UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
POST-RESTORATION MONITORING PROGRAM

ANNUAL REPORT
YEAR 3 – 2013

UPPER NEWPORT BAY ECOLOGICAL RESERVE
ORANGE COUNTY, CALIFORNIA

March 2014

Prepared for:

U.S. Army Corps of Engineers
Contact: Mr. Lawrence Smith
915 Wilshire Blvd, Suite 980
Los Angeles, CA 90017
Office: (213) 452-3846

Prepared by:

Merkel & Associates, Inc.
Contact: Ms. Rachel Woodfield
5434 Ruffin Road
San Diego, California 92123
Office: (858) 560-5465

Rachel A. Woodfield, Senior Biologist/Project Manager

Keith W. Merkel, Principal Consultant

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UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT POST-RESTORATION MONITORING PROGRAM

ANNUAL REPORT
YEAR 3 – 2013

Merkel and Associates, Inc.
March 2014

1.0 INTRODUCTION

Newport Bay is located on the southern California coast, approximately 40 miles south of Los Angeles (Figure 1). From the harbor entrance at the rocky headland at Corona del Mar, Newport Bay extends about 3.5 miles north northeastward. Newport Bay is a combination of two distinct units, termed "Lower Bay" and "Upper Newport Bay" (UNB), divided by the narrows at Pacific Coast Highway (PCH) Bridge (Figure 1). The 752-acre Lower Bay, where the majority of commerce and recreational boating exists, is heavily developed (predominantly as residential properties) and is a deep basin coastal lagoon. The 1,000-acre UNB is a drowned river valley, geologically much older than the Lower Bay, and is largely undeveloped. This portion of the bay is more formally considered to be an estuary. Much of UNB is included in the Upper Newport Bay Ecological Reserve, managed by the California Department of Fish and Wildlife (CDFW) (formerly the California Department of Fish and Game).

Upper Newport Bay is one of the largest coastal wetlands remaining in southern California. Natural habitats within UNB include open marine waters, intertidal mudflats, cordgrass-dominated low salt marsh, pickleweed-dominated mid salt marsh, high salt marsh, salt panne, riparian, freshwater marsh, and upland. Because of its diversity of habitats and its location on the Pacific Flyway, UNB supports an impressive number and diversity of birds, particularly during fall and winter when shorebirds and waterfowl arrive from their northern breeding grounds. Upper Newport Bay also supports several endangered bird species and an endangered plant. The subtidal and intertidal waters of UNB provide important habitat for marine and estuarine fishes.

1.1. Restoration Need and Design

By the end of the 20th century, the ecological diversity and functionality of UNB was increasingly threatened by sedimentation from the surrounding urbanized watershed. The primary source of freshwater and sediment loads to UNB is San Diego Creek, which drains approximately 85 percent of the 98,500-acre San Diego Creek watershed. Sediment from the San Diego Creek watershed had increasingly filled open water areas within UNB. This sedimentation decreased the extent of tidal inundation, diminished water quality, degraded habitat for endangered species, migratory water birds, and marine and estuarine fishes. It also resulted in navigation problems in UNB marinas and navigation channels. If sediment deposition within UNB had been allowed to continue, the remaining open water areas would have eventually evolved into mudflats, and later, marsh or upland habitat, resulting in a loss of ecological diversity.

Site Locator and Vicinity Map

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 1

It became clear that a program was needed to develop a long-term management plan to control sediment deposition in UNB and to preserve the health of its habitats. Through a partnership among the U.S. Army Corps of Engineers (ACOE), the County of Orange, CDFW, and the California Coastal Conservancy, the UNB Ecosystem Restoration Project was developed.

