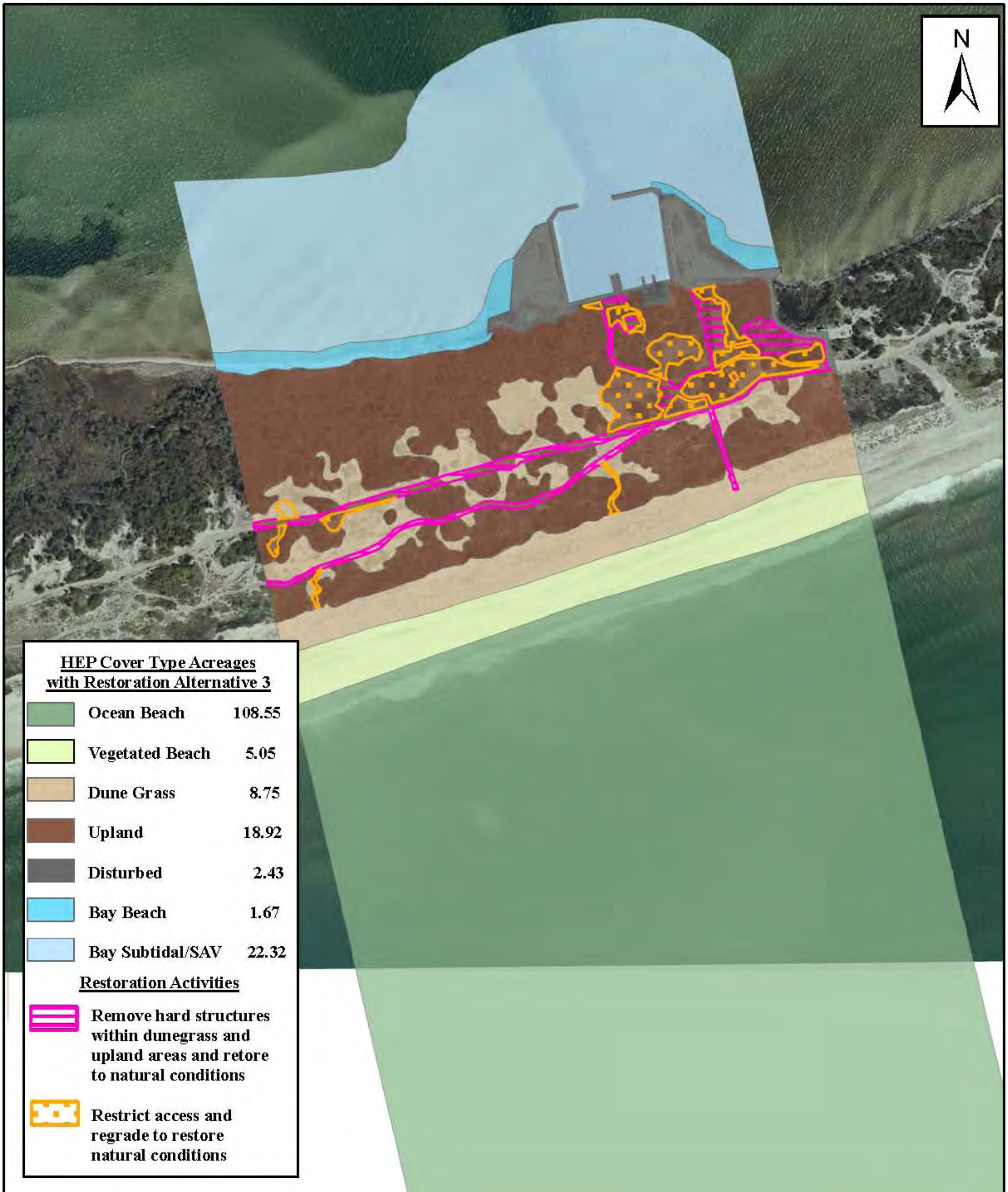
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

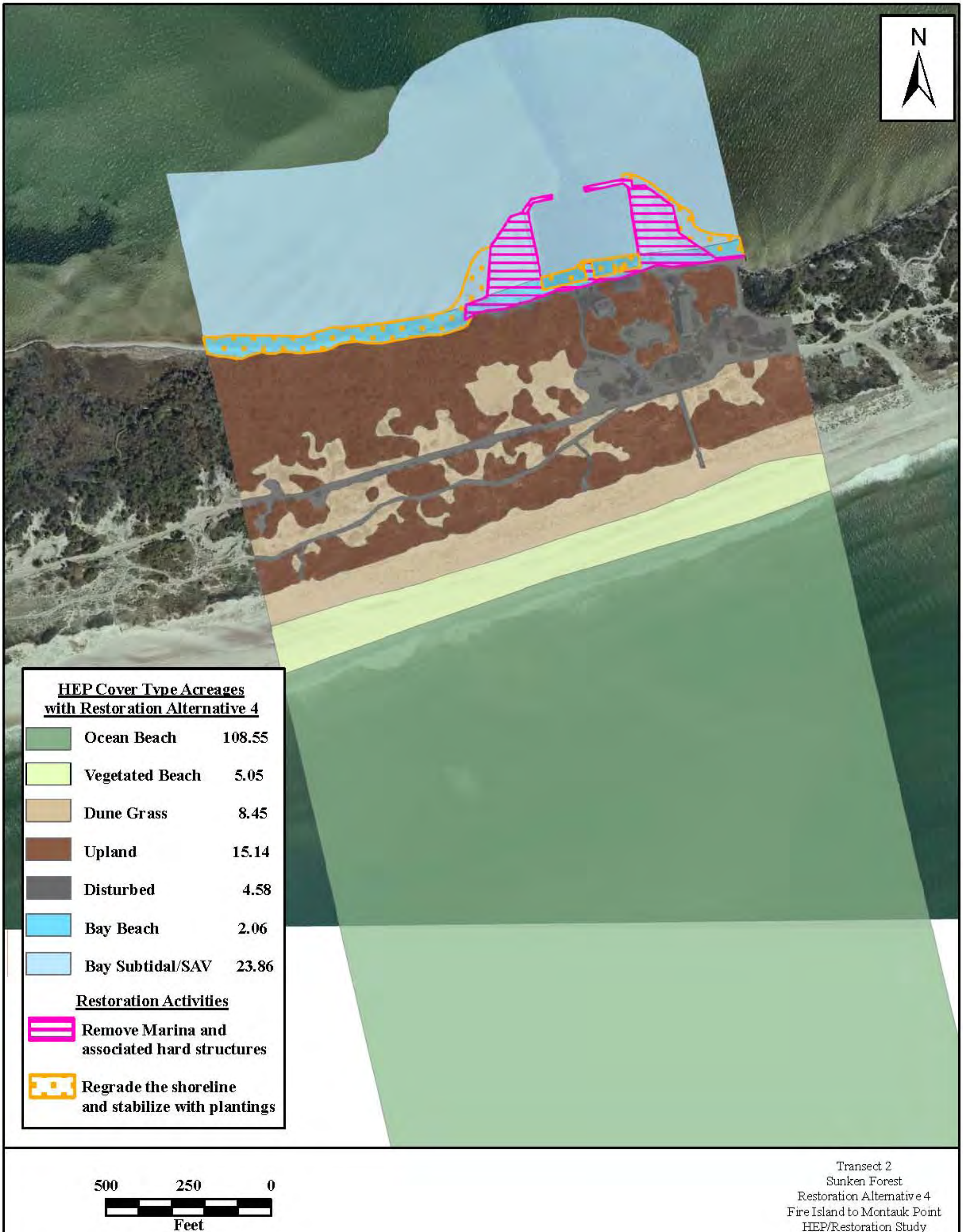



500 250 0 500

Feet

Transect 2
Sunken Forest
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study

08/06

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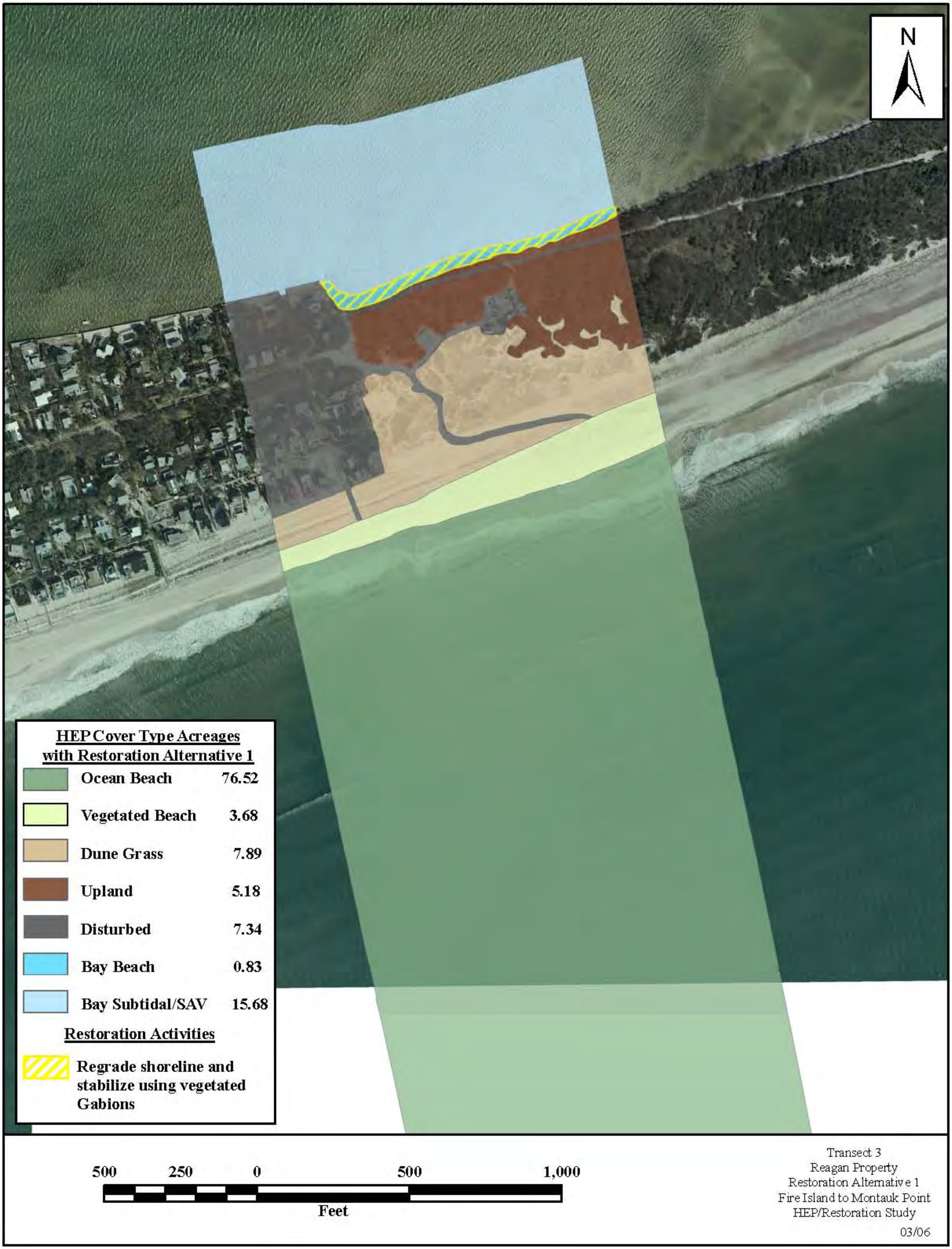
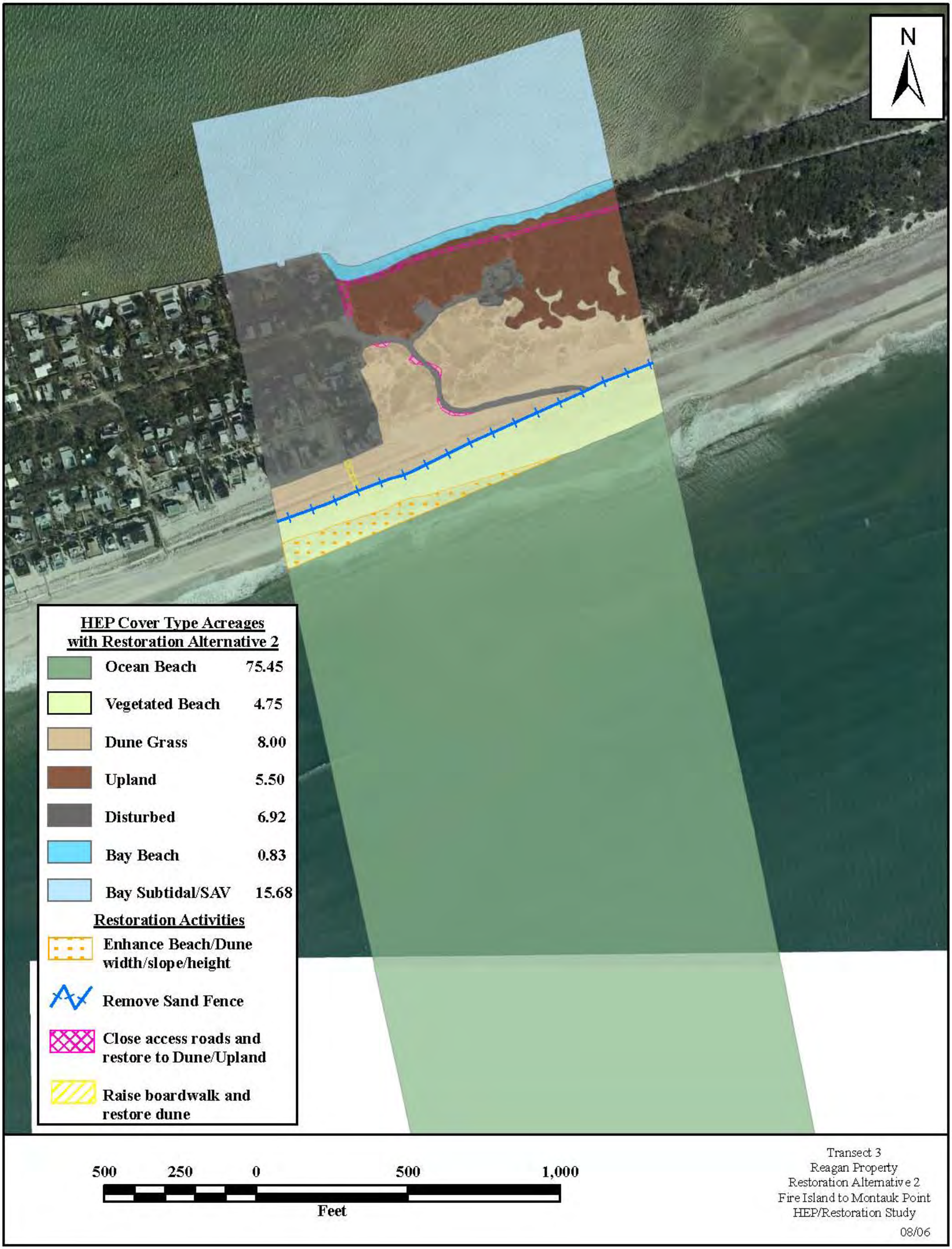
Restoration Alternative 4
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages
with Restoration Alternative 1
Ocean Beach 76.52
Vegetated Beach 3.68
Dune Grass 7.89
Upland 5.18
Disturbed 7.34
Bay Beach 0.83
Bay Subtidal/SAV 15.68
Restoration Activities
Regrade shoreline and stabilize using vegetated Gabions
500 250 0 500 1,000
Feet
Transect 3
Reagan Property
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
03/06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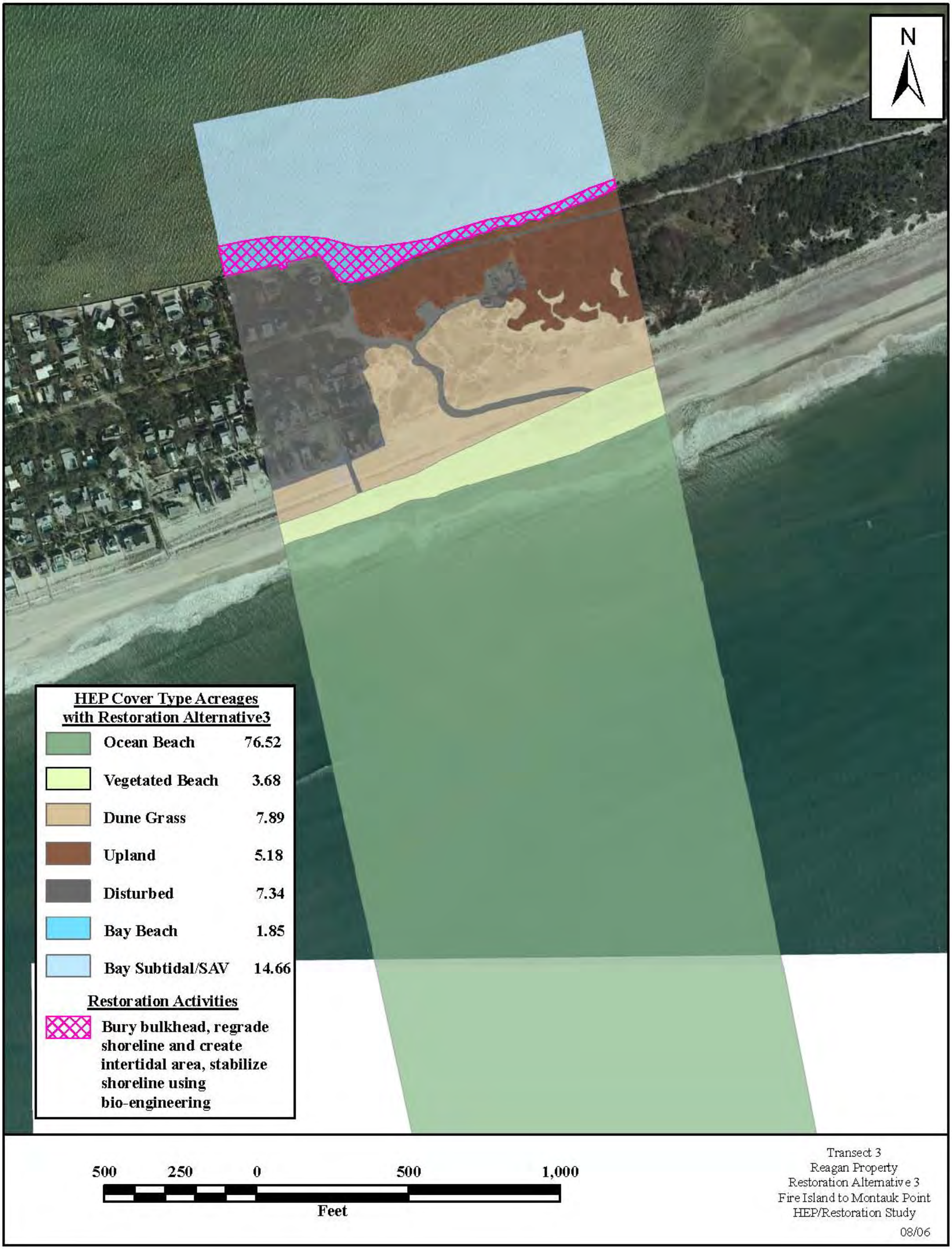
HEP Cover Type Acreages with Restoration Alternative 2
Ocean Beach 75.45
Vegetated Beach 4.75
Dune Grass 8.00
Upland 5.50
Disturbed 6.92
Bay Beach 0.83
Bay Subtidal/SAV 15.68
Restoration Activities
Enhance Beach/Dune width/slope/height
Remove Sand Fence
Close access roads and restore to Dune/Upland
Raise boardwalk and restore dune
500 250 0 500 1,000
Feet
Transect 3
Reagan Property
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06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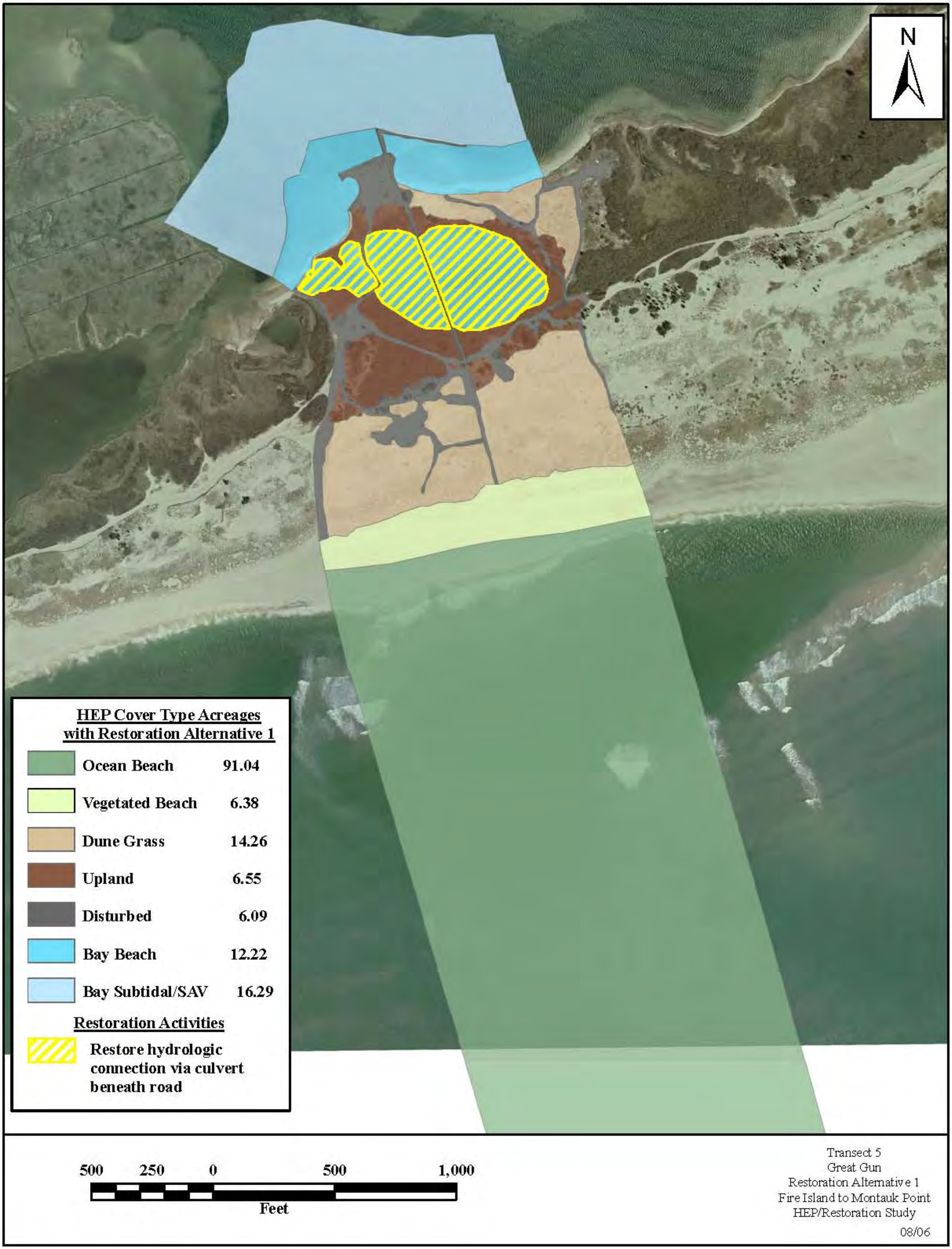
HEP Cover Type Acreages
with Restoration Alternative3
Ocean Beach 76.52
Vegetated Beach 3.68
Dune Grass 7.89
Upland 5.18
Disturbed 7.34
Bay Beach 1.85
Bay Subtidal/SAV 14.66
Restoration Activities
Bury bulkhead, regrade shoreline and create intertidal area, stabilize shoreline using bio-engineering
500 250 0 500 1,000
Feet
Transect 3
Reagan Property
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06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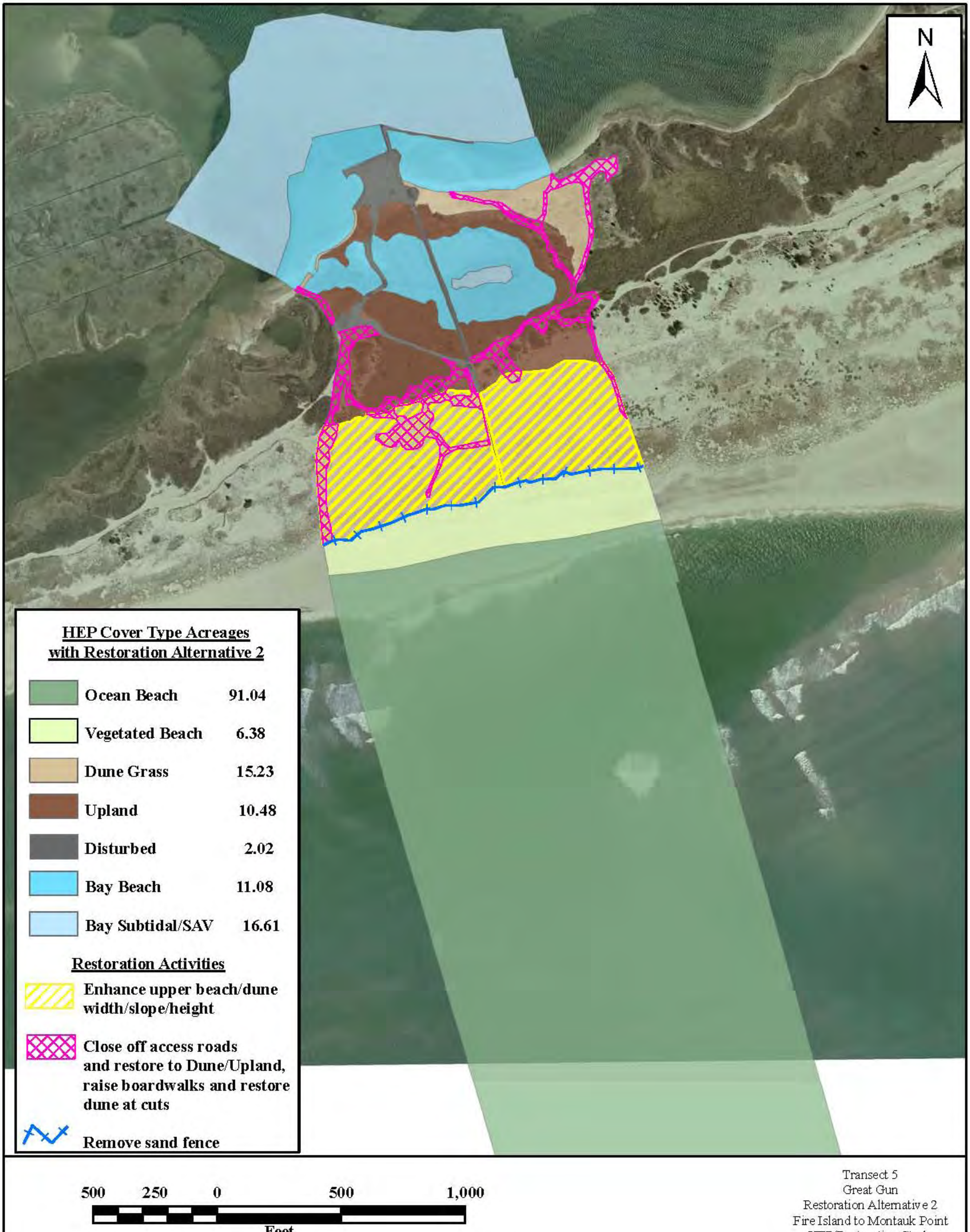
Ocean Beach 91.04
Vegetated Beach 6.38
Dune Grass 14.26
Upland 6.55
Disturbed 6.09
Bay Beach 12.22
Bay Subtidal/SAV 16.29
Restoration Activities
Restore hydrologic connection via culvert beneath road
500 250 0 500 1,000
Feet
Transect 5
Great Gun
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06




Transect 5
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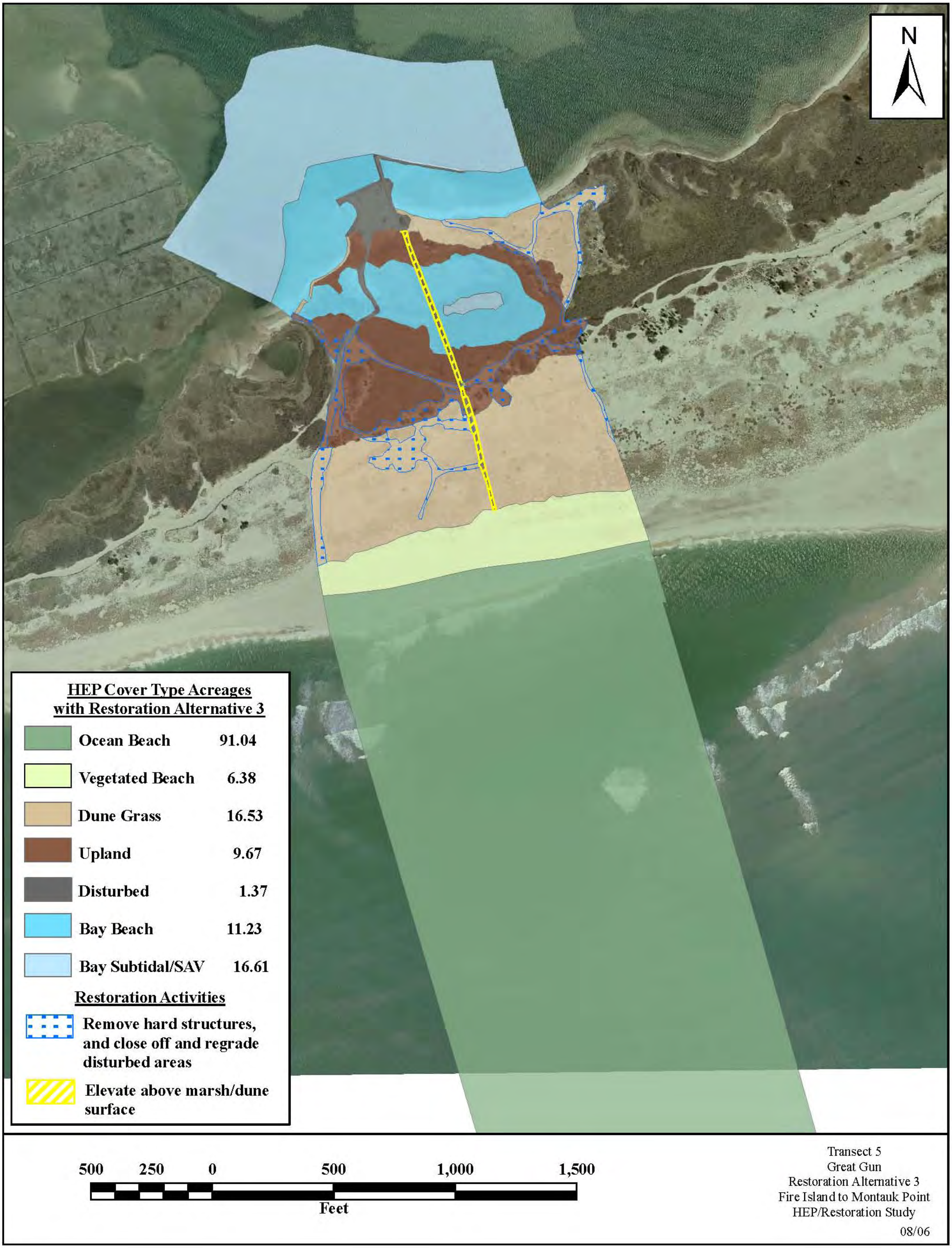
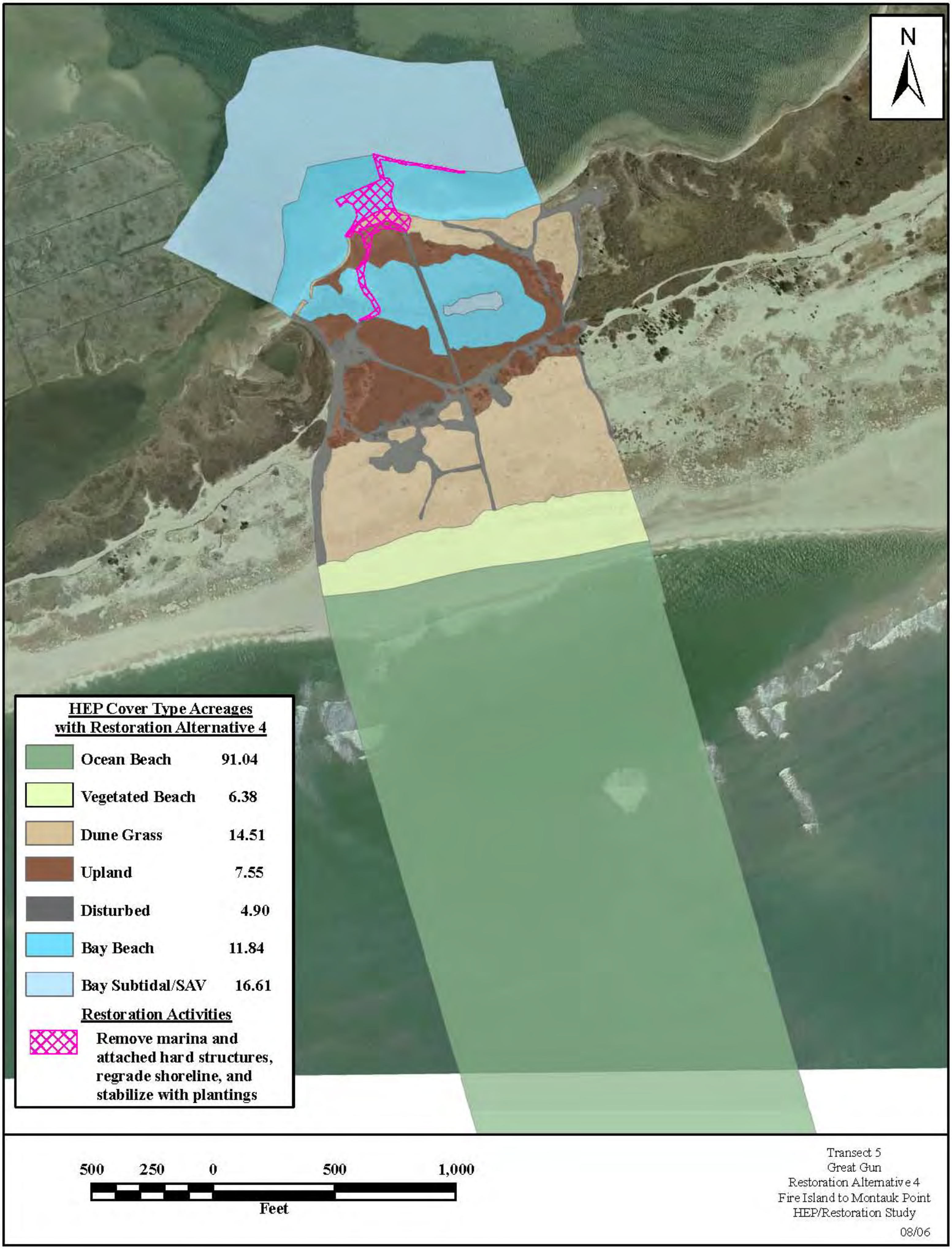
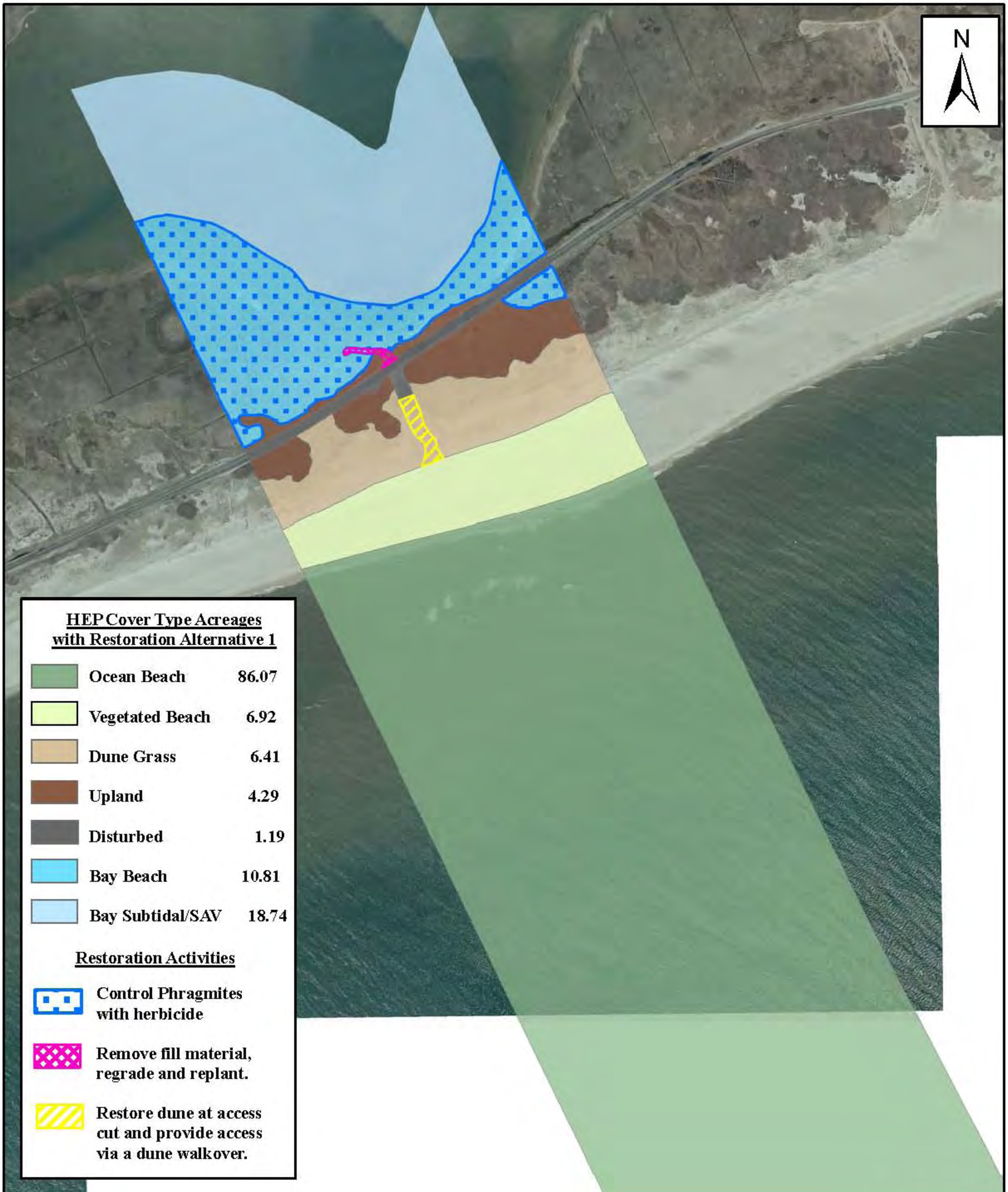
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06



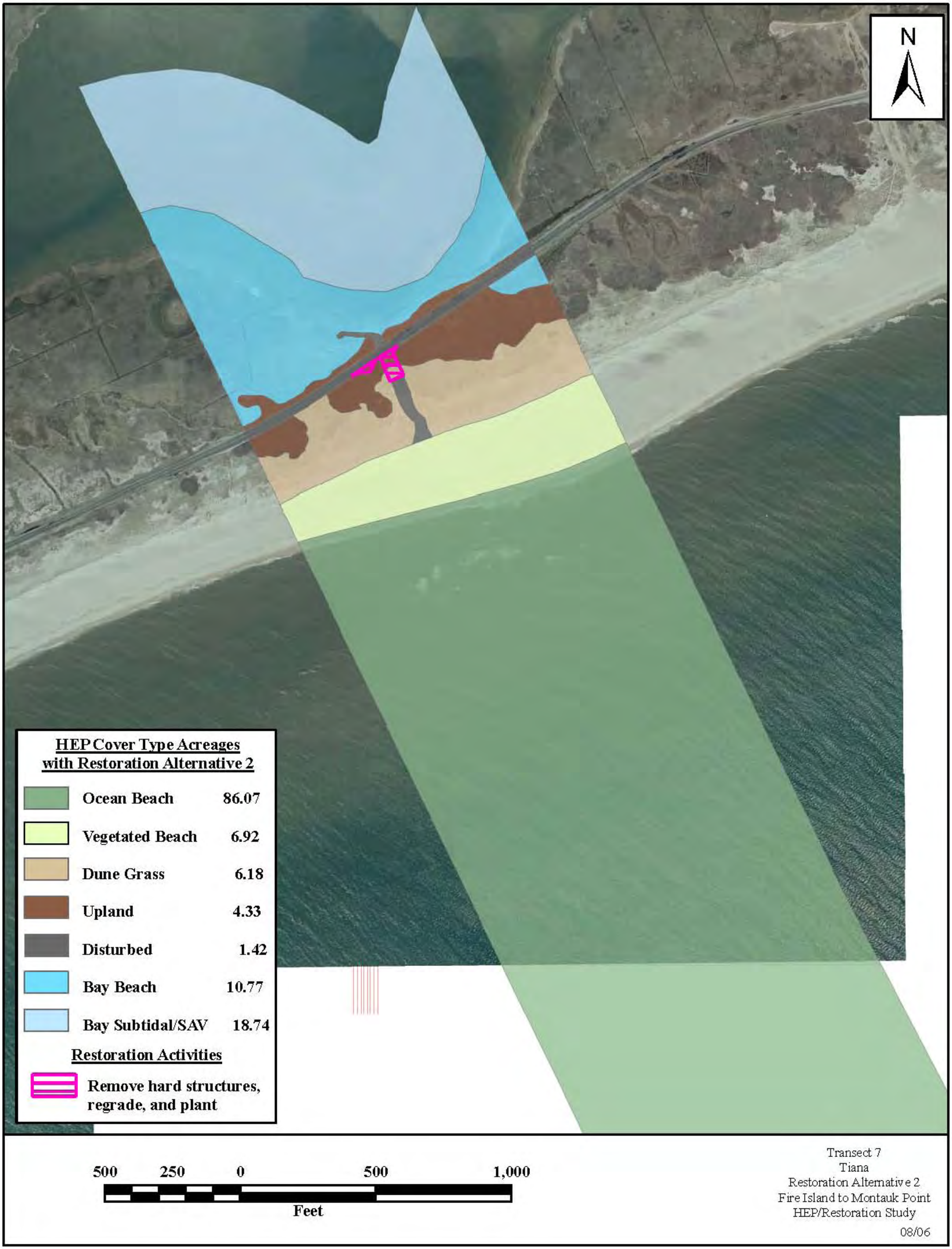
N
HEP Cover Type Acreages
with Restoration Alternative 3
Ocean Beach 91.04
Vegetated Beach 6.38
Dune Grass 16.53
Upland 9.67
Disturbed 1.37
Bay Beach 11.23
Bay Subtidal/SAV 16.61
Restoration Activities
Remove hard structures, and close off and regrade disturbed areas
Elevate above marsh/dune surface
500 250 0 500 1,000 1,500
Feet
Transect 5
Great Gun
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

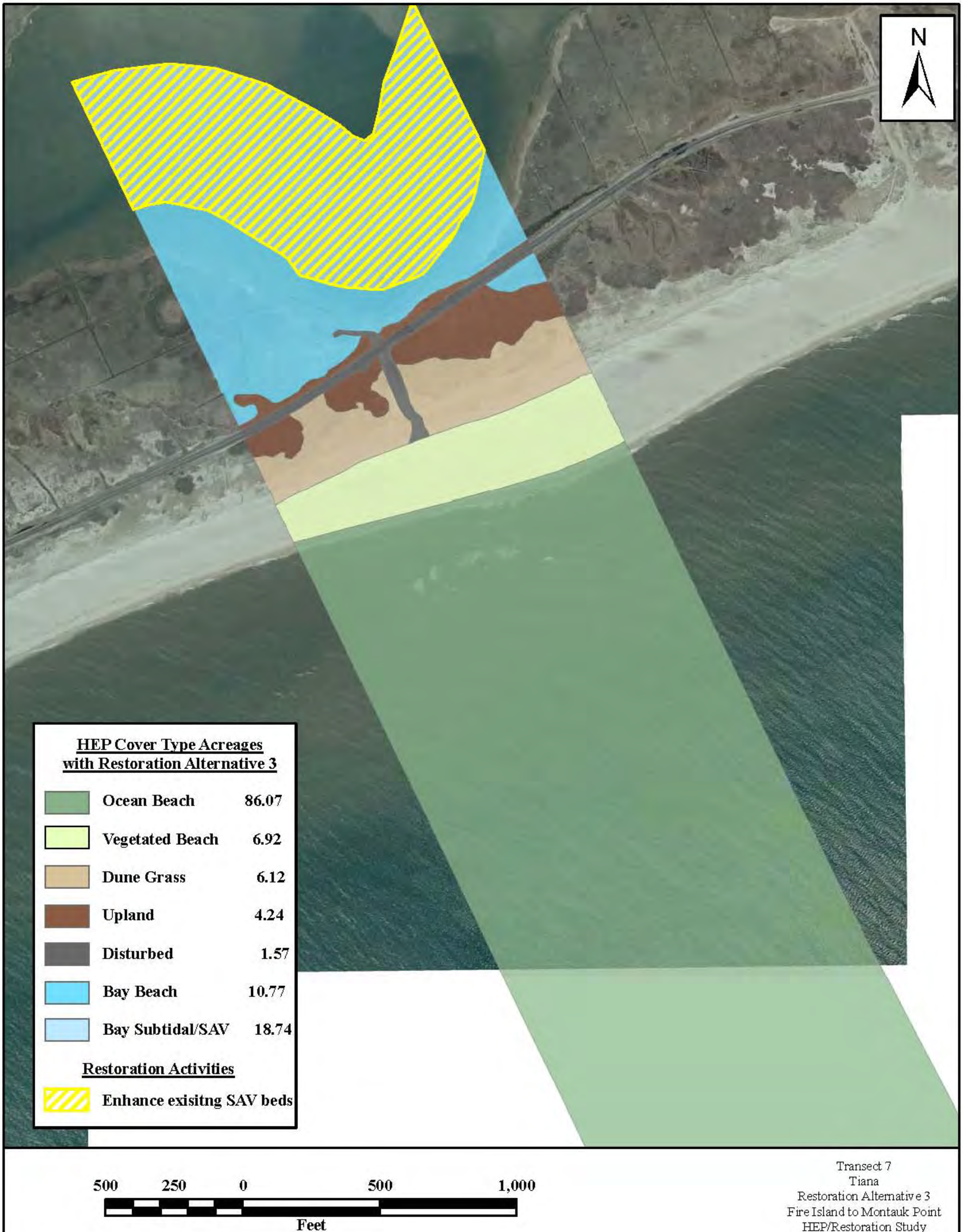



Transect 5
Great Gun
Restoration Alternative 4
Fire Island to Montauk Point
HEP/Restoration Study
08/06




Transect 7
Tiana
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages
with Restoration Alternative 2
Ocean Beach 86.07
Vegetated Beach 6.92
Dune Grass 6.18
Upland 4.33
Disturbed 1.42
Bay Beach 10.77
Bay Subtidal/SAV 18.74
Restoration Activities
Remove hard structures, regrade, and plant
500 250 0 500 1,000
Feet
Transect 7
Tiana
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

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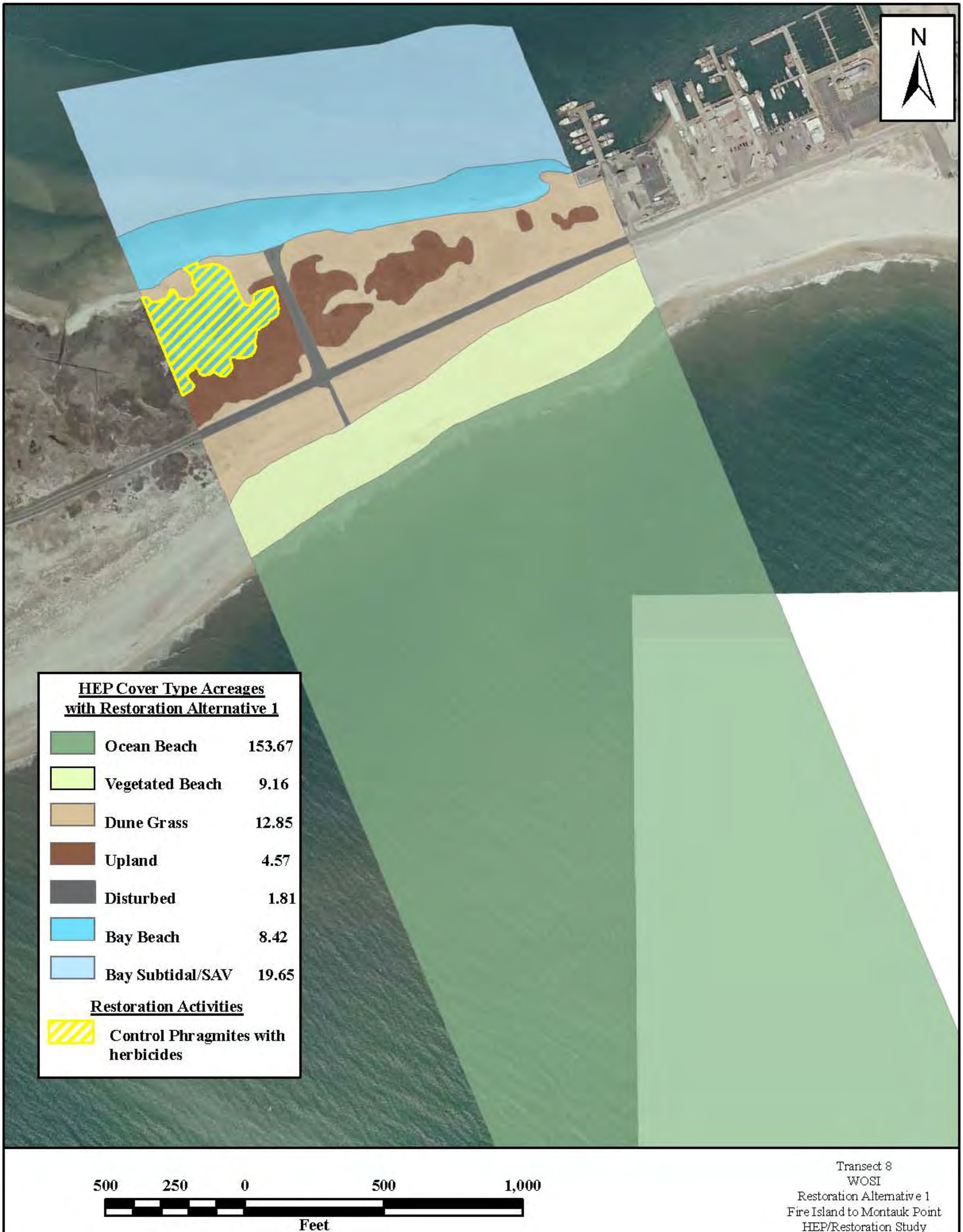
HEP/Restoration Study
08/06