The restoration project was designed to allow for the effective management of sediments deposited into the bay, reduce the frequency of maintenance dredging, improve or restore estuarine habitats, sustain a mix of open water, mudflat, and marsh habitat, increase tidal circulation for water quality, reduce predator access to sensitive habitats, improve public use and recreational access, and improve educational opportunities. Sediment will continue to be deposited into UNB to varying degrees depending on what control measures are implemented in the watershed. Therefore, one of the most important components of the project was to develop a plan to control sediments by designing two in-bay basins into which the bulk of the sediment would be captured and from which effective maintenance dredging removals could be undertaken.

1.2. UNB Ecosystem Restoration Project Implementation

After an extensive process of planning and environmental review, the restoration project was initiated in 2006. The first phase was conducted from April 2006 to July 2009. The second phase was conducted from November 2009 to October 2010. The total cost of restoration was approximately $37.4 million. Key project features included expansion and deepening of two sediment control basins (Basin I/III and Basin II), deepening of channels around five restoration islands, creation of three large mudflats, relocation of a least tern nesting island, installation of maintenance access at the two nesting islands, and installation of interpretive signs and buoys. Approximately 2.35 million cubic yards of sediment was dredged as part of the project. A detailed project summary and map labeled with key restoration features is provided in Appendix A.

1.3. Post-restoration Monitoring

In order to detect and document the long-term development processes following the restoration, the ACOE prepared the Post-restoration Monitoring Program for the Upper Newport Bay Ecosystem Restoration Project (ACOE 2010). The program outlines ten years of biological and physical monitoring, as detailed in the following sections. The schedule for the various monitoring events is provided in Table 1. The table has been adjusted slightly from prior versions to reflect the actual months the monitoring was conducted in during the first three years of monitoring.

The ACOE has contracted with Merkel & Associates, Inc. (M&A) to implement portions of the first three years of the Post-Restoration Monitoring Program, after which time the ACOE commitment to post-restoration reporting will be completed and the County of Orange and CDFW will share the responsibility for the monitoring and reporting in Years 4 through 10 (note that Year 4 has no monitoring requirements).

Table 1. Post-restoration monitoring program schedule – final version.

TASK	Post-Restoration Annual Cycle												Post-Restoration Program					
	J	F	M	A	M	J	J	A	S	O	N	D	Year 1 2011	Year 2 2012	Year 3 2013	Year 5 2015	Year 8 2018	Year 10 2020
Physical Monitoring Program																		
Bathymetric Mapping	▬	▬											X-ACOE Jan	X-ACOE Jan	X-ACOE Jan	X	X	
Tidal Monitoring	▬			▬			▬			▬			X	X		X		X
Water Quality	▬			▬			▬			▬			X	X		X		X
Least Tern Island Elevations	▬	▬	▬										X	X	X	X	X	X
Biological Monitoring Program																		
General Avian Surveys	▬			▬			▬				▬			X		X		X
Species of Special Concern				▬	▬	▬	▬	▬	▬					X-CDFW		X-CDFW		X-CDFW
Fisheries	▬			▬			▬			▬				X		X		X
Epibenthic	▬			▬			▬			▬				X		X		X
Benthic Infauna	▬						▬							X		X		X
Vegetation																		
Aerial Photogrammetry and Georeferencing				▬	▬	▬							X-ACOE Jan	X	X	X	X	
Vegetation Mapping and Groundtruthing							▬	▬	▬				X	X	X	X	X	
Veg Transects									▬					X		X	X	
Cordgrass Monitoring					▬	▬	▬							X		X	X	
CRAM Survey									▬					X				
Data Management and Analysis																		
Quality Assurance Program	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	X	X	X	X	X	X
Reporting Program																		
Quarterly Summary Reports		✦			✦			✦			✦			X		X		X
Annual Reports												✦	X	X	X	X	X	X

RESTORATION CONSTRUCTION COMPLETED OCTOBER 2010

▬ Data Collection ✦ Project Milestone / Report Deliverable

The goals and questions to be assessed by the program, as excerpted from the Monitoring Program document, include:

1. Are the sediment basins performing according to the design goals?
    a. Do the basins have enough capacity such that maintenance dredging will not be required for 20+ years (given the rate of sediment accumulation within the basins)?
    b. Are the basins trapping the majority of the sediment that enters the upper bay, and thus minimizing sediment accumulation in the tidal channels and the lower portions of the bay?