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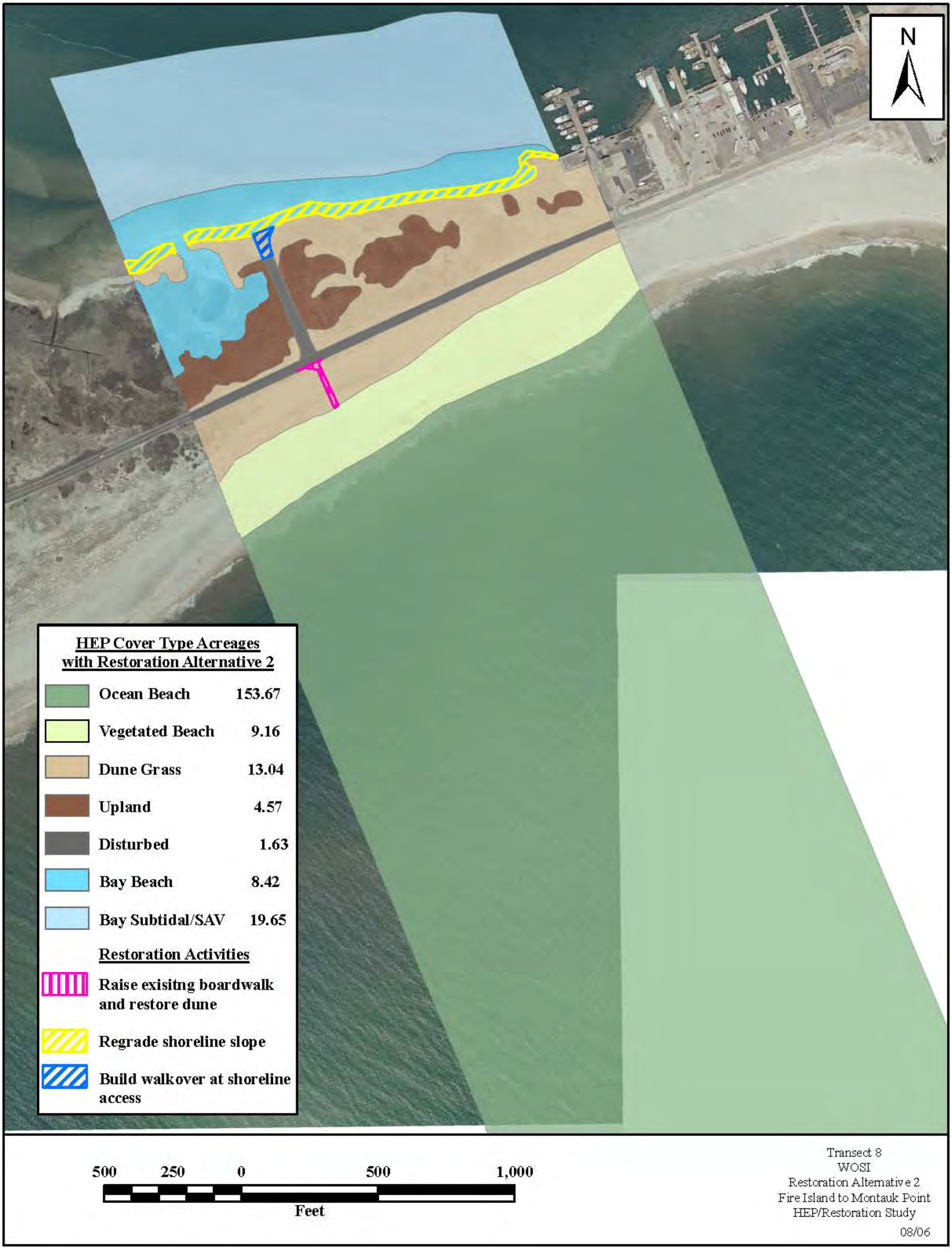
Fire Island to Montauk Point
HEP/Restoration Study
08/06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HEP Cover Type Acreages
with Restoration Alternative 2
Ocean Beach 153.67
Vegetated Beach 9.16
Dune Grass 13.04
Upland 4.57
Disturbed 1.63
Bay Beach 8.42
Bay Subtidal/SAV 19.65
Restoration Activities
Raise exisitng boardwalk and restore dune
Regrade shoreline slope
Build walkover at shoreline access
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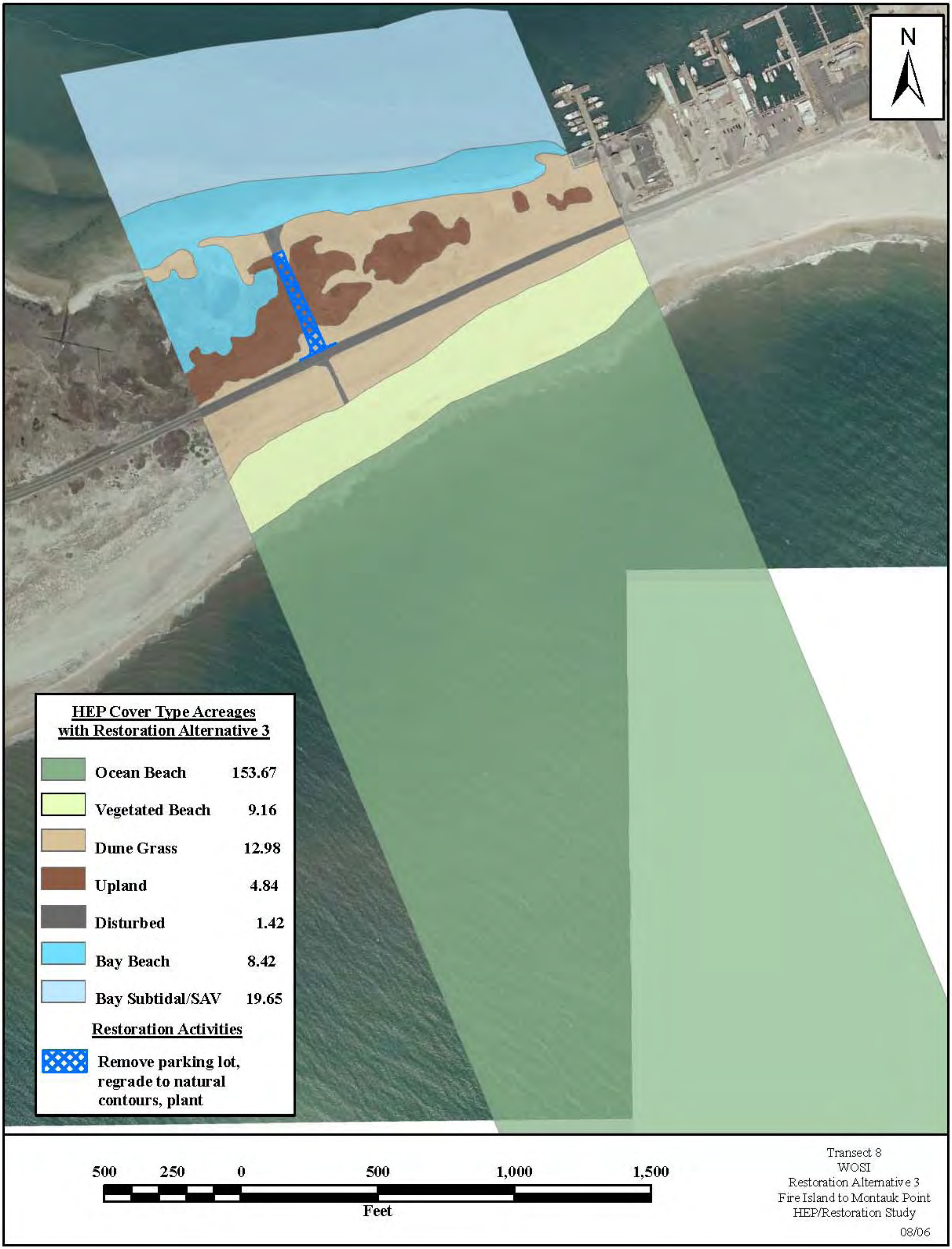
Feet
Transect 8
WOSI
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06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Ocean Beach 153.67
Vegetated Beach 9.16
Dune Grass 12.98
Upland 4.84
Disturbed 1.42
Bay Beach 8.42
Bay Subtidal/SAV 19.65
Restoration Activities
Remove parking lot, regrade to natural contours, plant
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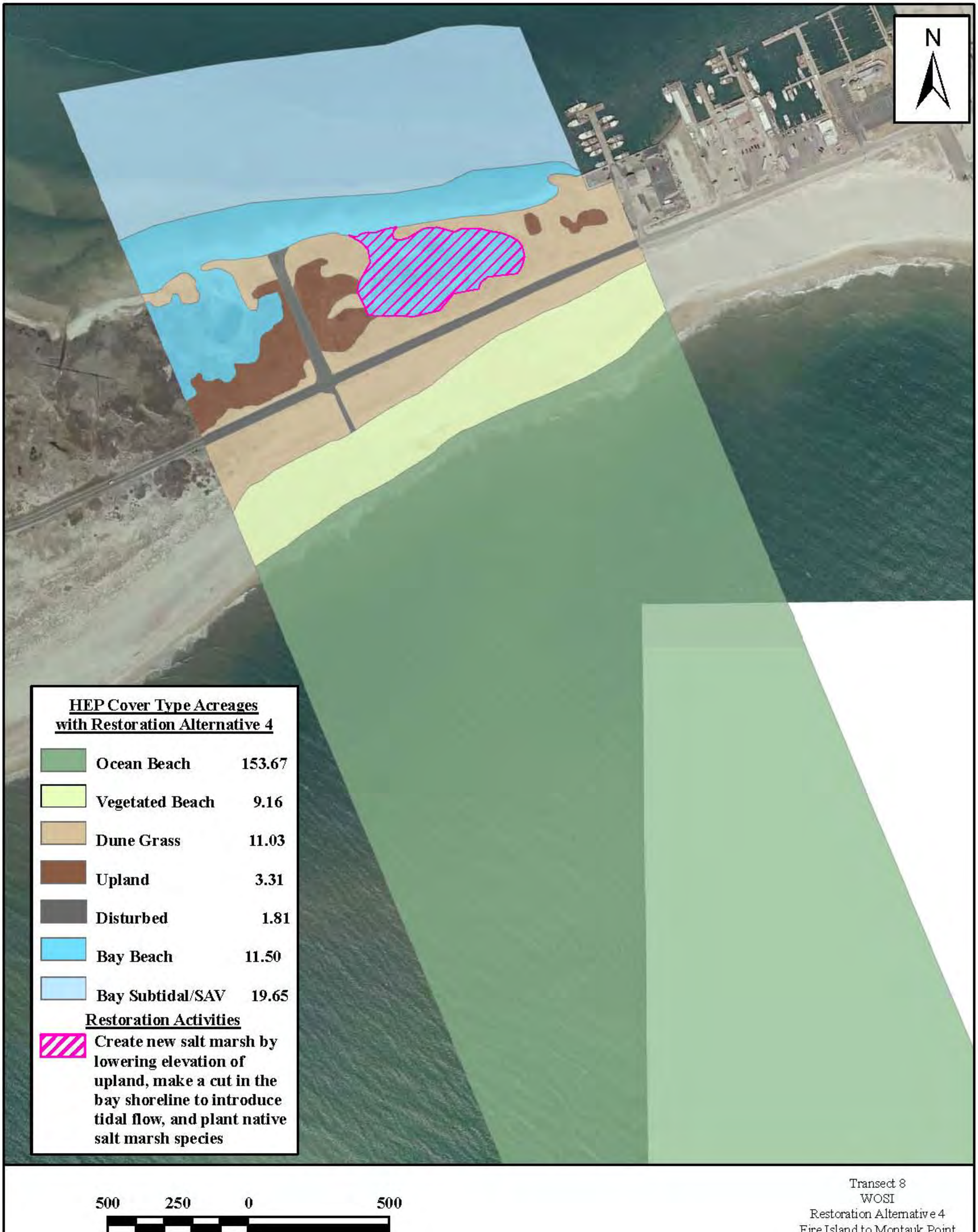
Feet
Transect 8
WOSI
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

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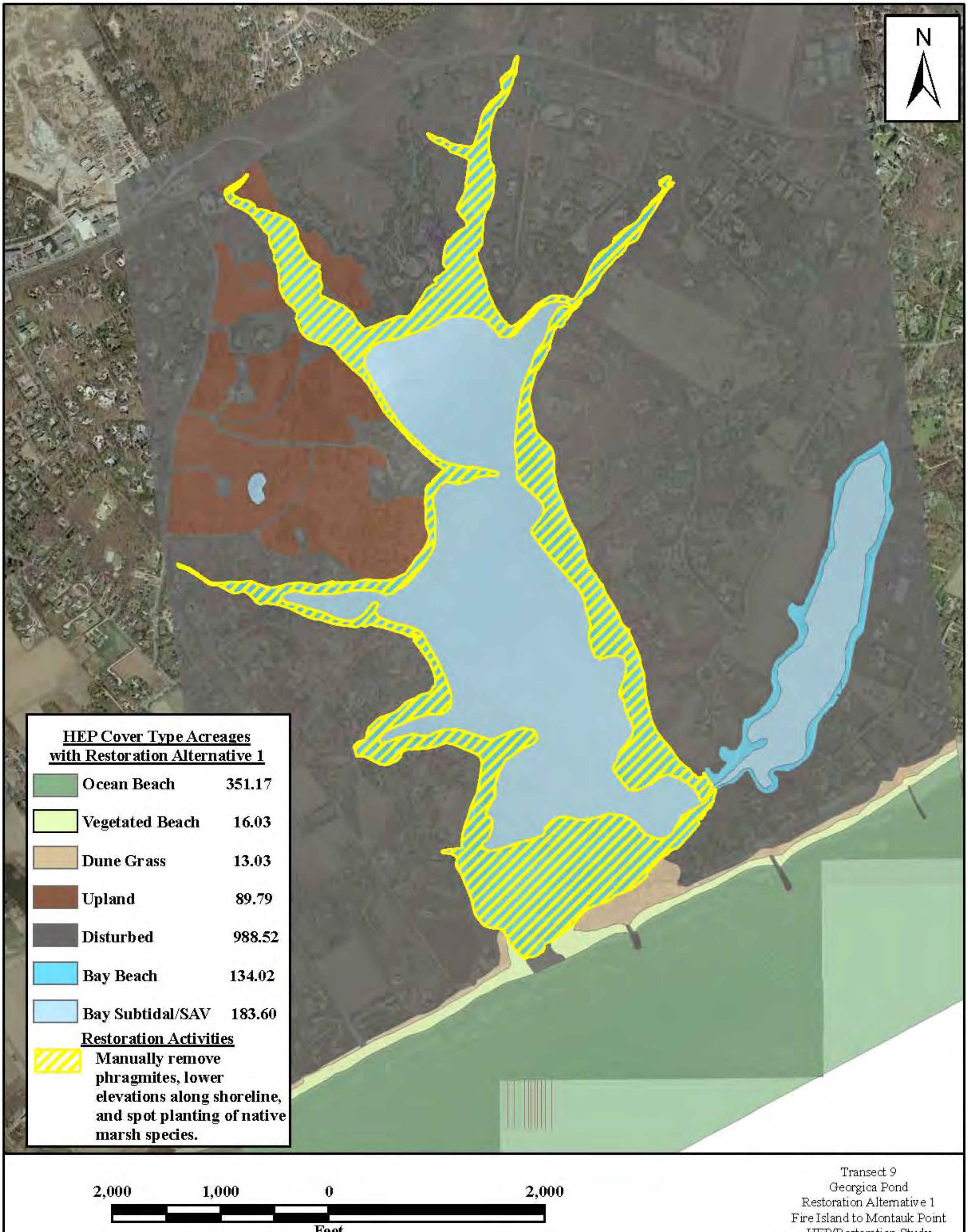


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Georgica Pond
Restoration Alternative 1
Fire Island to Montauk Point
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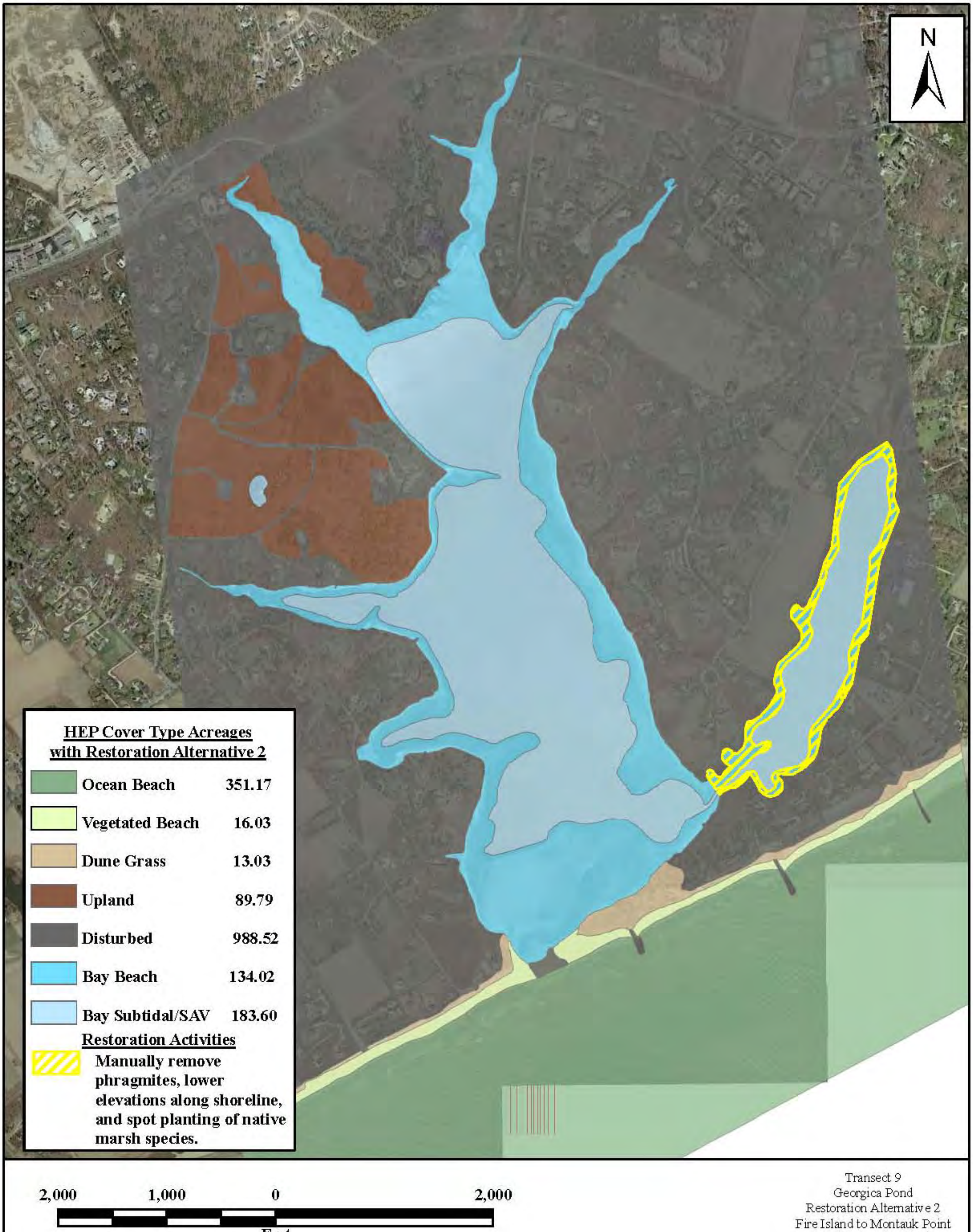
08/06

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Georgica Pond
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HEP/Restoration Study
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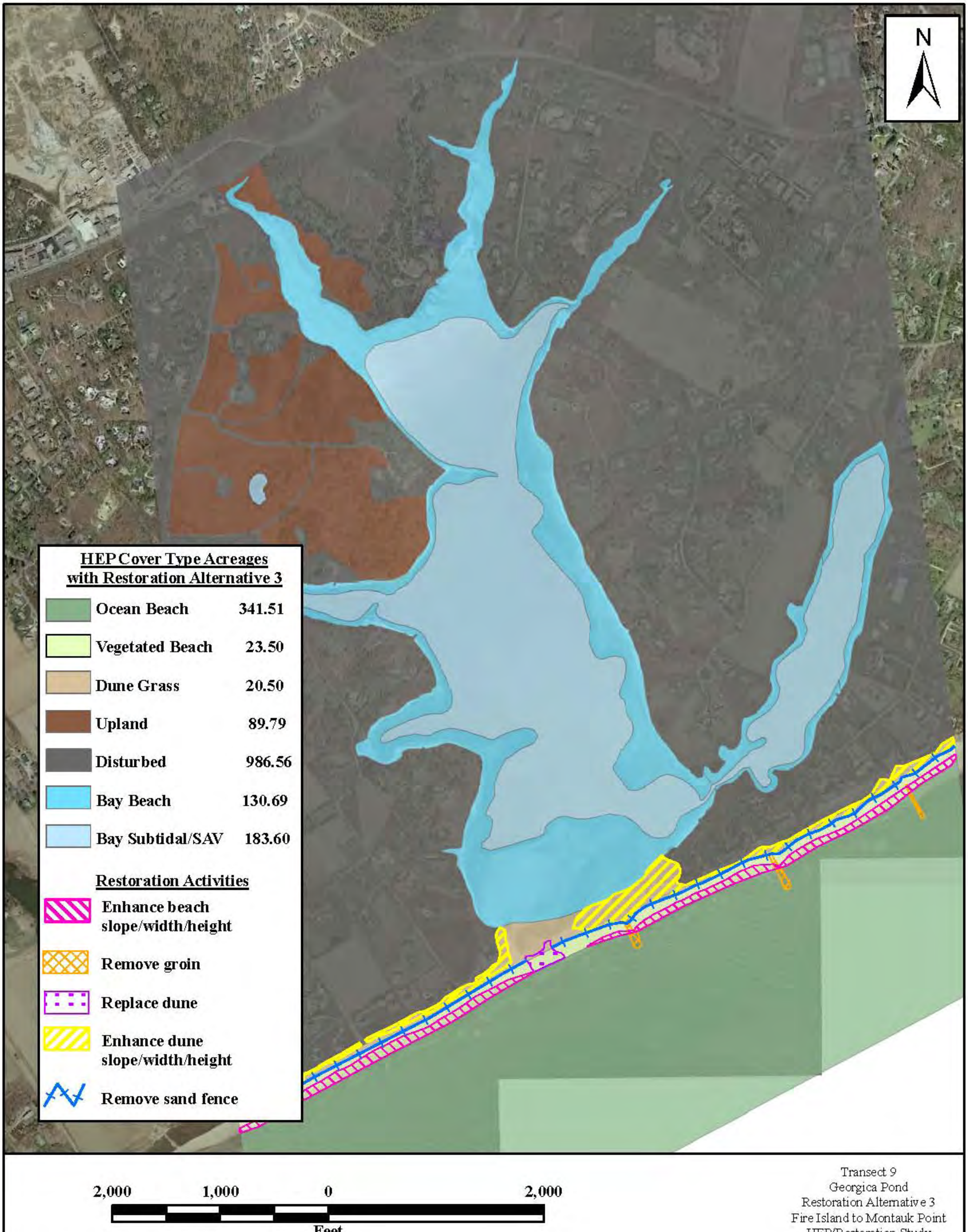


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Georgica Pond
Restoration Alternative 3
Fire Island to Montauk Point
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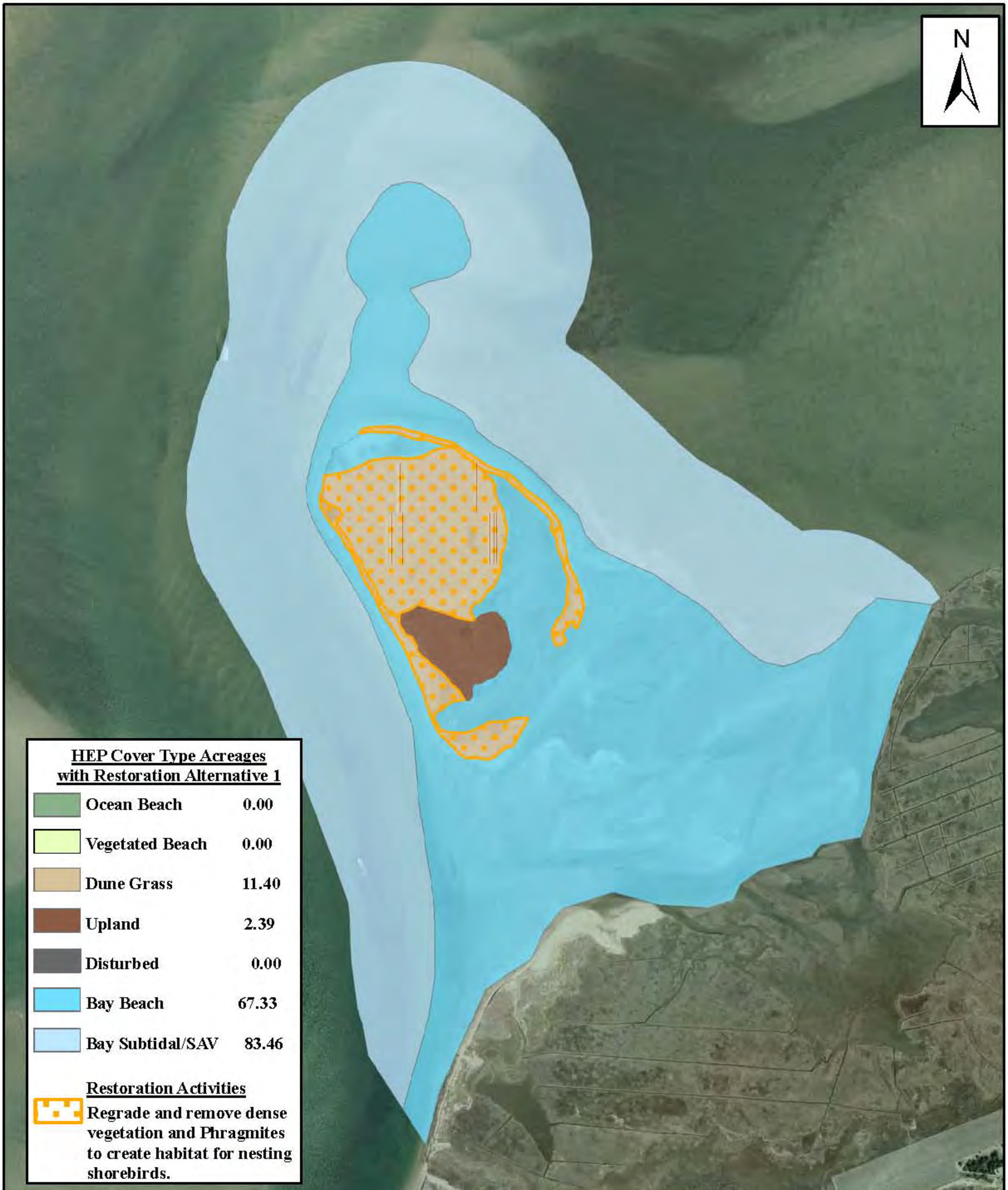
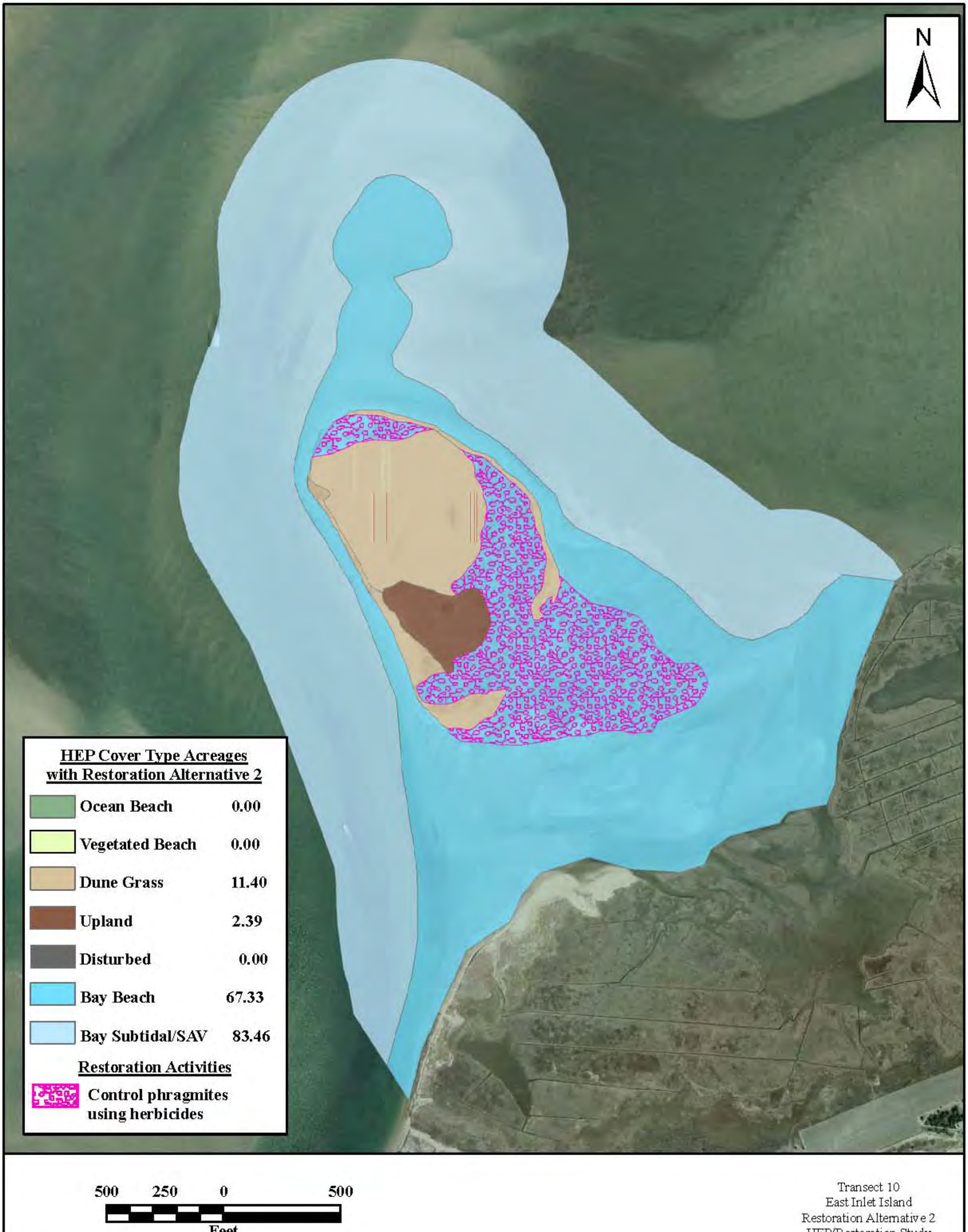
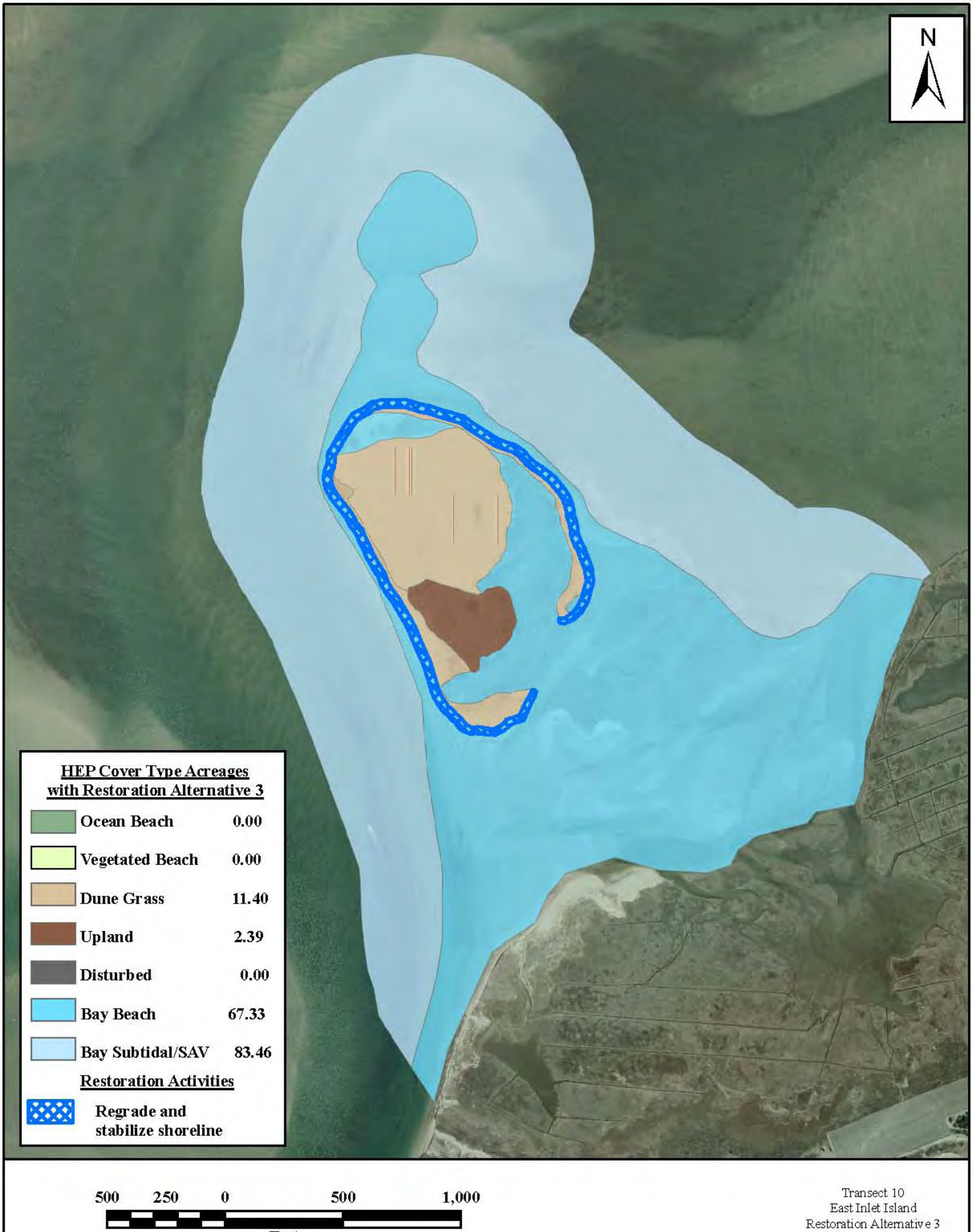