2. Has the restoration project reduced turbidity in the bay (by trapping incoming sediment deep in the basins)?

3. Are the deepened basins receiving adequate dissolved oxygen? There are concerns about increased density stratification and reduced oxygen supply to the deepest layers.

4. Has the project resulted in increased eelgrass survival in the upper bay?

5. Has the project resulted in increased (water) volume within the bay such that the water residence time in the bay is significantly increased [sic]?

6. Has the project resulted in improved diversity and abundance of benthic infauna and epifauna?

7. Has the project resulted in a significant increase in the number of targeted birds using UNB? Targeted species include listed species.

8. Has the project led to significant increases in fisheries habitat? Tracking habitat utilization and relative abundance across multiple species [sic].

9. Has the project resulted in the gain or loss of any habitat type greater then 10%?

The restoration project was completed in October 2010. The first monitoring year extended from January to December 2011, the second year from January to December 2012, and the third year from January to December 2013. This document serves as the third annual report, covering monitoring performed in 2013.

1.4. Horizontal and Vertical Reference Data

Measurement units of numerical data from the monitoring program are presented as a combination of metric and English Standard System units in this report. Typically, collected scientific data would be reported using metric units such as hectares and meters. However, UNB has a long regulatory, engineering, and biological monitoring history that has made use of a blend of metric and English units. As a result, presentation of data has sought to continue using the units of measure that are most applicable to the various monitoring elements. Additionally, for some parameters such as tidal elevation and habitat area measurements, metric unit presentations are

less familiar to most readers than English units. Therefore, where an area measurement has been made through GIS-based mapping efforts, the results are presented in hectares, with conversions to acres provided due to the greater ease with which many readers can envision areas in this unit of measurement. Tidal data are presented in feet, rather than meters, due to the greater familiarity of most readers with tidal ranges in feet and the historic usage of English units for this element of the project. Additionally, discussion of sediment accumulation and dredging volumes will be in cubic yards due to the prevalence of this unit in the commercial dredging field. All other data, primarily biological measurements taken in the field, are reported in metric units.

The vertical datum used throughout this document is Mean Lower Low Water (83-01 epoch). Horizontally geo-referenced data are on the California State Plane Zone 6, North American Datum of 1983 (NAD 83).

2.0 PHYSICAL MONITORING

During the third year post-restoration, physical monitoring was limited to collection of bathymetric data and checking the elevation of the new least tern island (Table 1).

2.1. Bathymetric Monitoring

Methods

The ACOE completed the annual bathymetric surveys of the restoration project area and provided the collected data to M&A for analysis. ACOE Los Angeles District survey personnel collected bathymetric data in 2013 between February 26 and 28, 2013. The information collected was a merged dataset from single beam and multi-beam sonar on a 3-foot grid. The vertical datum was feet MLLW and the horizontal datum was State Plane, Zone 6, NAD 83, feet. This dataset served as the Year 3 (2013) post-restoration bathymetric condition.