500 250 0 500 1,000
Feet

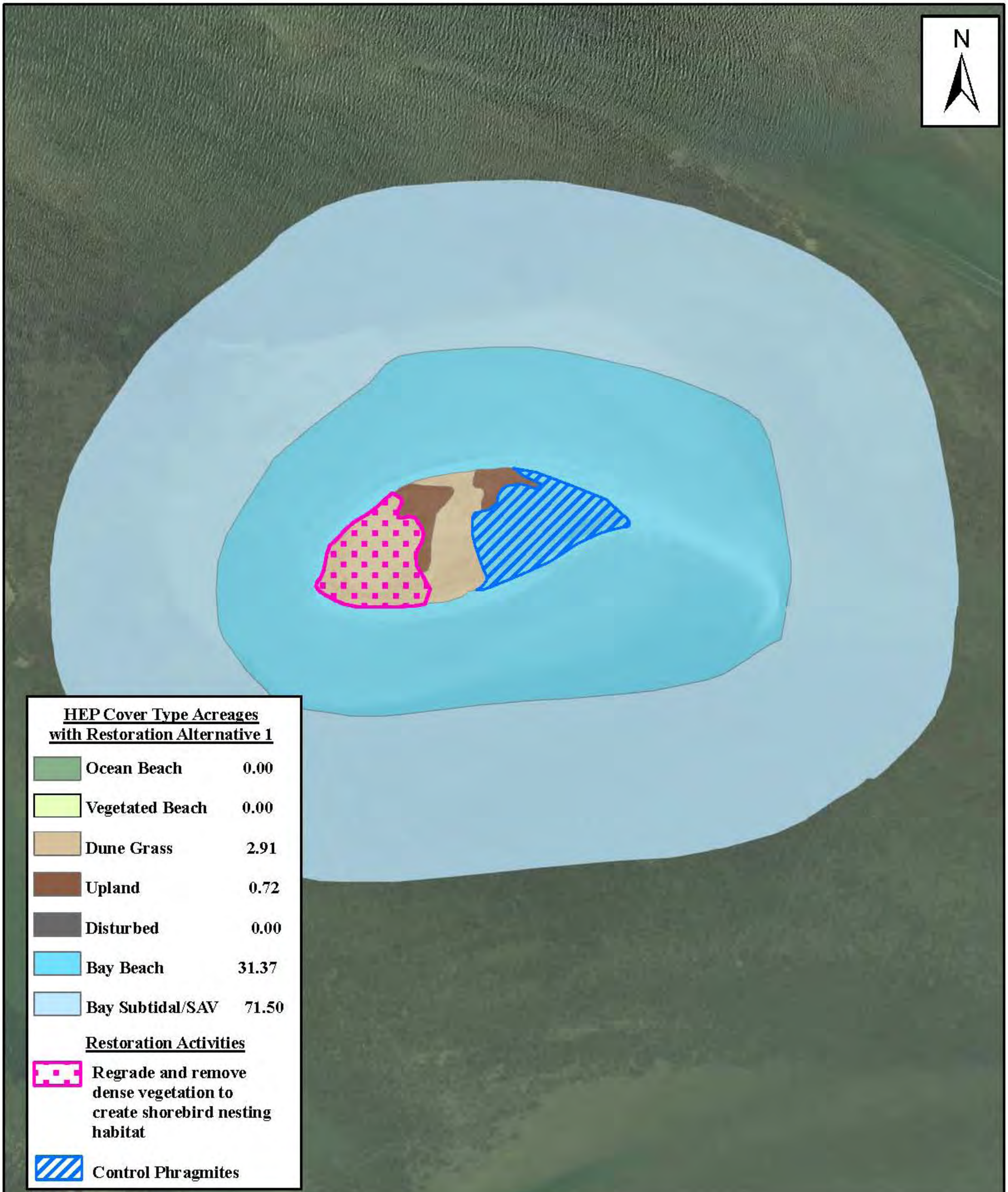
Transect 10
East Inlet Island
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06




Transect 10
East Inlet Island
Restoration Alternative 2
HEP/Restoration Study
08/06

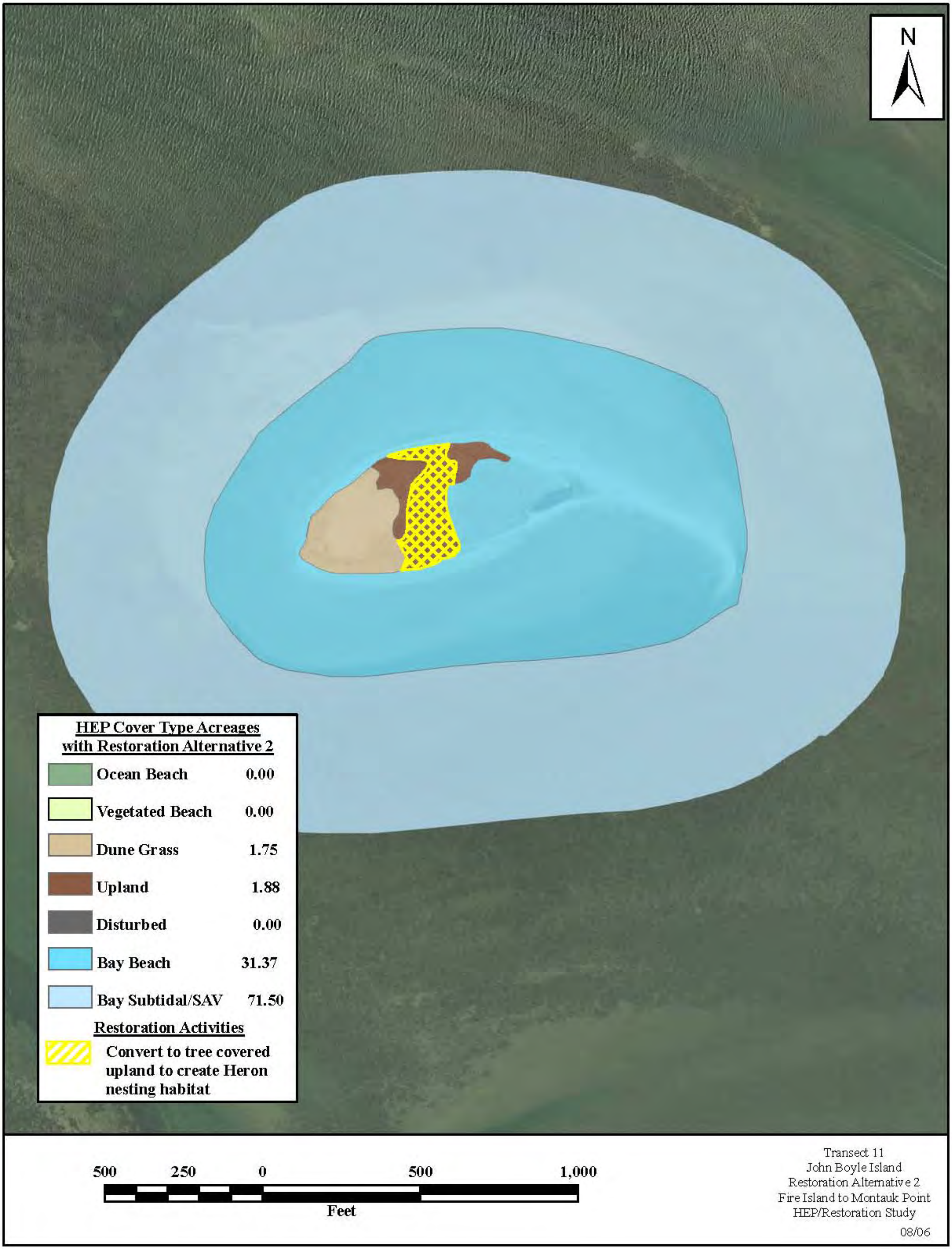


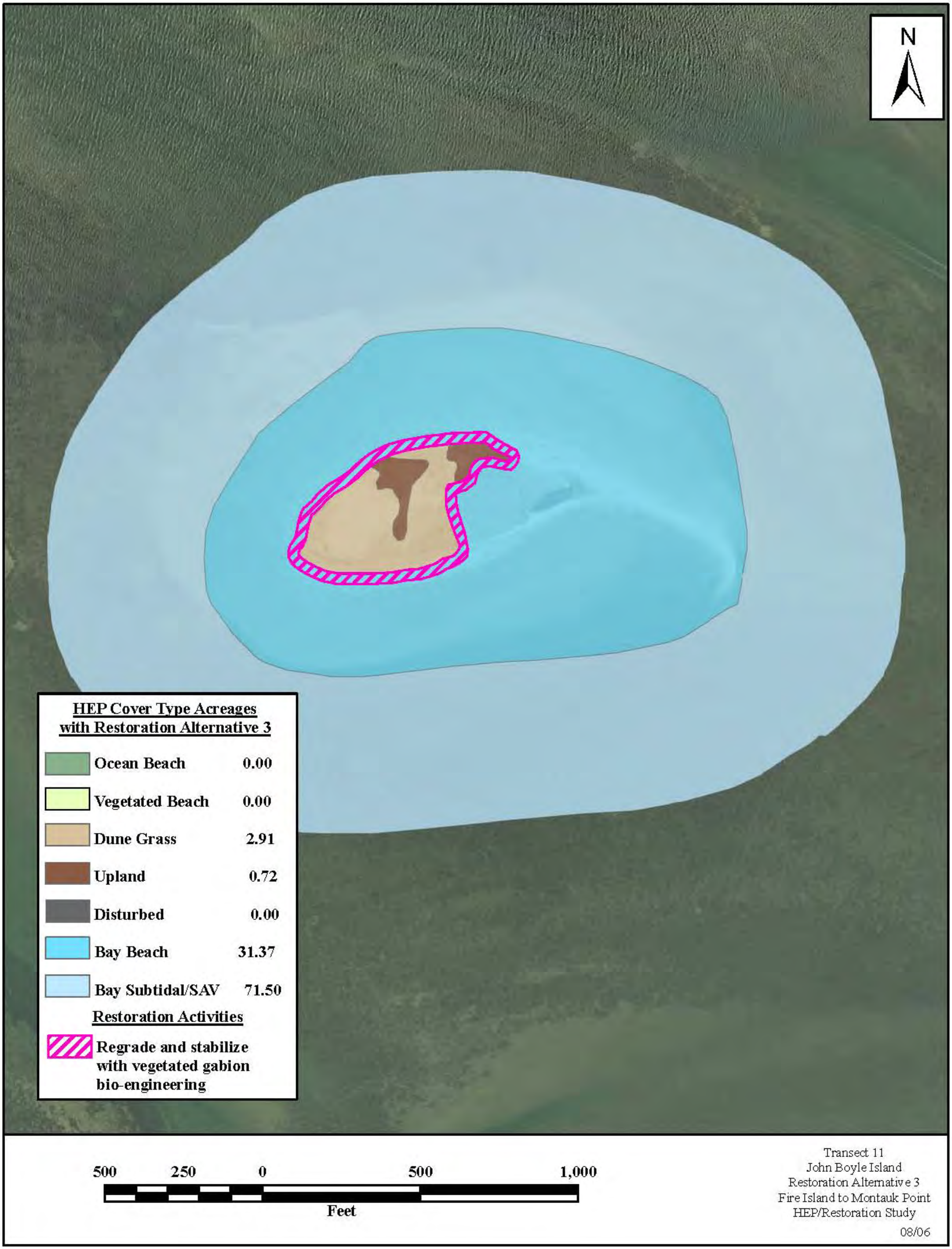

Transect 10
East Inlet Island
Restoration Alternative 3
HEP/Restoration Study
08/06

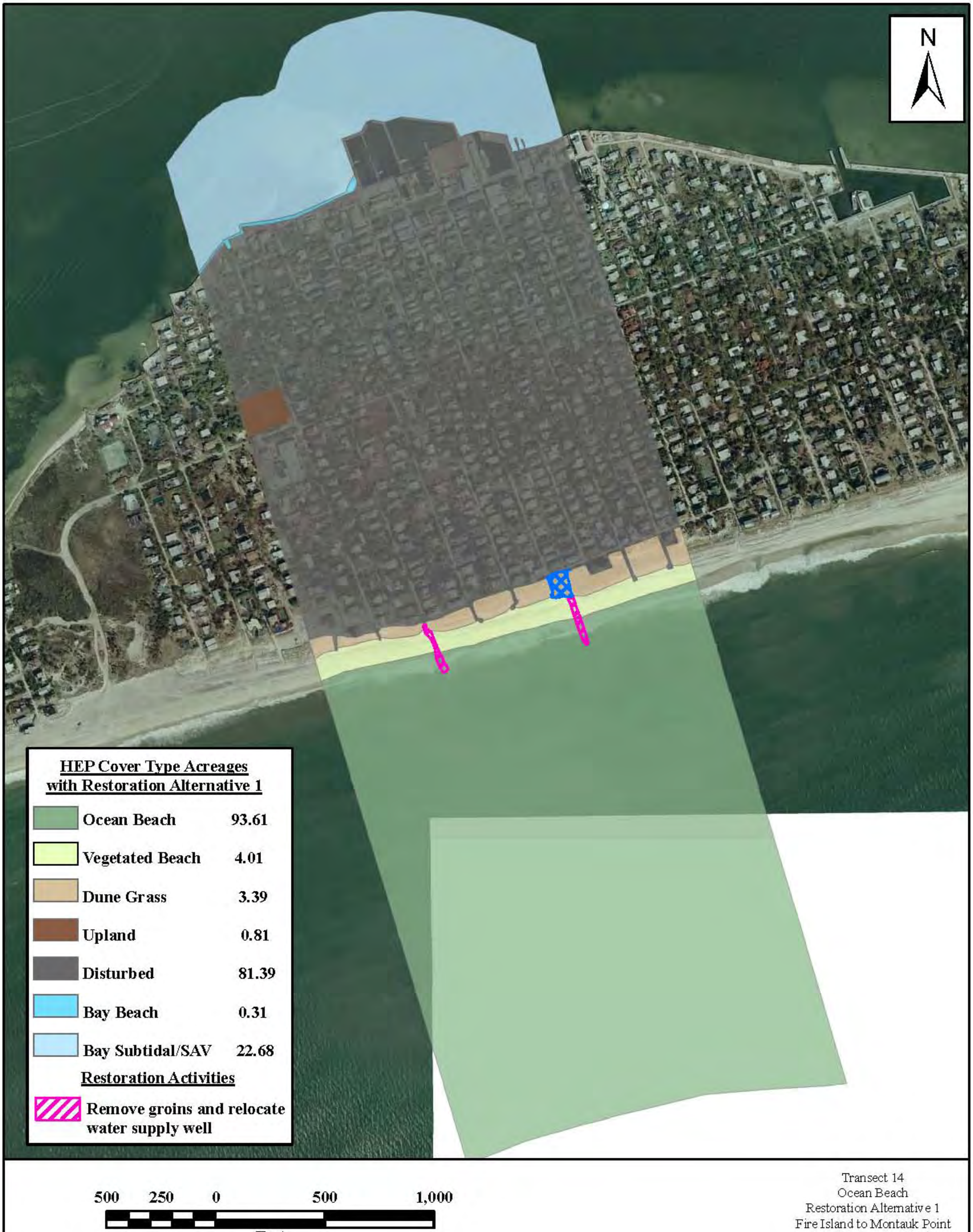




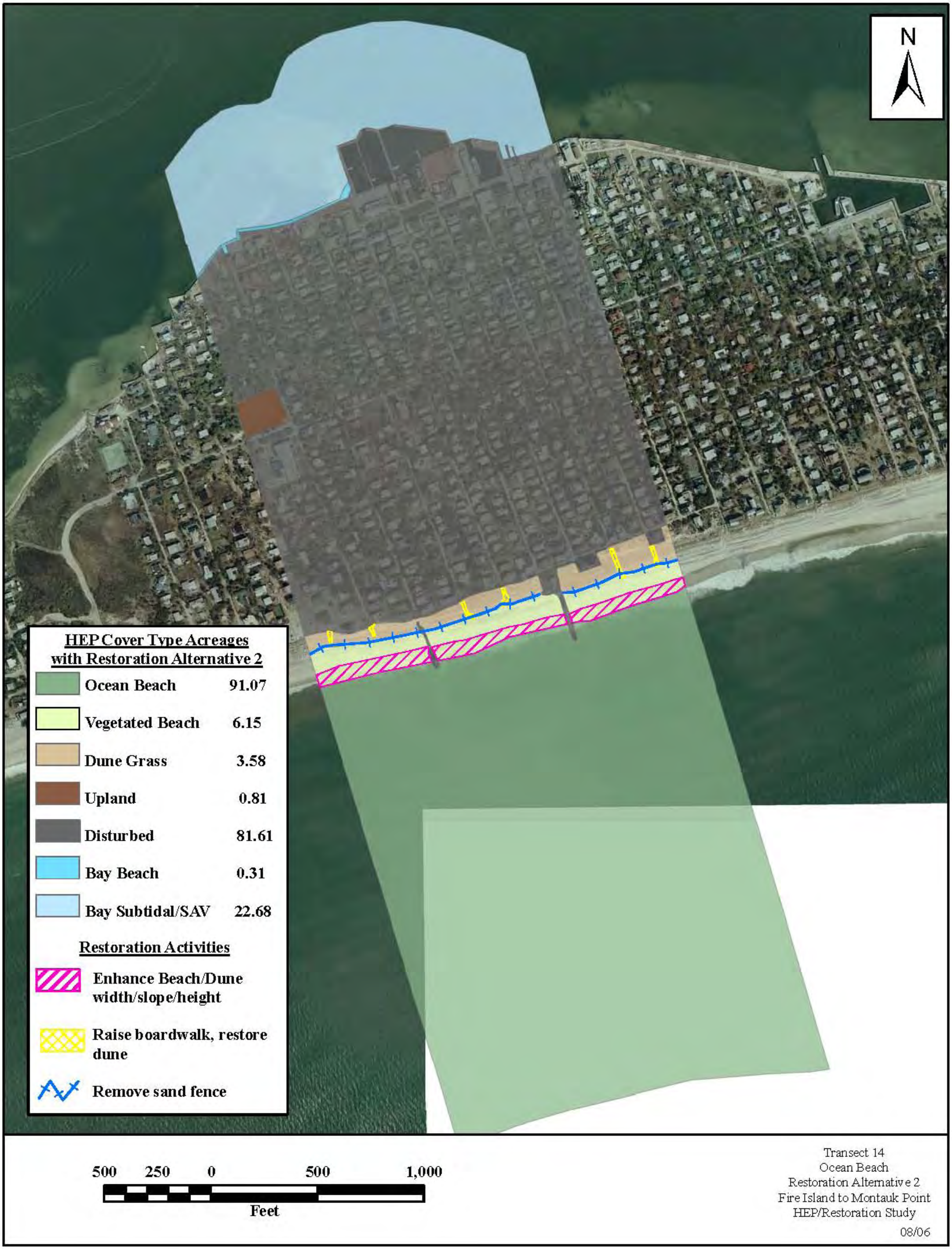
Transect 11
John Boyle Island
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

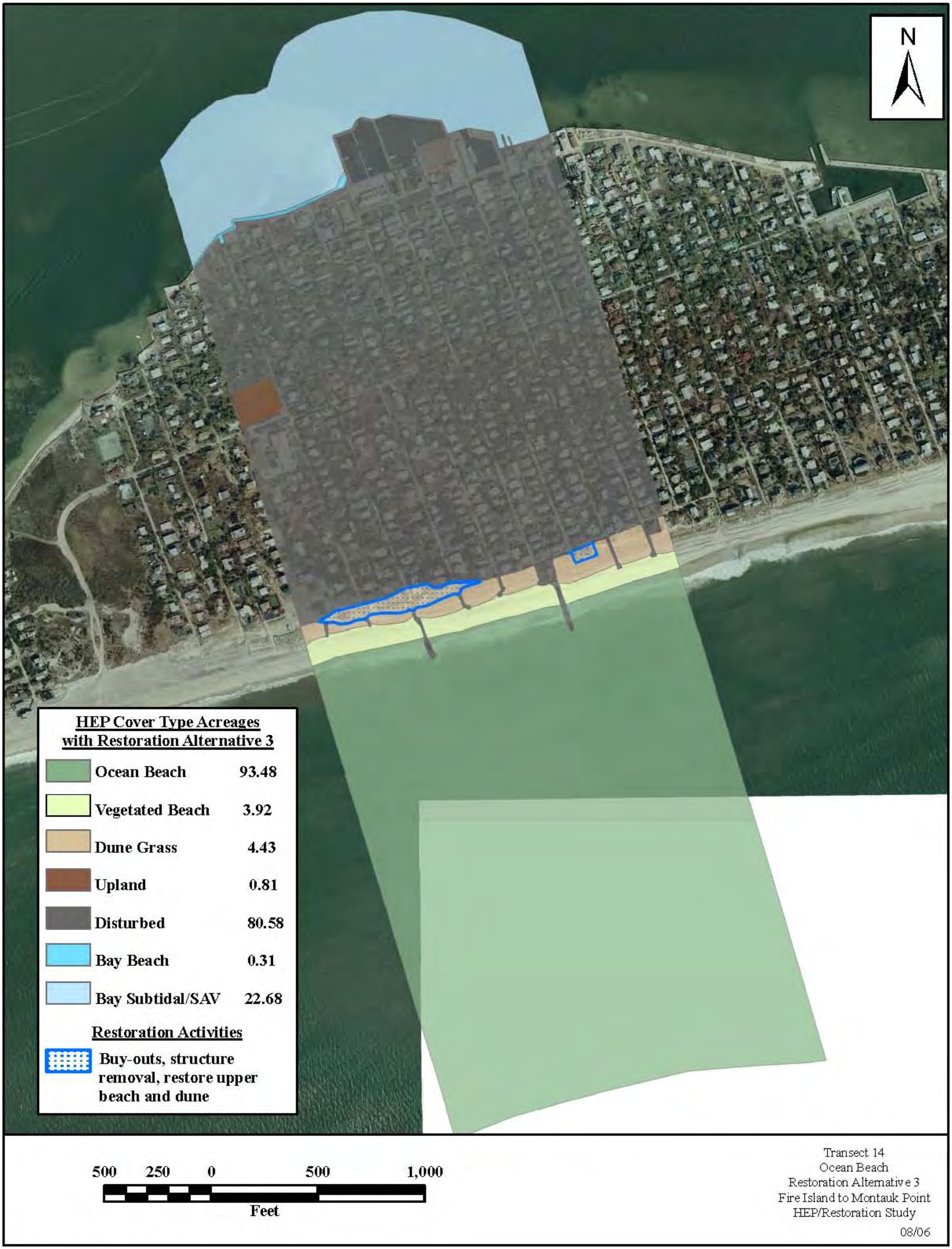

N
HEP Cover Type Acreages
with Restoration Alternative 2
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 1.75
Upland 1.88
Disturbed 0.00
Bay Beach 31.37
Bay Subtidal/SAV 71.50
Restoration Activities
Convert to tree covered upland to create Heron nesting habitat
500 250 0 500 1,000
Feet
Transect 11
John Boyle Island
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

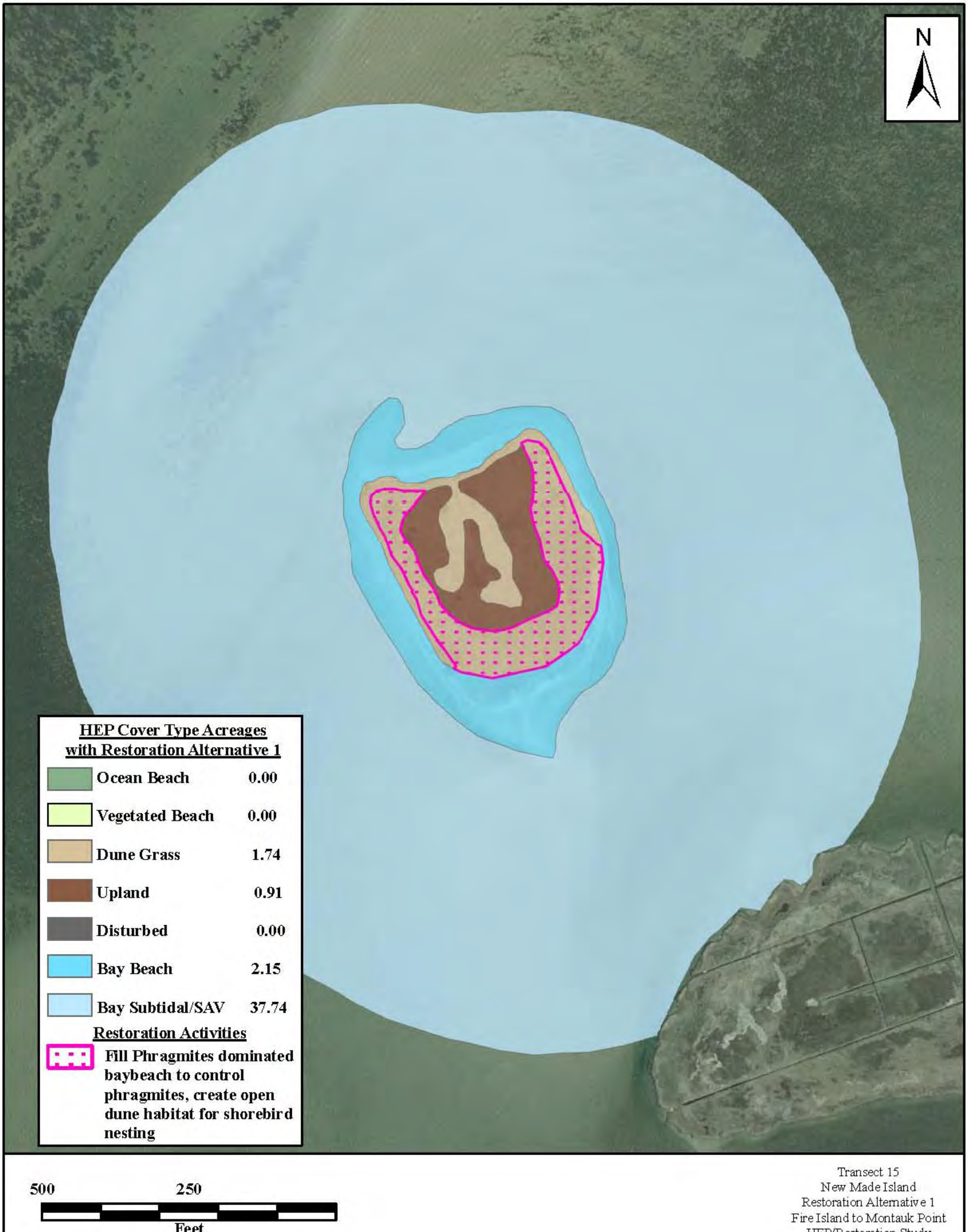

N
HEP Cover Type Acreages with Restoration Alternative 3
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 2.91
Upland 0.72
Disturbed 0.00
Bay Beach 31.37
Bay Subtidal/SAV 71.50
Restoration Activities
Regrade and stabilize with vegetated gabion bio-engineering
500 250 0 500 1,000
Feet
Transect 11
John Boyle Island
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06



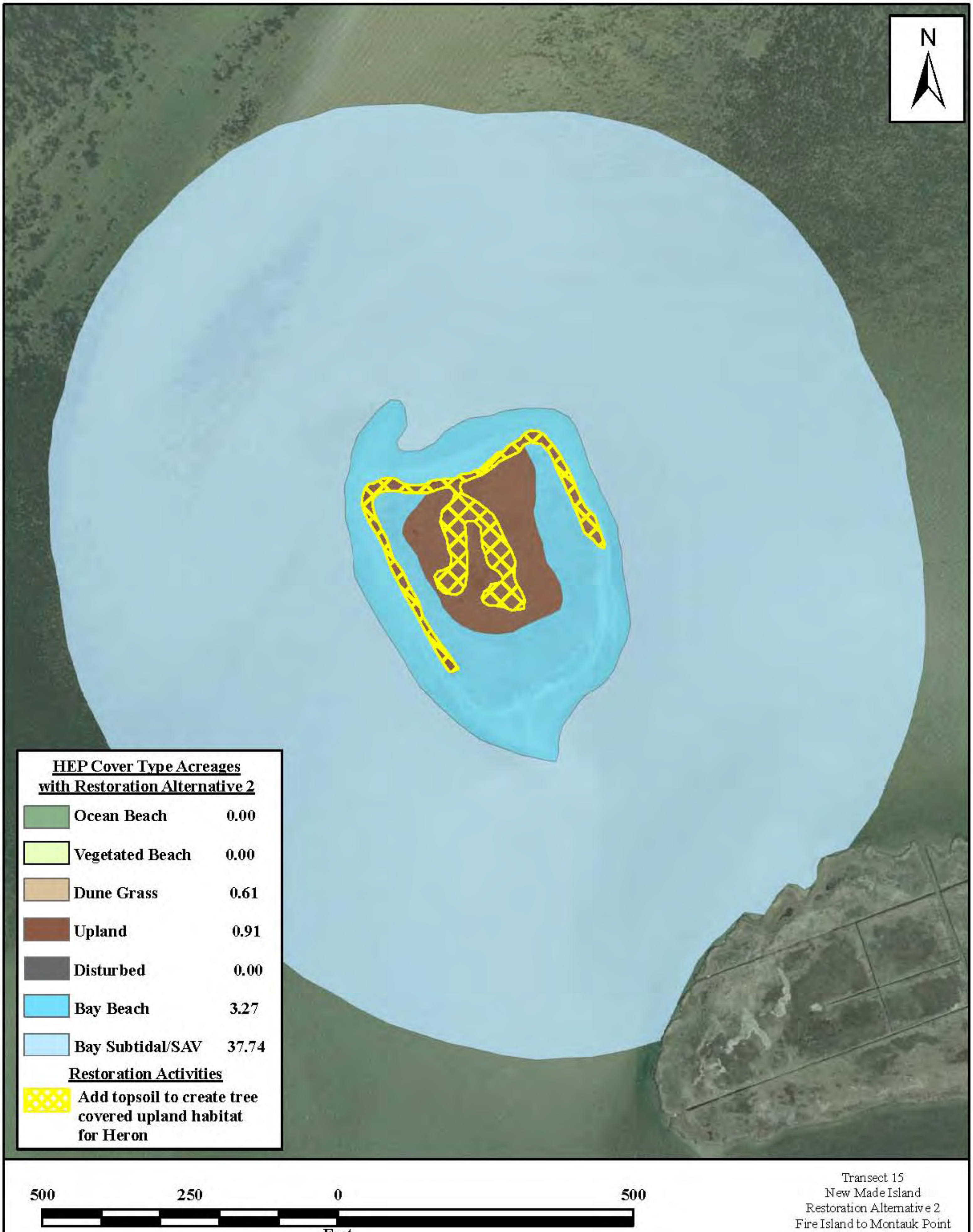

Transect 14
Ocean Beach
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages with Restoration Alternative 2
Ocean Beach 91.07
Vegetated Beach 6.15
Dune Grass 3.58
Upland 0.81
Disturbed 81.61
Bay Beach 0.31
Bay Subtidal/SAV 22.68
Restoration Activities
Enhance Beach/Dune width/slope/height
Raise boardwalk, restore dune
Remove sand fence
500 250 0 500 1,000
Feet
Transect 14
Ocean Beach
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

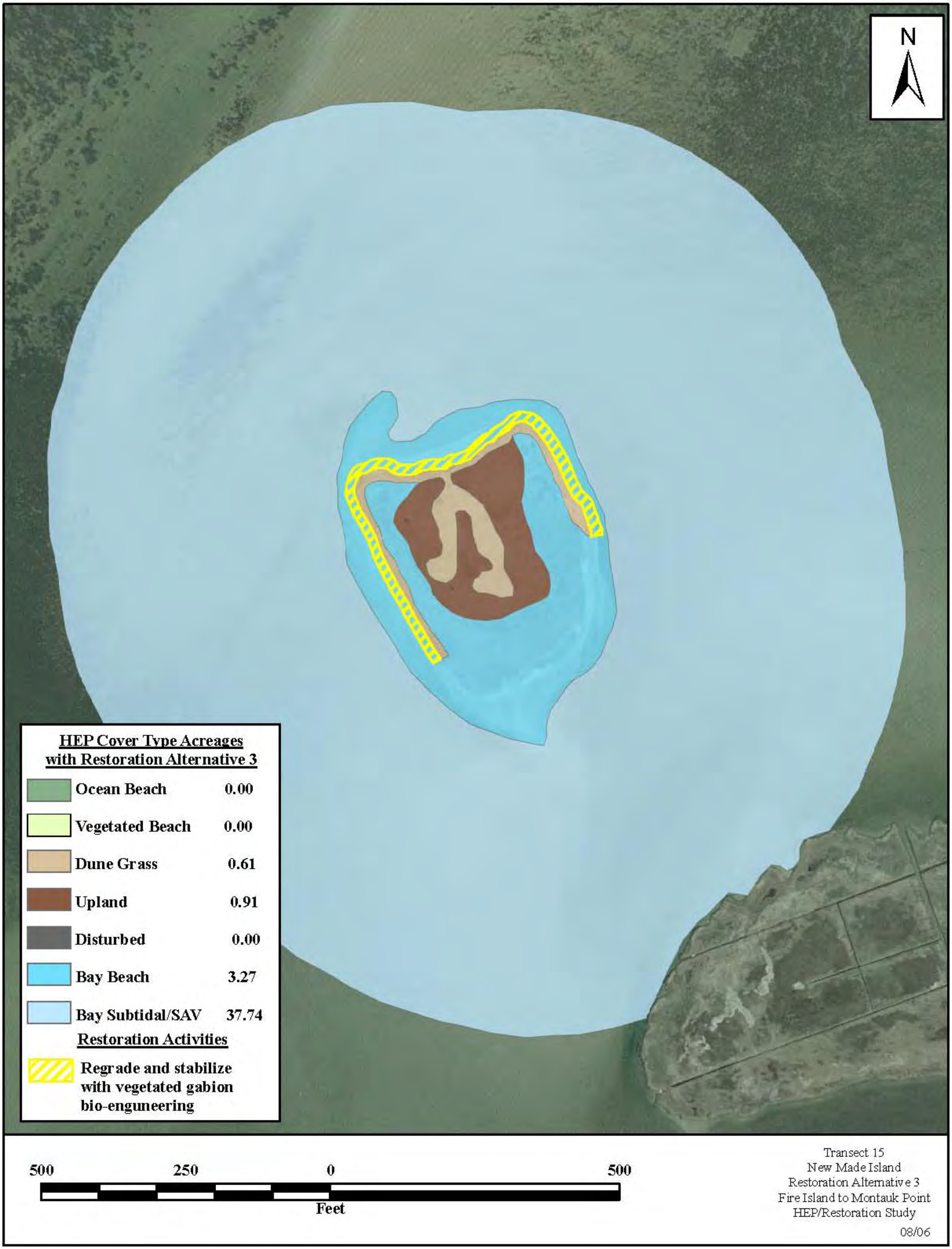

N
HEP Cover Type Acreages
with Restoration Alternative 3
Ocean Beach 93.48
Vegetated Beach 3.92
Dune Grass 4.43
Upland 0.81
Disturbed 80.58
Bay Beach 0.31
Bay Subtidal/SAV 22.68
Restoration Activities
Buy-outs, structure removal, restore upper beach and dune
500 250 0 500 1,000
Feet
Transect 14
Ocean Beach
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

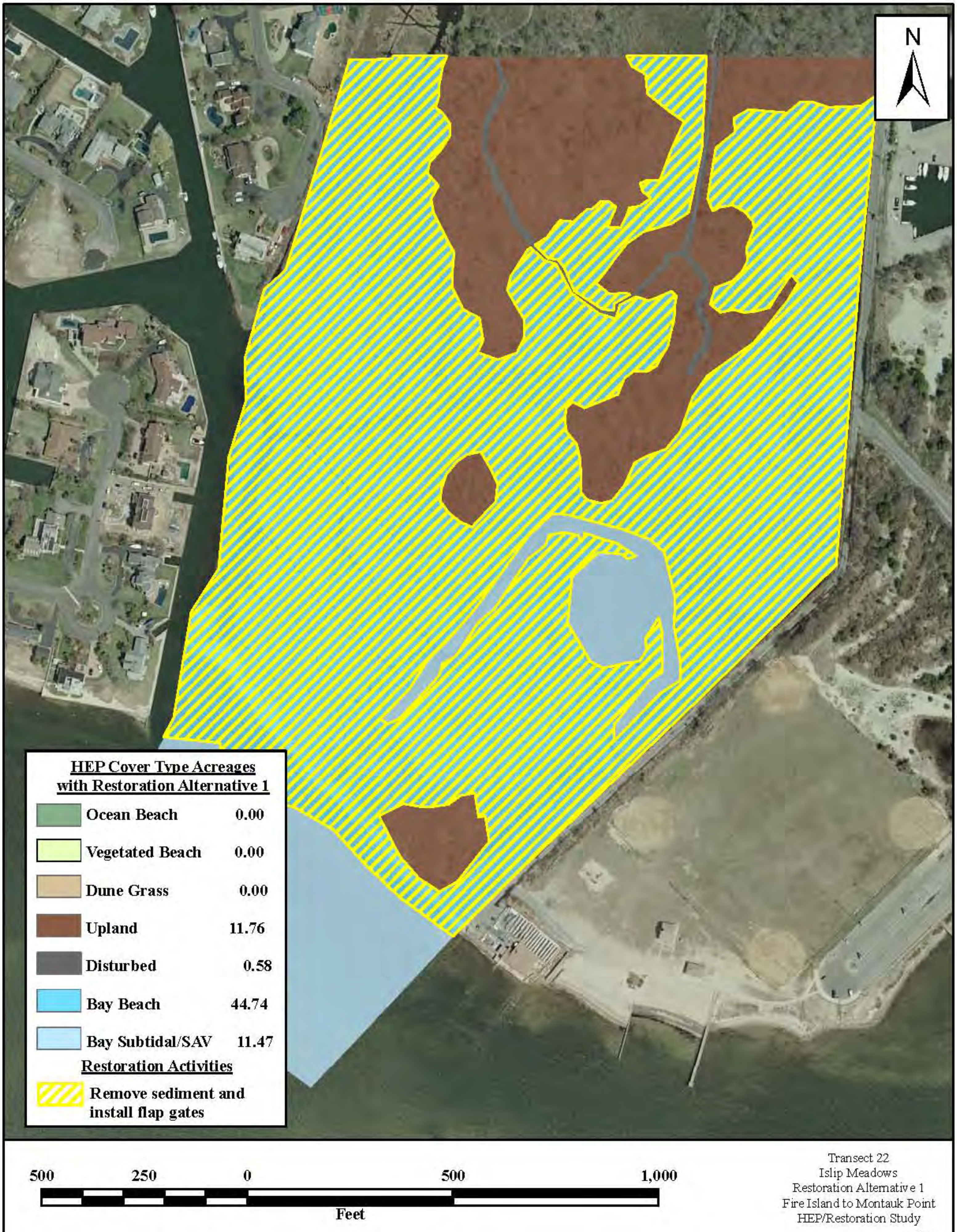



Transect 15
New Made Island
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

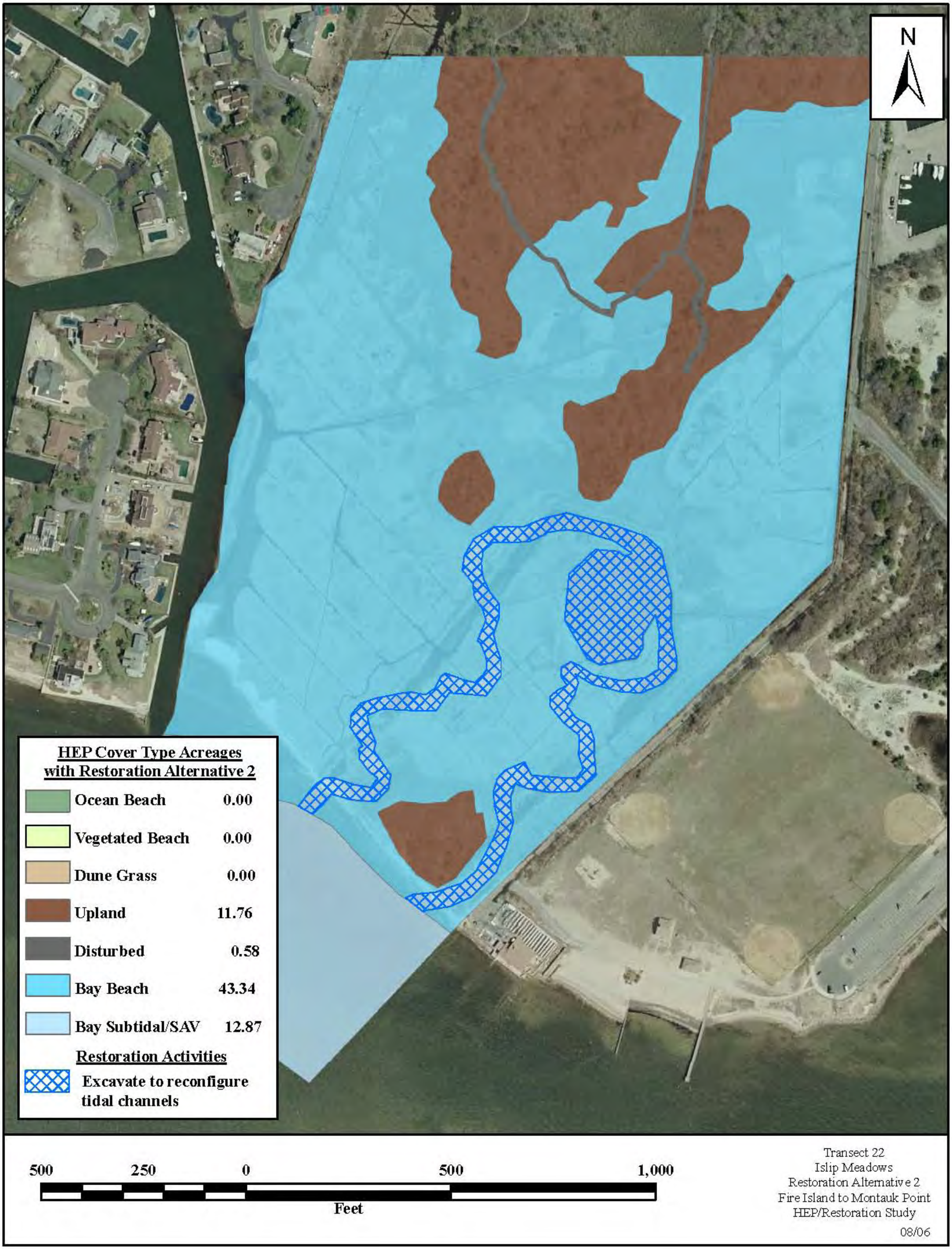


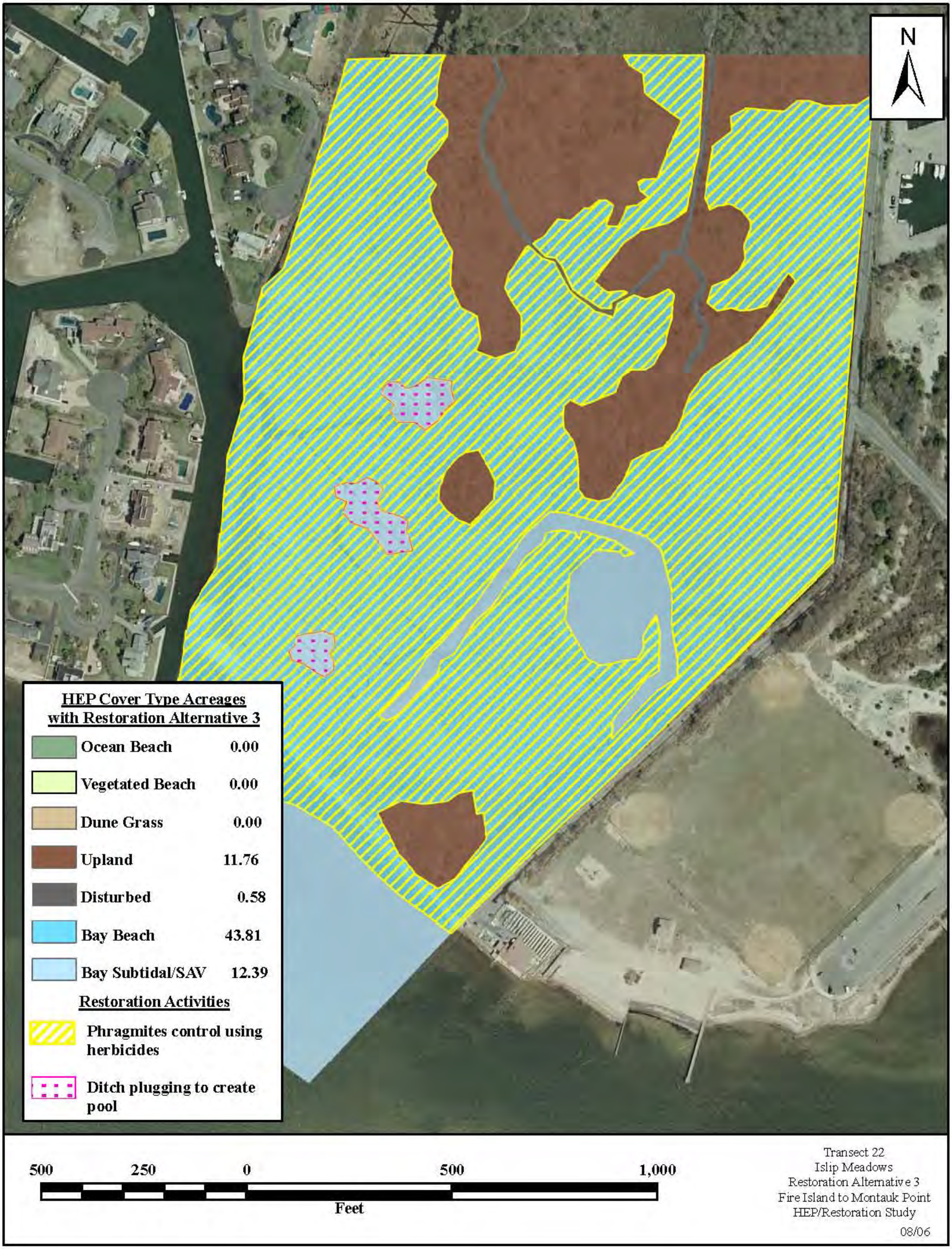

Transect 15
New Made Island
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages
with Restoration Alternative 3
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.61
Upland 0.91
Disturbed 0.00
Bay Beach 3.27
Bay Subtidal/SAV 37.74
Restoration Activities
Regrade and stabilize
with vegetated gabion
bio-enguneering
500
250
0
500
Feet
Transect 15
New Made Island
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

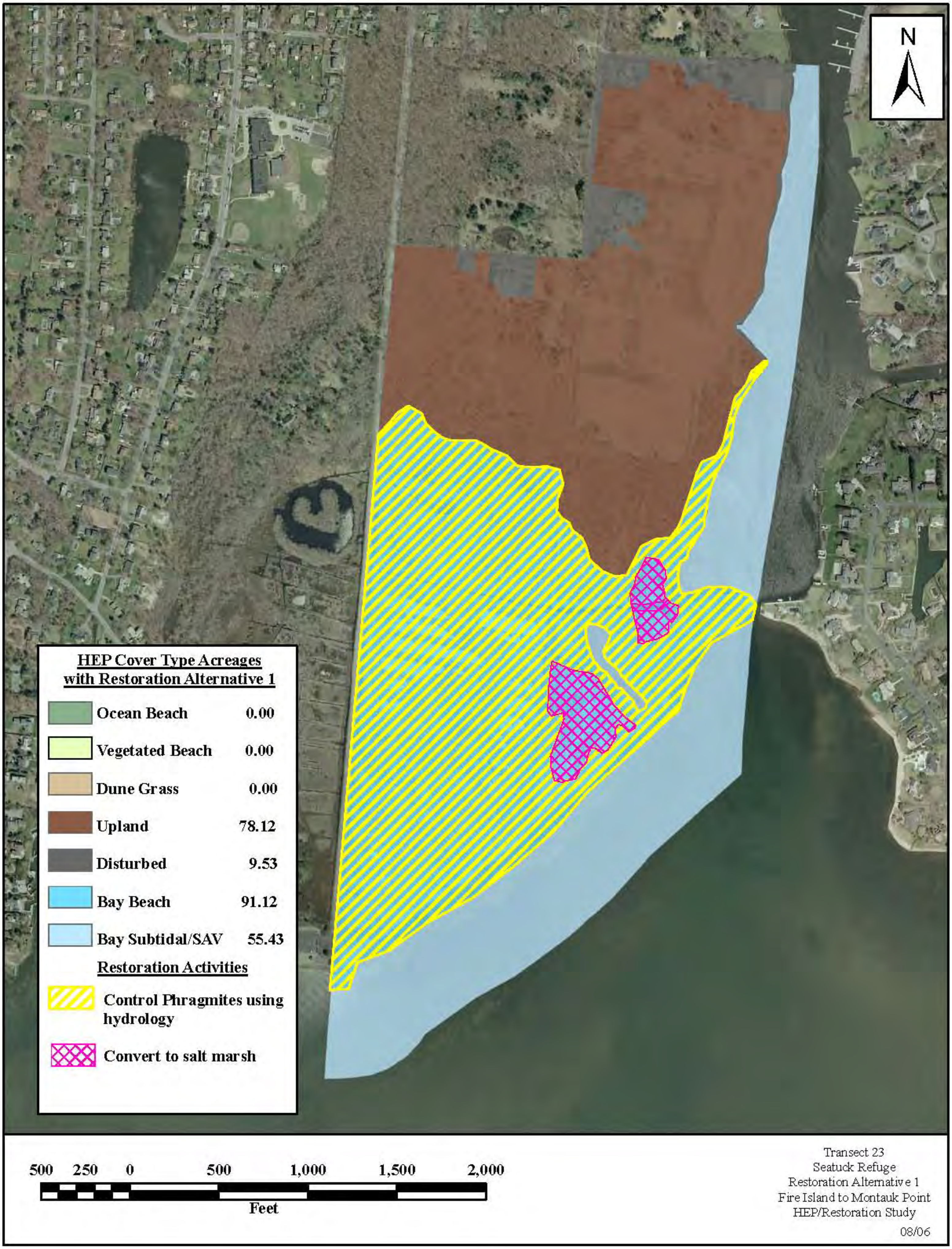


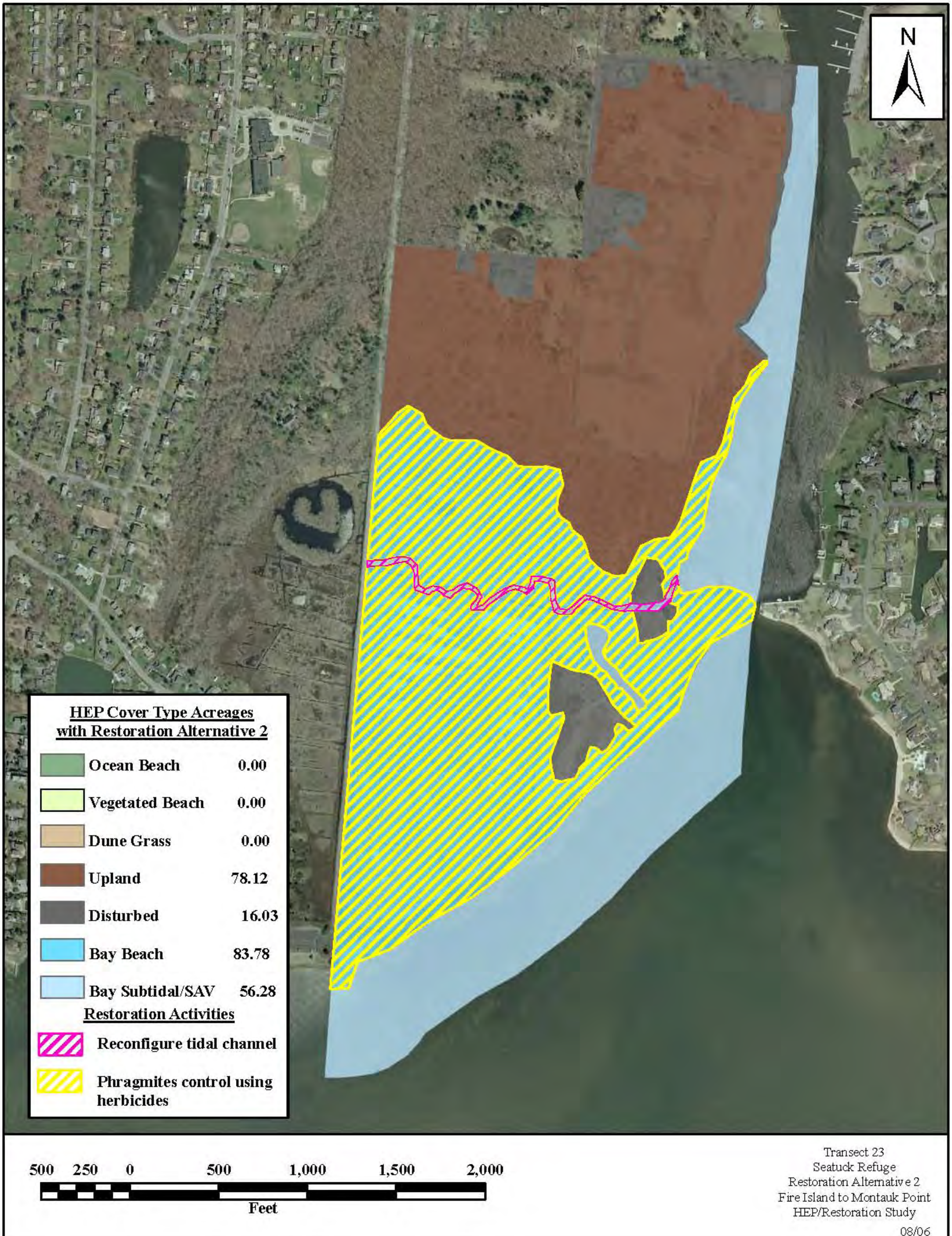

Transect 22
Islip Meadows
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

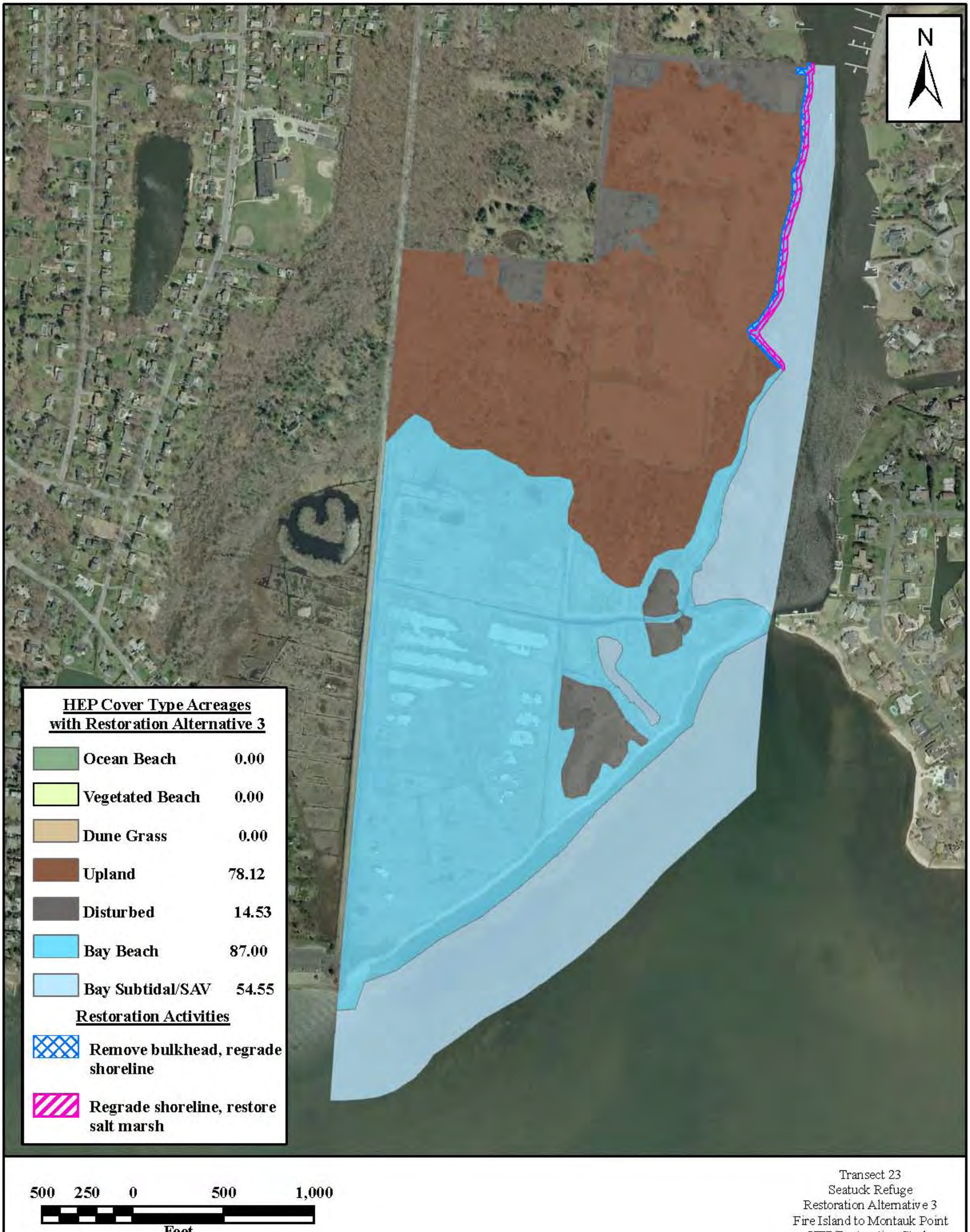

N
HEP Cover Type Acreages with Restoration Alternative 2
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.00
Upland 11.76
Disturbed 0.58
Bay Beach 43.34
Bay Subtidal/SAV 12.87
Restoration Activities
Excavate to reconfigure tidal channels
500 250 0 500 1,000
Feet
Transect 22
Islip Meadows
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06



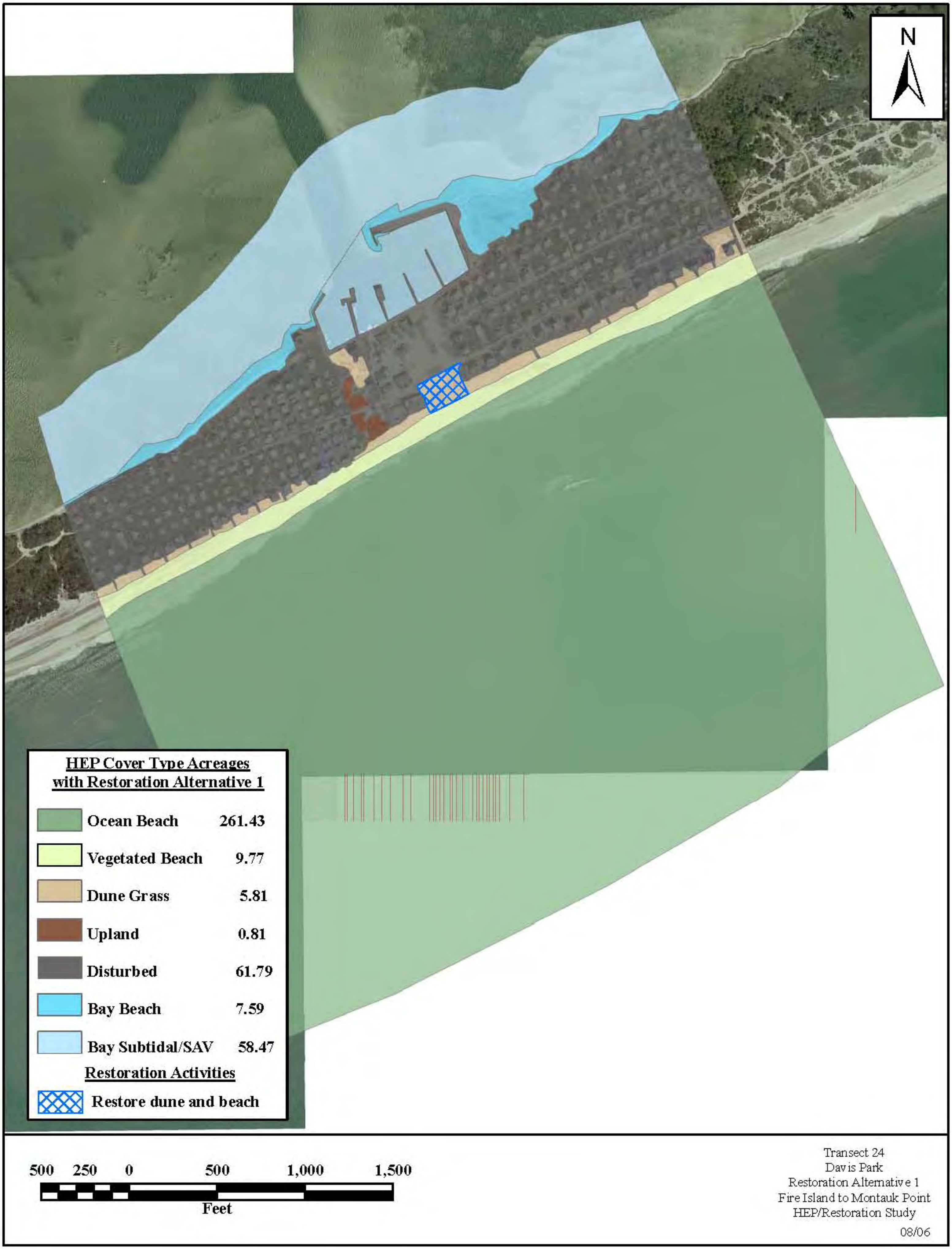

Transect 22
Islip Meadows
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages with Restoration Alternative 1
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.00
Upland 78.12
Disturbed 9.53
Bay Beach 91.12
Bay Subtidal/SAV 55.43
Restoration Activities
Control Phragmites using hydrology
Convert to salt marsh
500 250 0 500 1,000 1,500 2,000
Feet
Transect 23
Seatuck Refuge
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

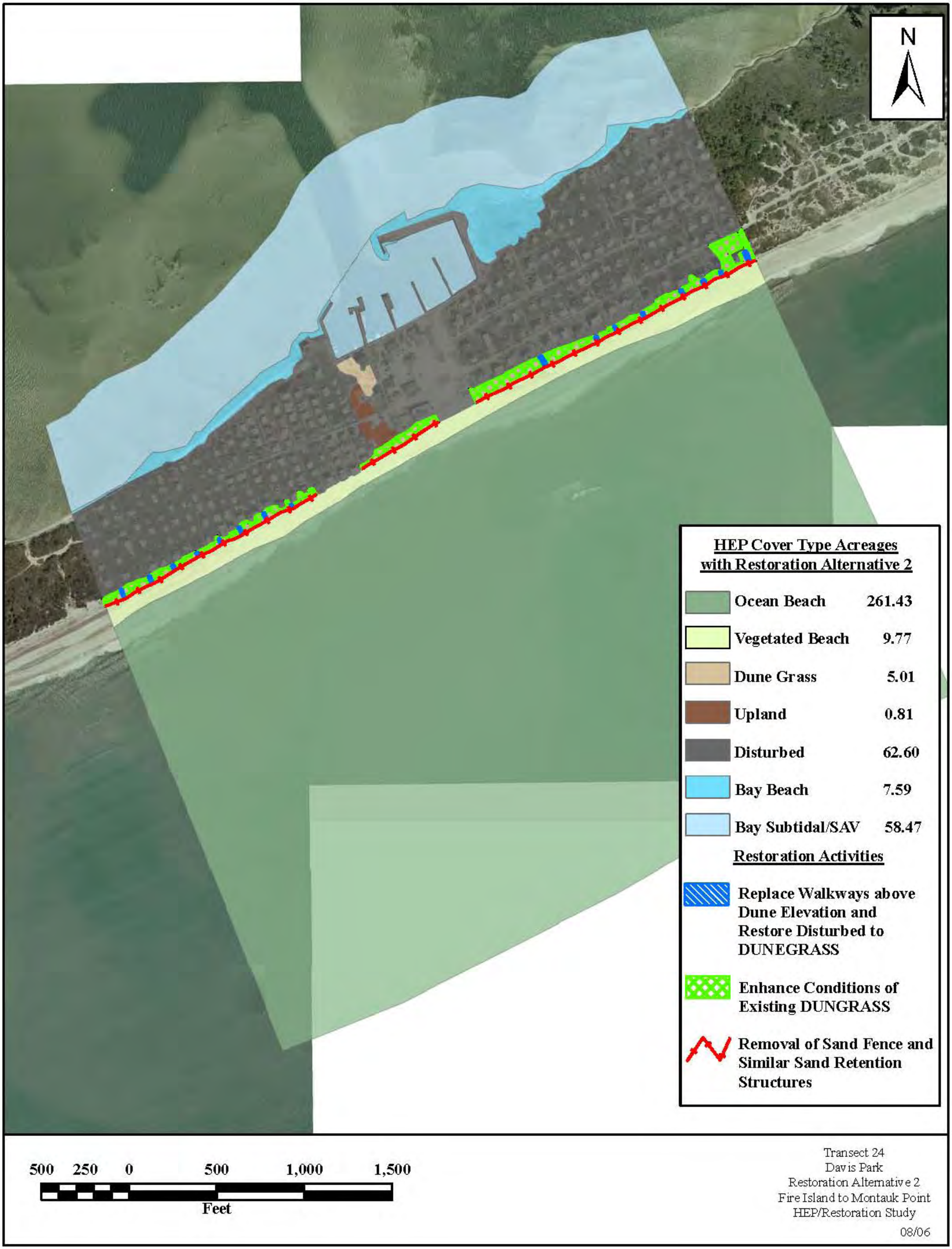

N
HEP Cover Type Acreages
with Restoration Alternative 2
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.00
Upland 78.12
Disturbed 16.03
Bay Beach 83.78
Bay Subtidal/SAV 56.28
Restoration Activities
Reconfigure tidal channel
Phragmites control using herbicides
500 250 0 500 1,000 1,500 2,000
Feet
Transect 23
Seatuck Refuge
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

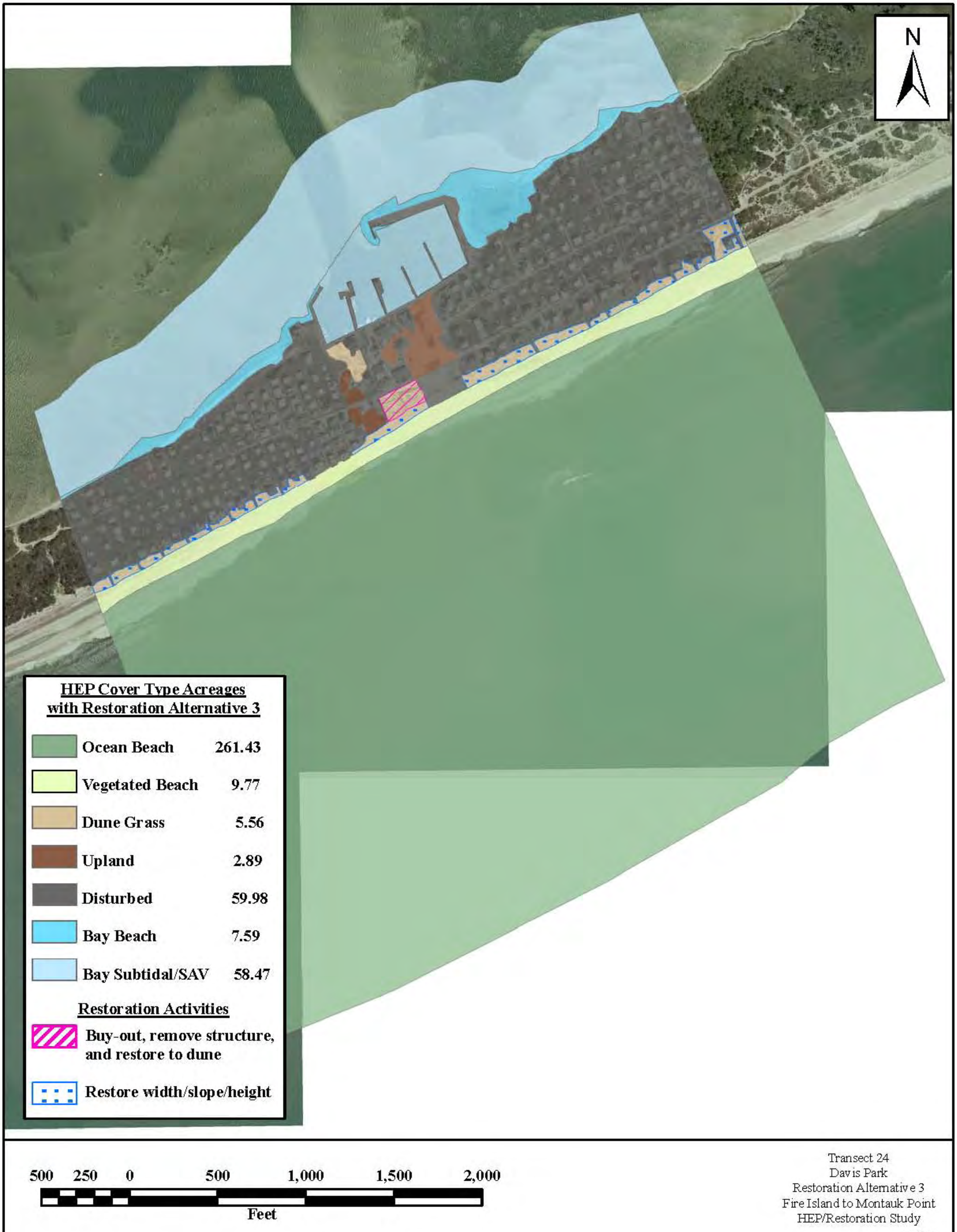



Transect 23
Seatuck Refuge
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06



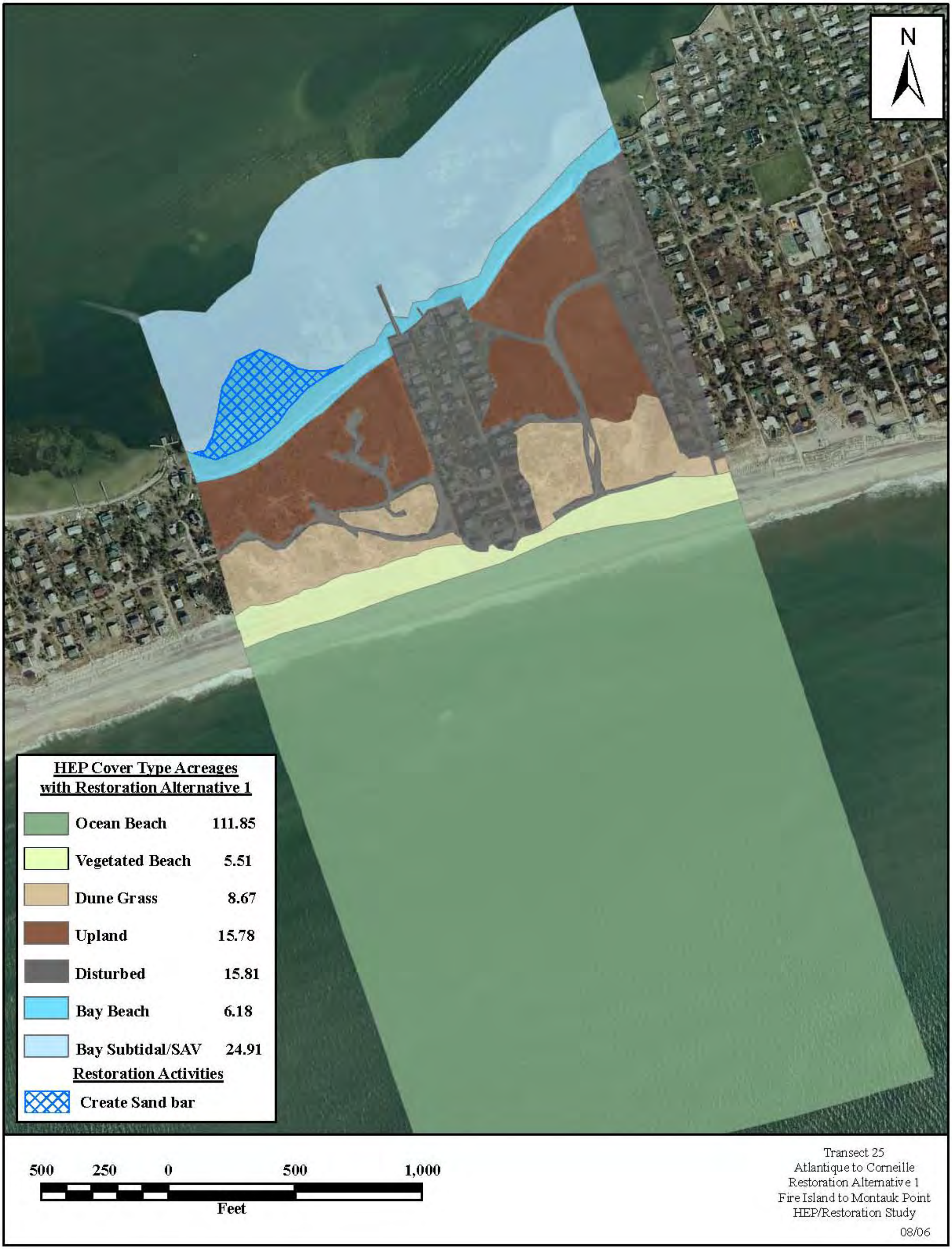
N
HEP Cover Type Acreages
with Restoration Alternative 1
Ocean Beach 261.43
Vegetated Beach 9.77
Dune Grass 5.81
Upland 0.81
Disturbed 61.79
Bay Beach 7.59
Bay Subtidal/SAV 58.47
Restoration Activities
Restore dune and beach
500 250 0 500 1,000 1,500
Feet
Transect 24
Davis Park
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

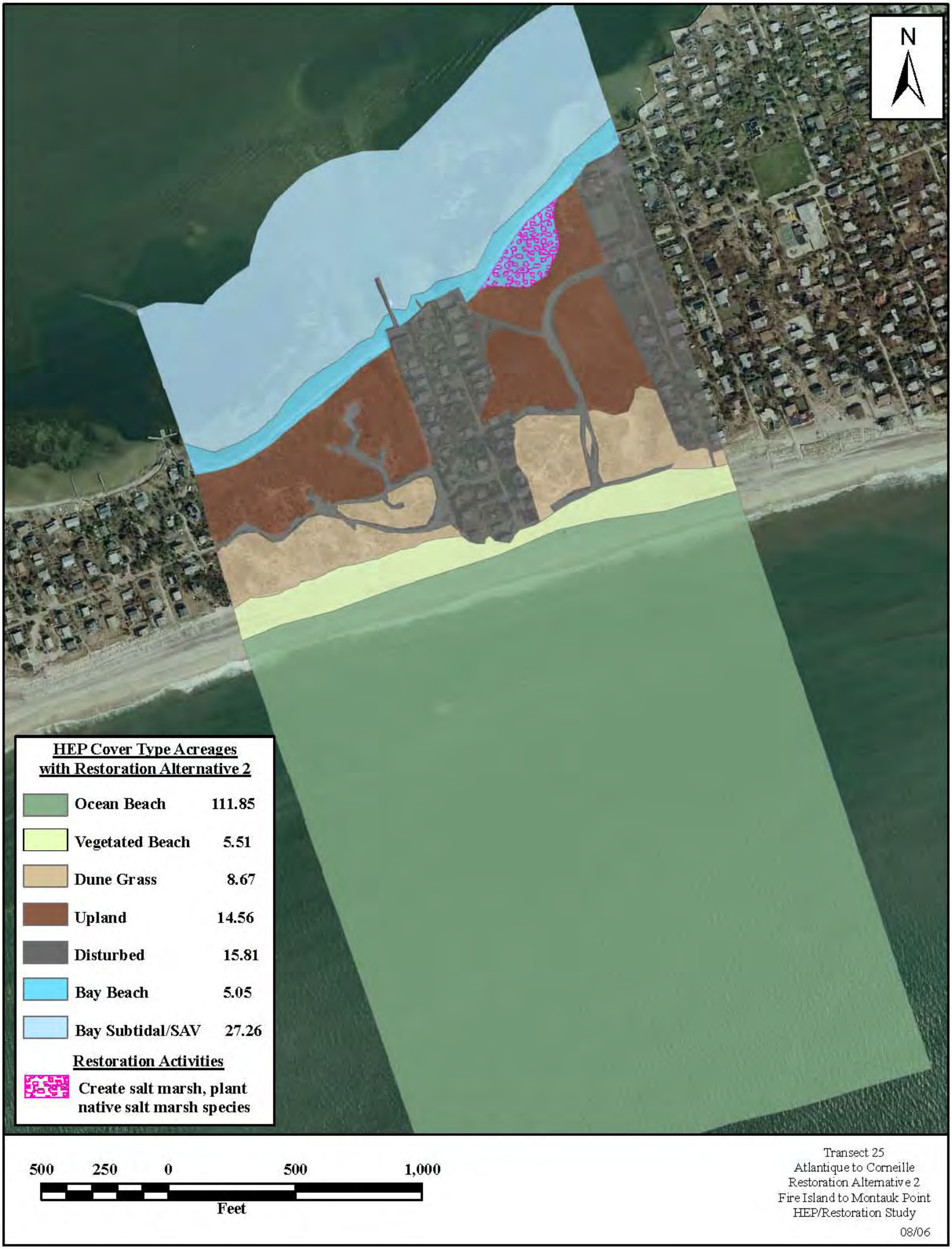

N
HEP Cover Type Acreages with Restoration Alternative 2
Ocean Beach 261.43
Vegetated Beach 9.77
Dune Grass 5.01
Upland 0.81
Disturbed 62.60
Bay Beach 7.59
Bay Subtidal/SAV 58.47
Restoration Activities
Replace Walkways above Dune Elevation and Restore Disturbed to DUNEGRASS
Enhance Conditions of Existing DUNGRASS
Removal of Sand Fence and Similar Sand Retention Structures
500 250 0 500 1,000 1,500
Feet
Transect 24
Davis Park
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06



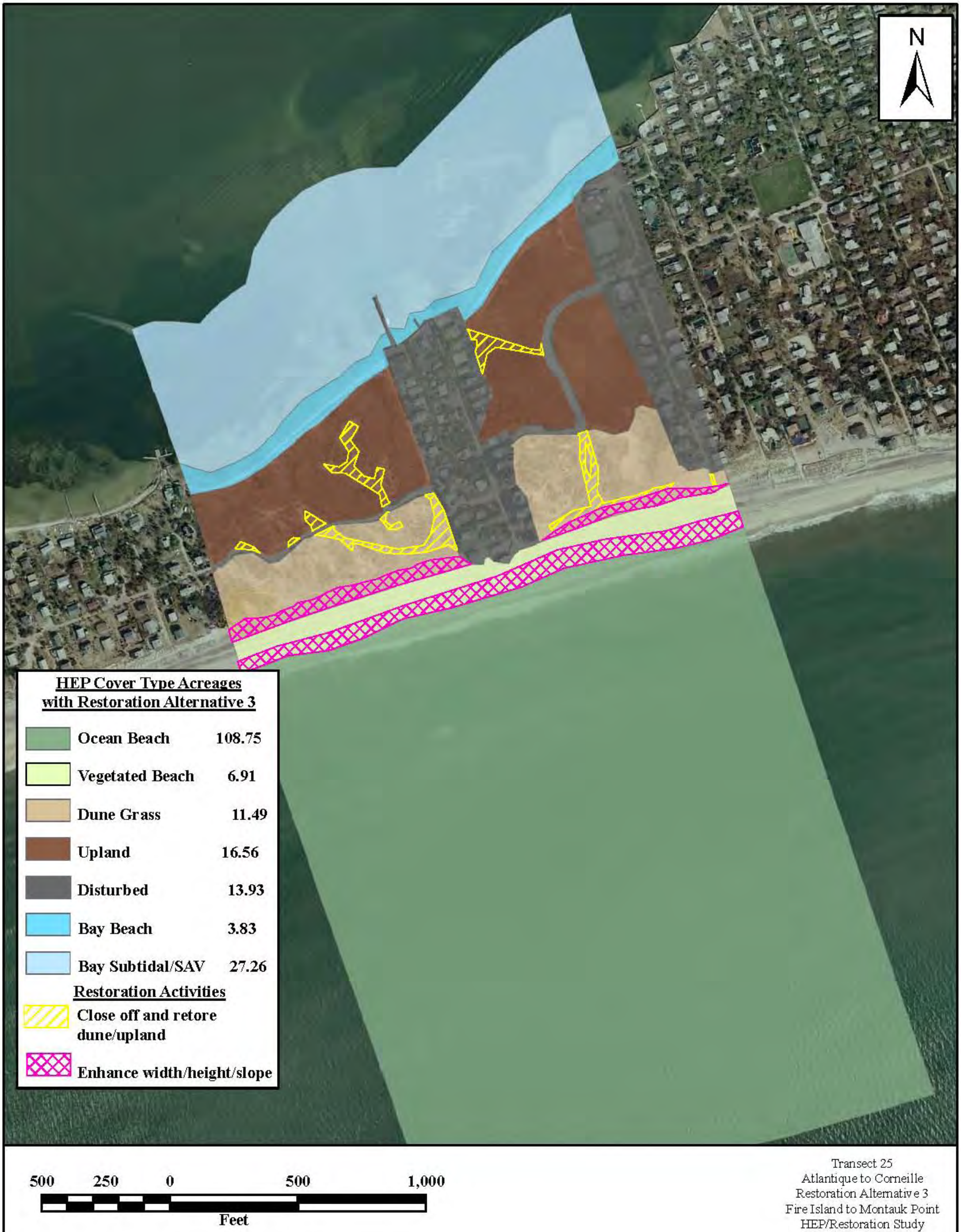

Transect 24
Davis Park
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study

08/06

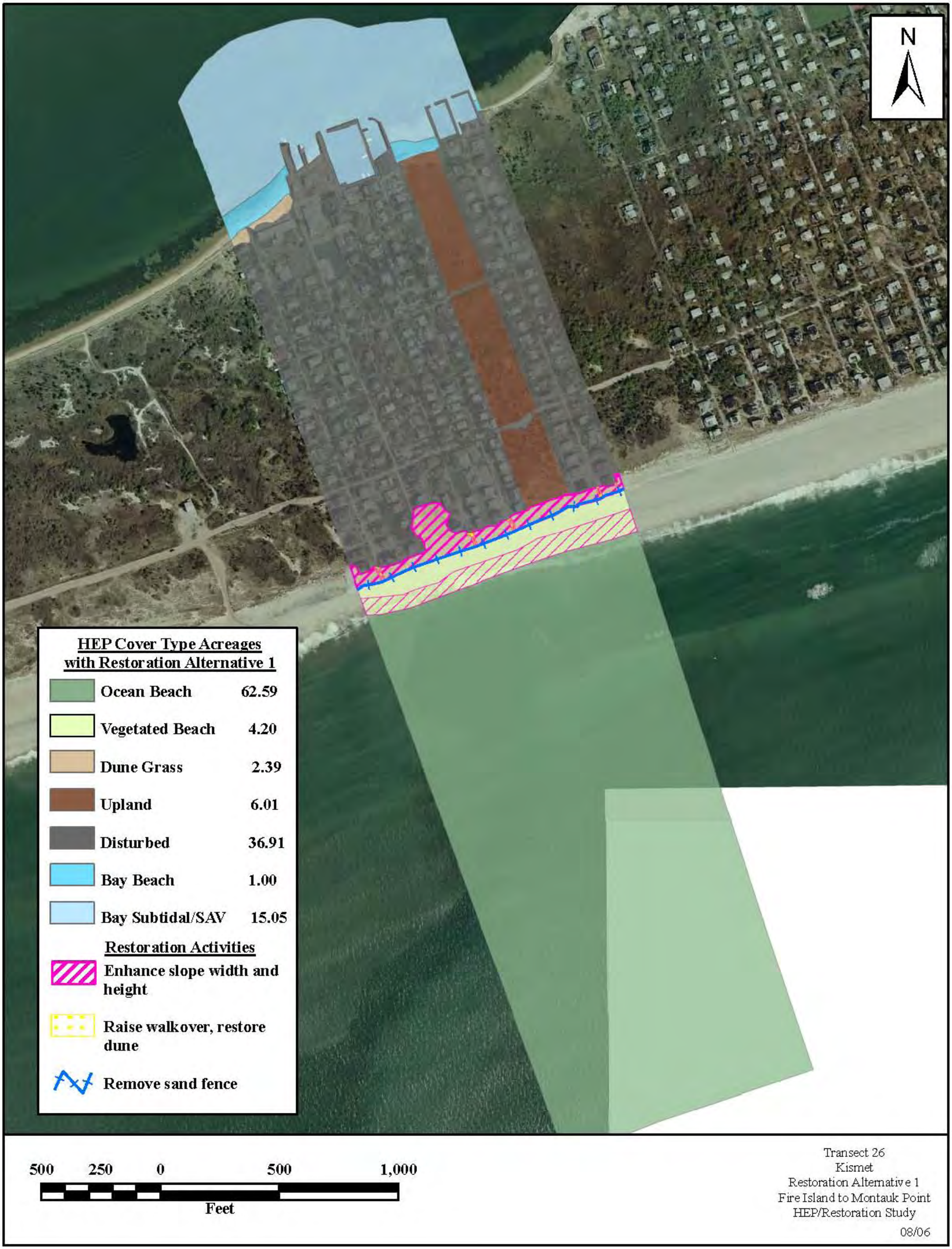

N
HEP Cover Type Acreages
with Restoration Alternative 1
Ocean Beach 111.85
Vegetated Beach 5.51
Dune Grass 8.67
Upland 15.78
Disturbed 15.81
Bay Beach 6.18
Bay Subtidal/SAV 24.91
Restoration Activities
Create Sand bar
500 250 0 500 1,000
Feet
Transect 25
Atlantique to Corneille
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

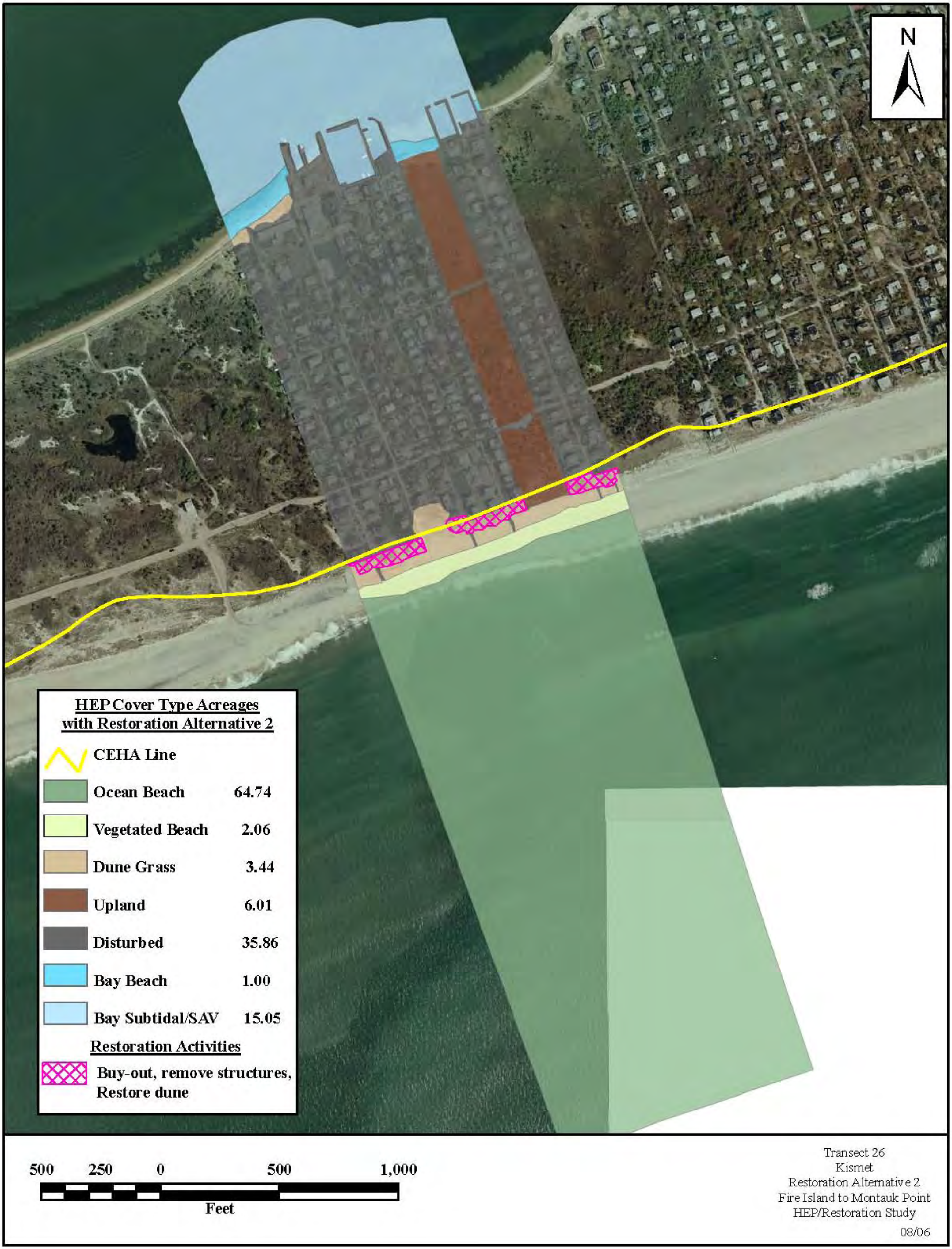


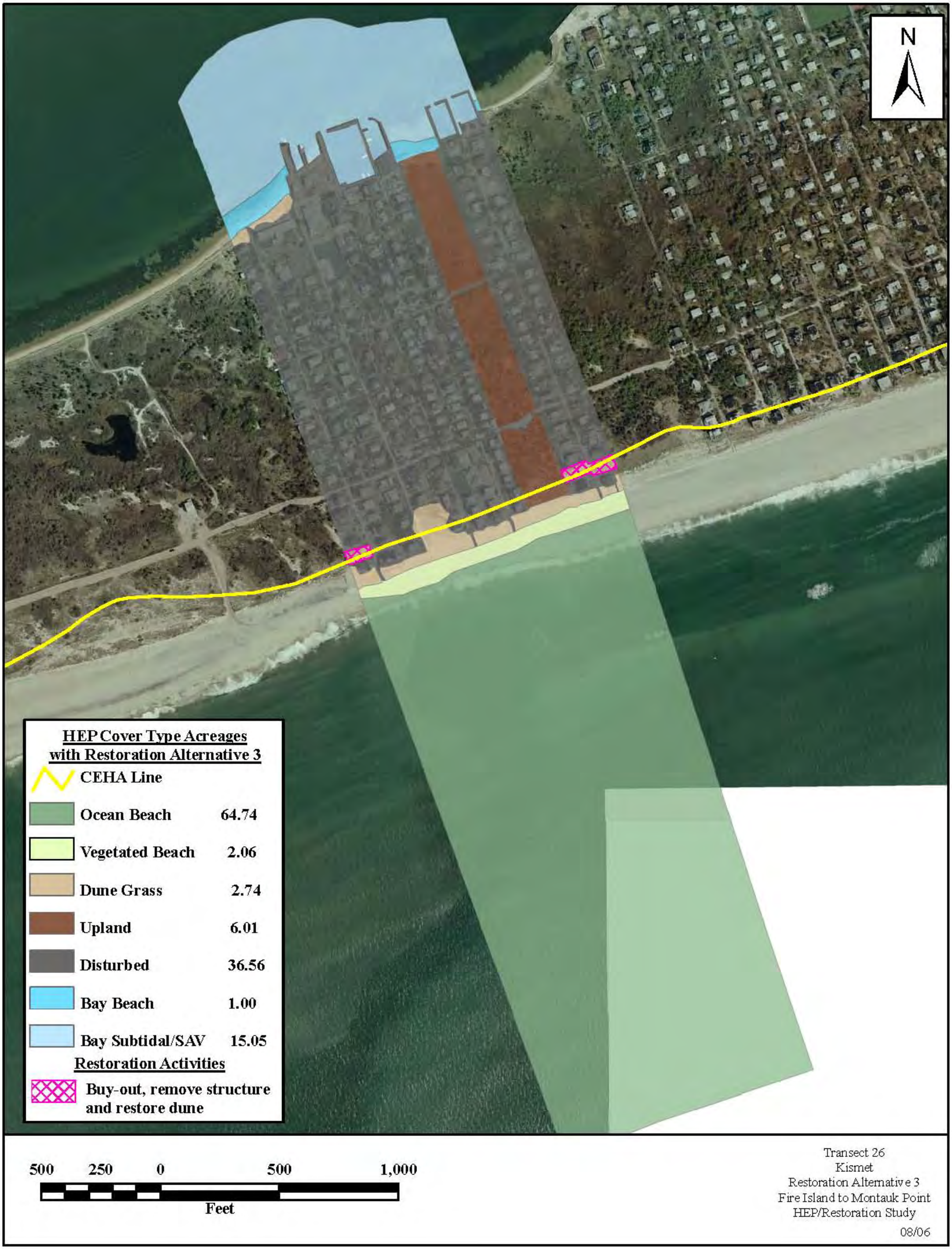

Transect 25
Atlantique to Corneille
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06



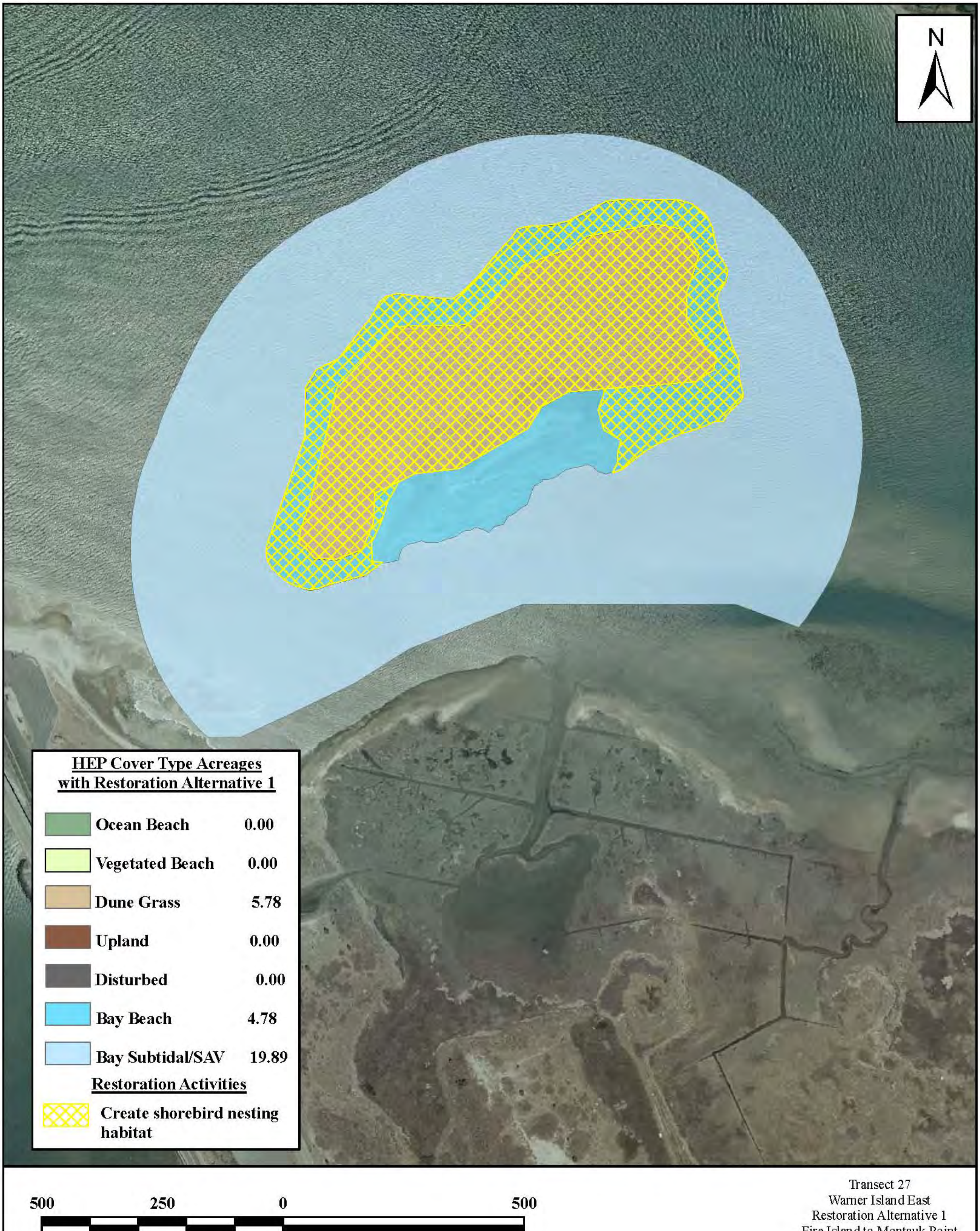

Transect 25
Atlantique to Corneille
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages
with Restoration Alternative 1
Ocean Beach 62.59
Vegetated Beach 4.20
Dune Grass 2.39
Upland 6.01
Disturbed 36.91
Bay Beach 1.00
Bay Subtidal/SAV 15.05
Restoration Activities
Enhance slope width and height
Raise walkover, restore dune
Remove sand fence
500 250 0 500 1,000
Feet
Transect 26
Kismet
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

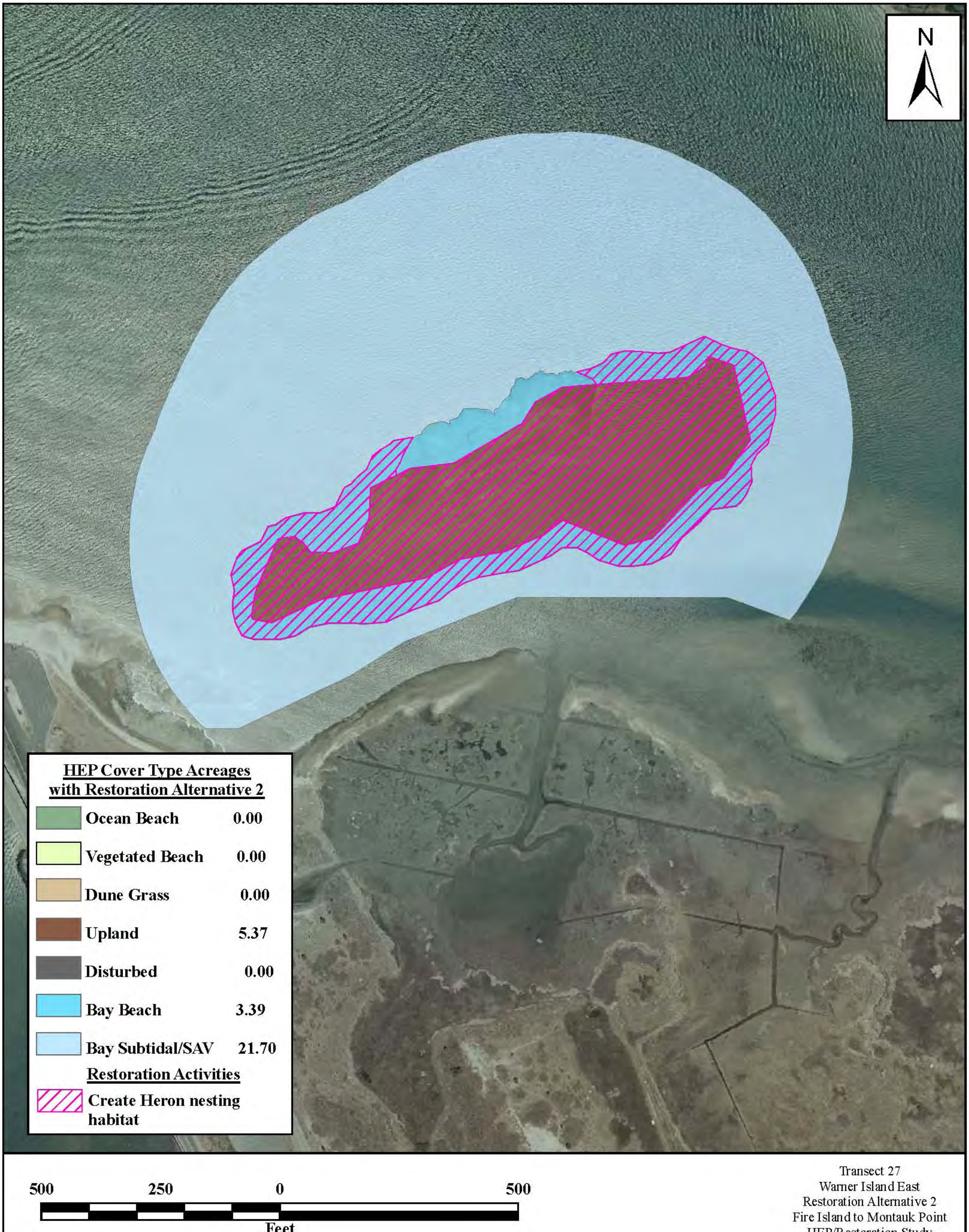

N
HEP Cover Type Acreages
with Restoration Alternative 2
CEHA Line
Ocean Beach 64.74
Vegetated Beach 2.06
Dune Grass 3.44
Upland 6.01
Disturbed 35.86
Bay Beach 1.00
Bay Subtidal/SAV 15.05
Restoration Activities
Buy-out, remove structures,
Restore dune
500 250 0 500 1,000
Feet
Transect 26
Kismet
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06



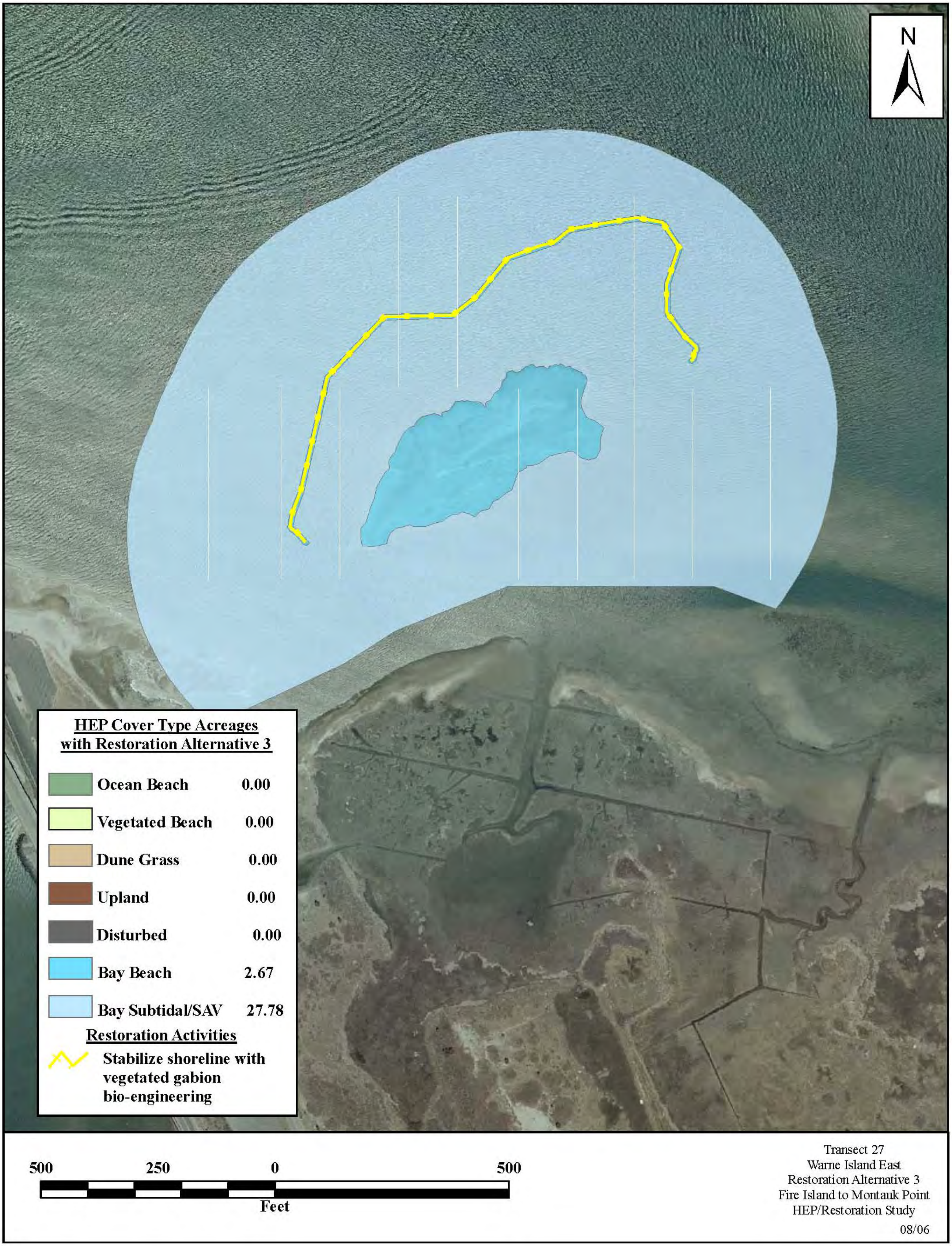

Transect 26
Kismet
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

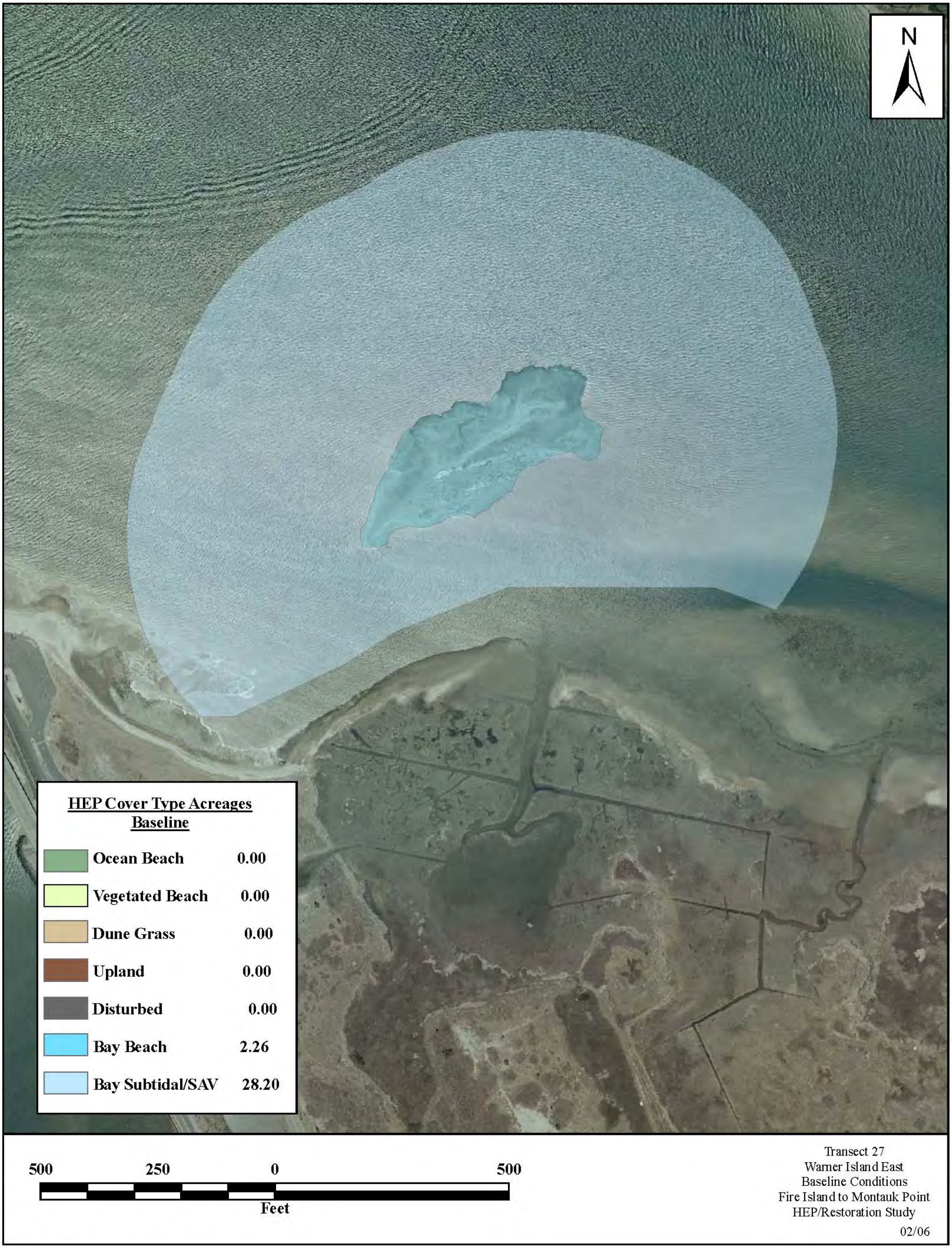



Transect 27
Warner Island East
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06

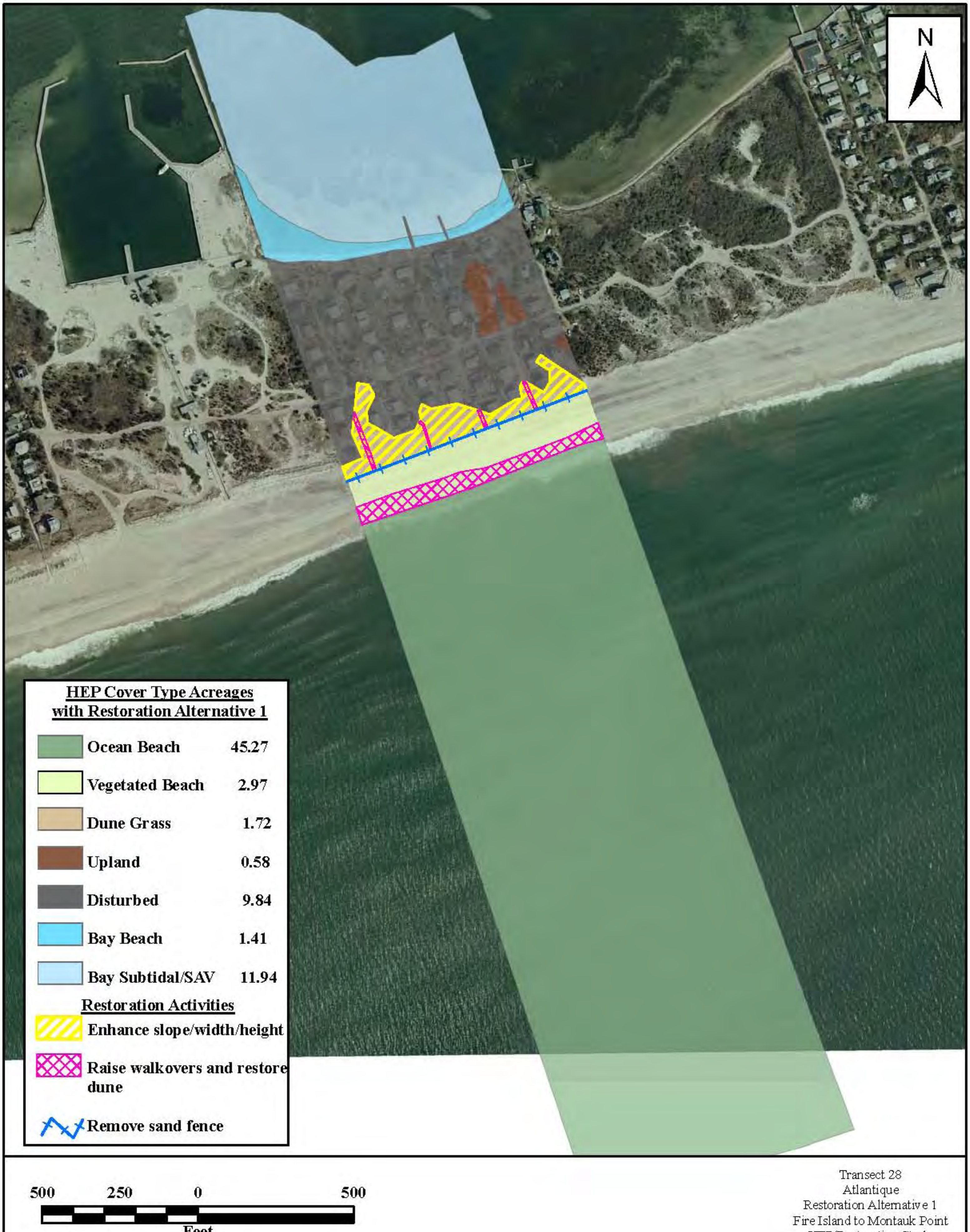



Transect 27
Warner Island East
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06

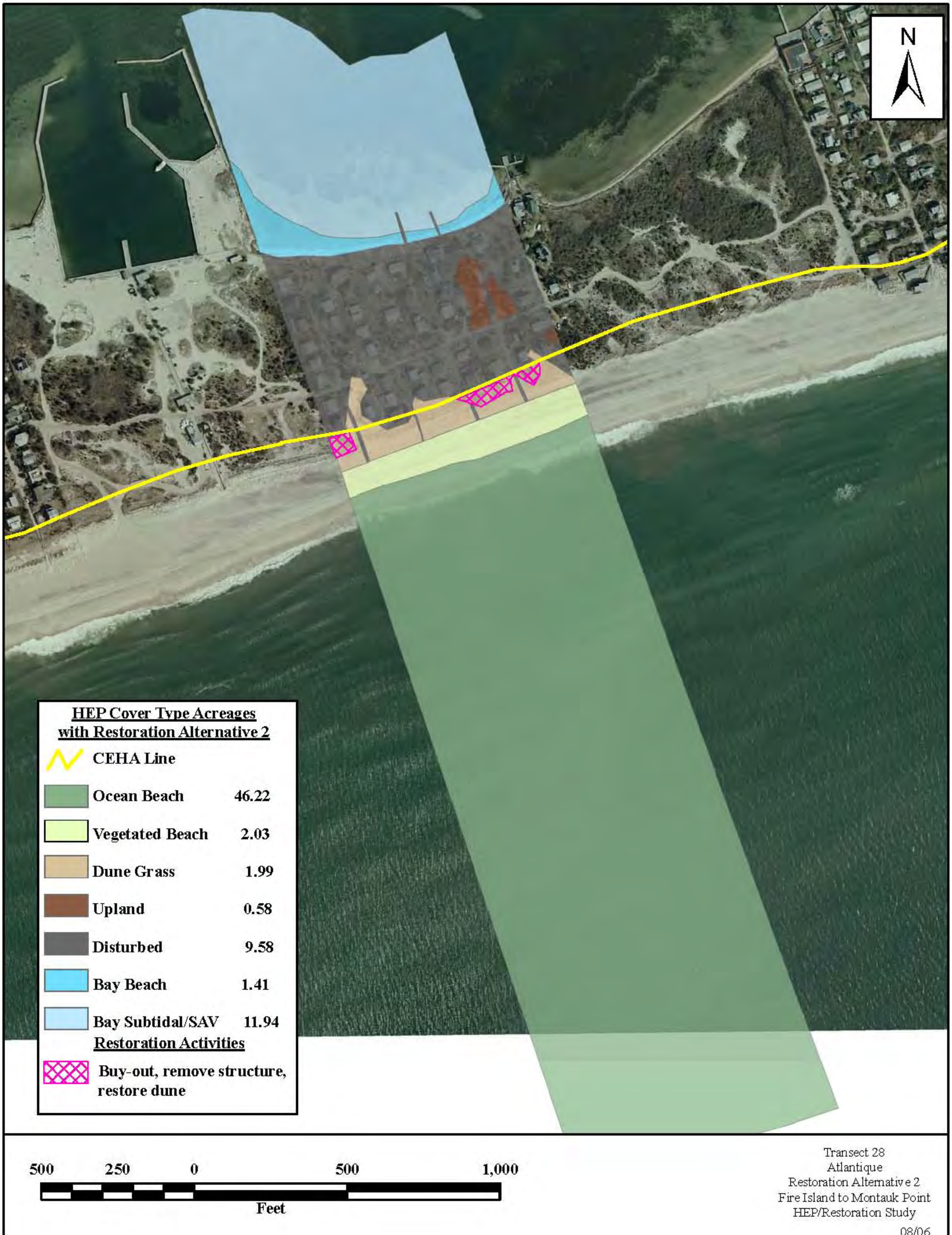

N
HEP Cover Type Acreages
with Restoration Alternative 3
Ocean Beach 0.00
Vegetated Beach 0.00
Dune Grass 0.00
Upland 0.00
Disturbed 0.00
Bay Beach 2.67
Bay Subtidal/SAV 27.78
Restoration Activities
Stabilize shoreline with vegetated gabion bio-engineering
500 250 0 500
Feet
Transect 27
Warne Island East
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06



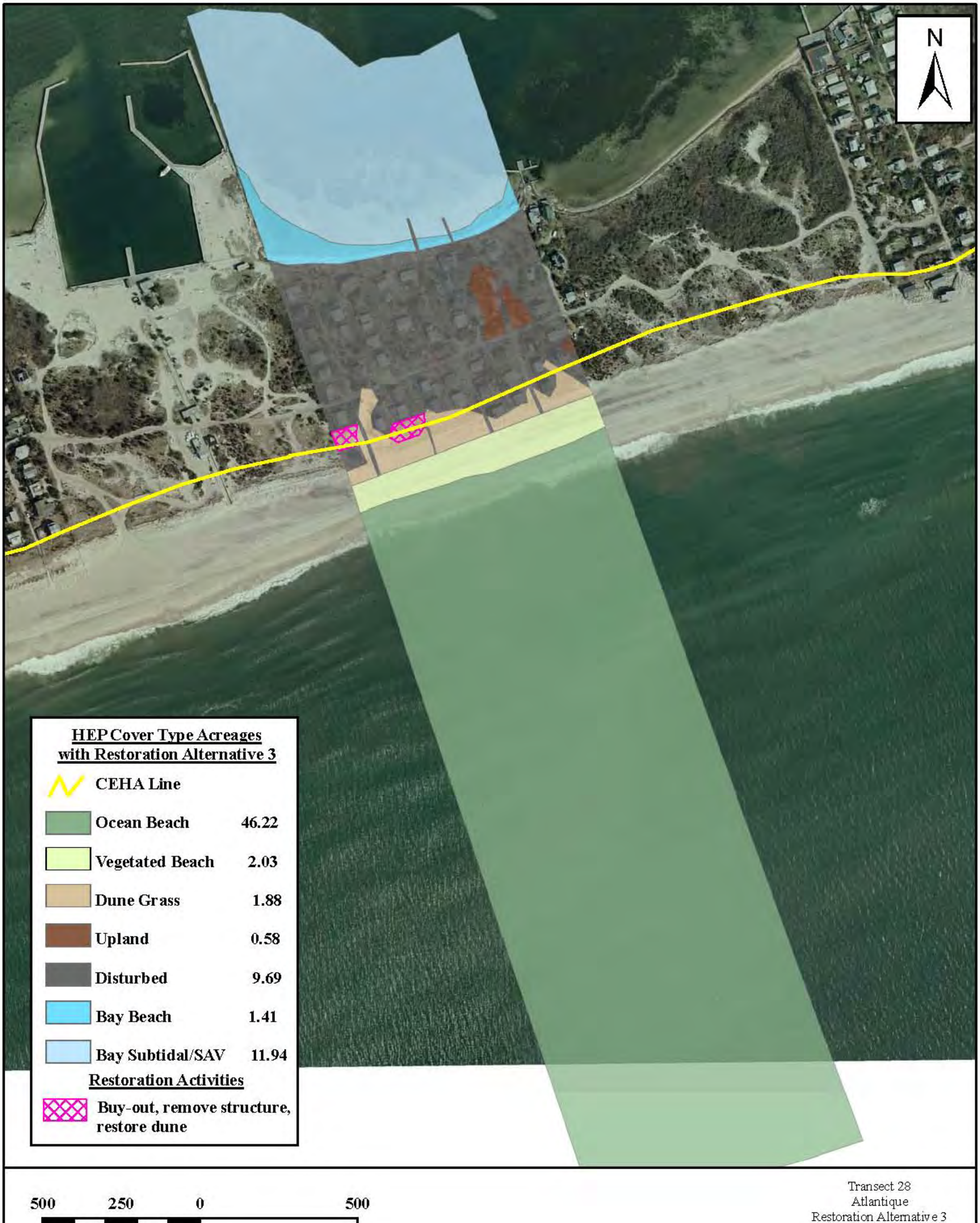

Transcect 27
Warner Island East
Baseline Conditions
Fire Island to Montauk Point
HEP/Restoration Study
02/06



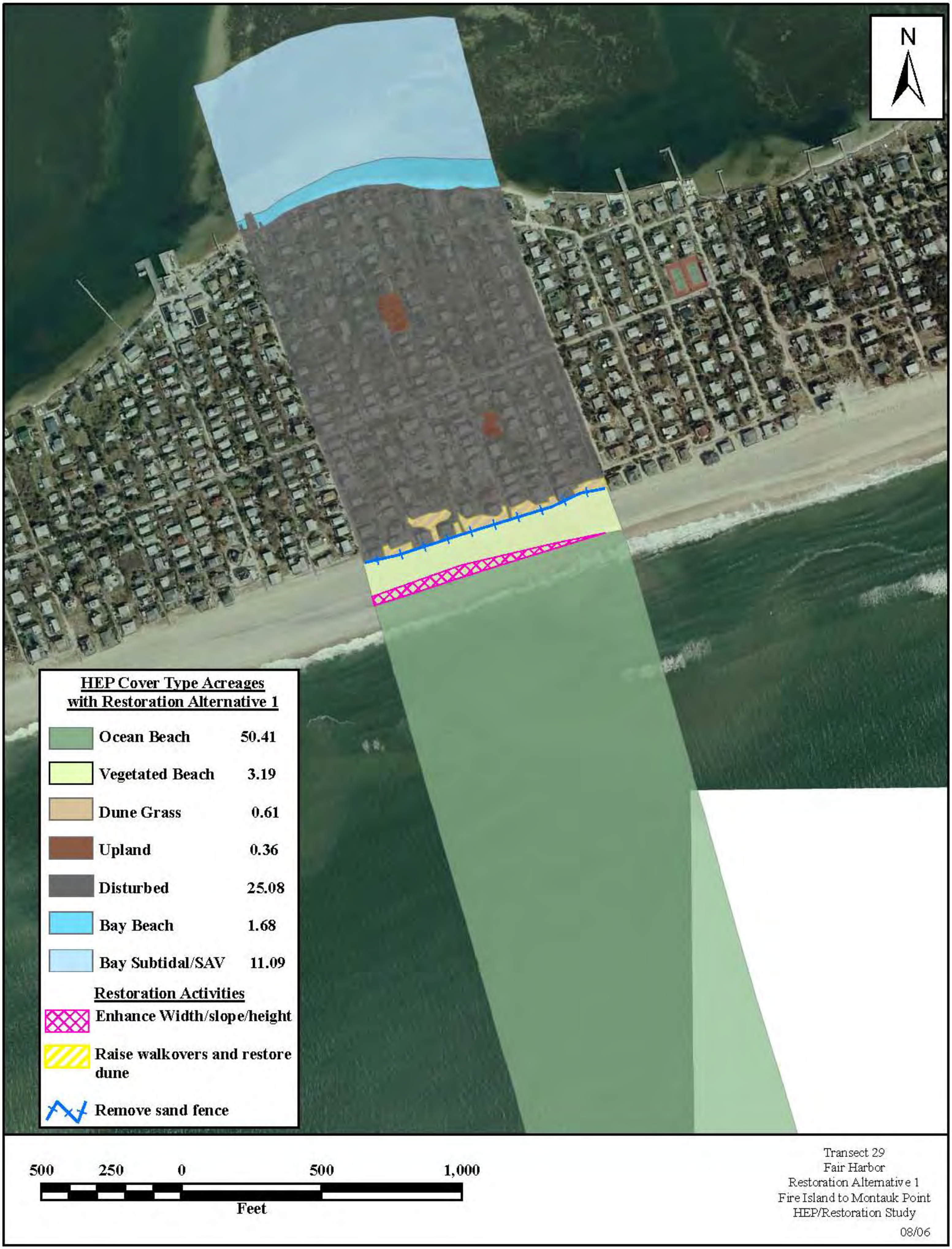

Transect 28
Atlantique
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06




Transect 28
Atlantique
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study
08/06




Transect 28
Atlantique
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06


N
HEP Cover Type Acreages
with Restoration Alternative 1
Ocean Beach 50.41
Vegetated Beach 3.19
Dune Grass 0.61
Upland 0.36
Disturbed 25.08
Bay Beach 1.68
Bay Subtidal/SAV 11.09
Restoration Activities
Enhance Width/slope/height
Raise walkovers and restore dune
Remove sand fence
500 250 0 500 1,000
Feet
Transect 29
Fair Harbor
Restoration Alternative 1
Fire Island to Montauk Point
HEP/Restoration Study
08/06


Transect 29
Fair Harbor
Restoration Alternative 2
Fire Island to Montauk Point
HEP/Restoration Study

08/06


N
HEP Cover Type Acreages
with Restoration Alternative 3
CEHA Line
Ocean Beach 50.98
Vegetated Beach 2.63
Dune Grass 2.26
Upland 0.36
Disturbed 23.43
Bay Beach 1.68
Bay Subtidal/SAV 11.09
Restoration Activities
Buy-out, Remove structure, restore to dune
500 250 0 500 1,000
Feet
Transect 29
Fair Harbor
Restoration Alternative 3
Fire Island to Montauk Point
HEP/Restoration Study
08/06

*Baseline Conditions for Cover Type and HEP Transects*

| Cover Type and/or HEP Transect | Dune Height [ft] | Foredune Width [ft] | Foredune Slope | | | VegBeach Width [ft] | VegBeach Slope | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Deg. | % | Ratio | | Deg. | % | Ratio |
| CT-1 Democrat Point | 19.7 | 185 | 2.7 | 5% | 1:21 | 231 | 2.2 | 4% | 1:26 |
| HEP-T1 Robert Moses | 16.6 | 254 | 1.3 | 2% | 1:45 | 121 | 4.3 | 7% | 1:13 |
| CT-2 & HEP-T14 Ocean Beach | 17.3 | 81 | 4.4 | 8% | 1:13 | 148 | 3.5 | 6% | 1:16 |
| CT-4 & HEP-T2 Sunken Forest | 20.7 | 89 | 6.2 | 11% | 1:9 | 175 | 2.9 | 5% | 1:19 |
| HEP-T3 Reagan Property | 14.7 | 70 | 3.0 | 5% | 1:19 | 129 | 4.0 | 7% | 1:14 |
| CT-3 Watch Hill | 19.9 | 58 | 8.8 | 15% | 1:6 | 129 | 4.0 | 7% | 1:14 |
| CT-6 HEP-T4 Old Inlet | 9.2 | 0 | | | | 432 | 1.0 | 2% | 1:60 |
| CT-5 & HEP-T5 Wilderness Area & Great ( | 19.1 | 103 | 4.5 | 8% | 1:13 | 190 | 2.7 | 5% | 1:21 |
| CT-7 & HEP-T6 Pikes Breach | 18.2 | 64 | 6.4 | 11% | 1:9 | 238 | 2.2 | 4% | 1:26 |
| CT-9 Westhampton Groin Field | 20.3 | 275 | 1.9 | 3% | 1:30 | 112 | 4.6 | 8% | 1:12 |
| CT-10 & HEP-T7 Tiana Beach | 21.9 | 90 | 6.9 | 12% | 1:8 | 160 | 3.2 | 6% | 1:18 |
| CT-11 & HEP-T8 WOSI | 15.0 | 19 | 12.0 | 21% | 1:5 | 207 | 2.5 | 4% | 1:23 |
| CT-13 Sagaponack | 16.9 | 115 | 2.9 | 5% | 1:20 | 116 | 4.5 | 8% | 1:13 |
| CT-12 & HEP-T9 Georgica Pond | 7.7 | 0 | 0.0 | 0% | | 209 | 1.6 | 3% | 1:37 |
| HEP-T18 Hook Pond | 22.8 | 101 | 6.7 | 12% | 1:9 | 103 | 5.0 | 9% | 1:11 |
| HEP-T16 Ditch Plains | 16.0 | 21 | 13.7 | 24% | 1:4 | 123 | 4.2 | 7% | 1:14 |
| HEP-T17 Ranch Rd Bluffs (see Note 8) | 30.0 | 10 | 62.2 | 190% | 1:0.5 | 70 | 7.3 | 13% | 1:8 |

**NOTES:**

(1) All elevations are referenced to NGVD'29
(2) Dimensions based on LIDAR Sep-2000 Transects cut roughly at the location of CT and/or HEP Transects (one each)
(3) Dune Height refers to the max elevation of the seawardmost dune system
(4) Foredune Width is distance between the Seaward Toe of Dune (roughly the +11ft contour) and the Dune Crest
(5) Foredune Slope is the average slope between the 11ft contour and the Dune Crest
(6) VegBeach Width is the distance from the MHW contour (+2ft) to the Seaward Toe of Dune (roughly the +11ft contour)
(7) VegBeach Slope is the average slope between the MHW contour and the Seaward Toe of Dune
(8) "Dune Height" is actually the height of the seawad edge of the bluff crest