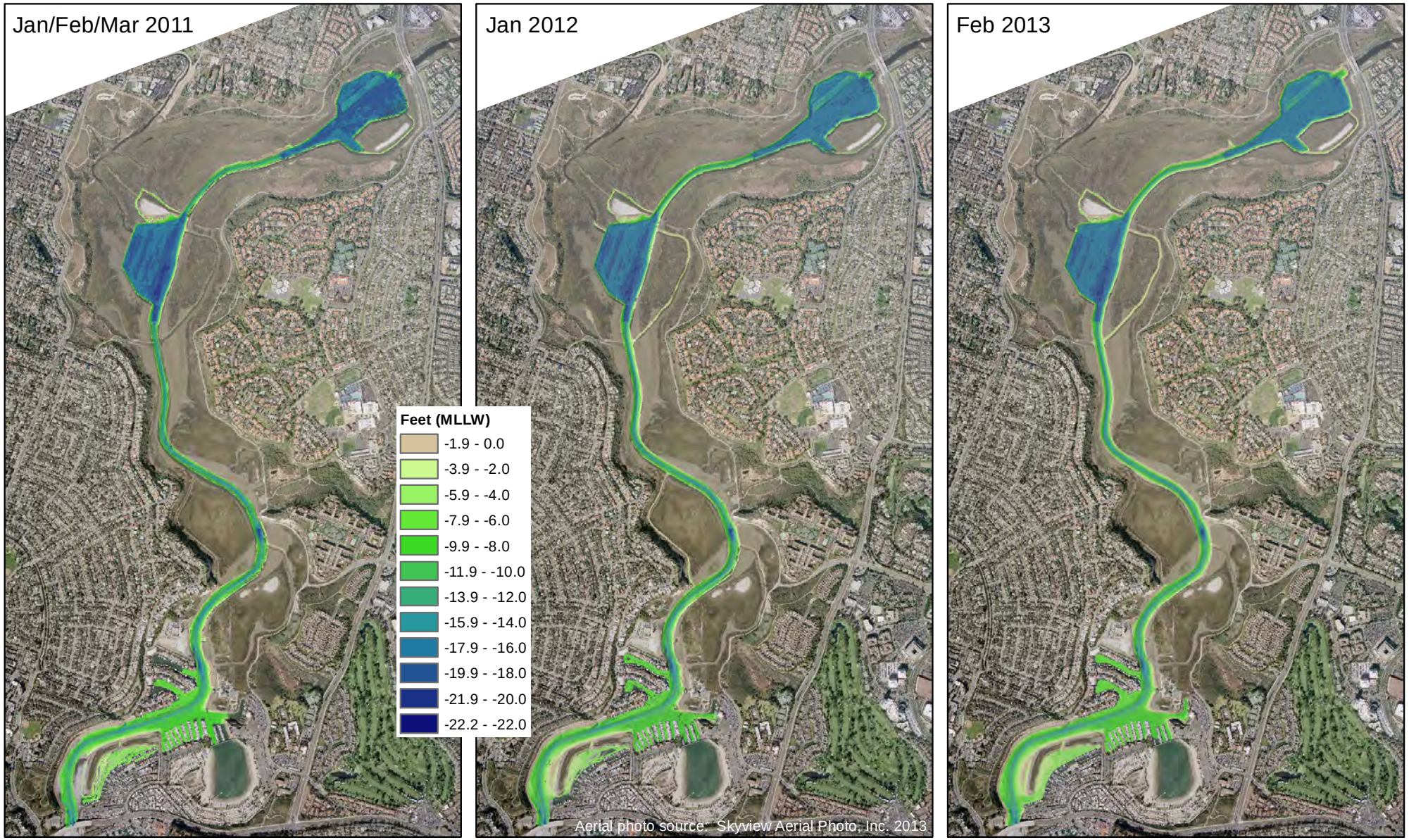
The bathymetric data were provided to M&A as point data. The point data were imported into the GIS software ESRI ArcView and converted to a grid with no subsequent interpolation. The Year 3 data are presented in Figure 2 alongside the Year 1 and Year 2 data also collected by ACOE and provided to M&A as point data.

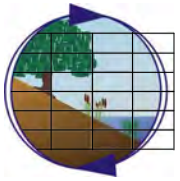
The ESRI extension 3D Analyst was used to perform a neat line loss/gain volume analysis between the grids to calculate the total volume change. Subtractions between the grids were performed and the resulting grids prepared to illustrate areas of accretion and erosion between years. These comparison plots are presented in Figure 3 and show comparisons between Years 1 and 2, Years 2 and 3, and Years 1 and 3. Regions within the study area that were not captured by both bathymetric surveys have been left blank and excluded from calculations of change.

Areas of positive change (accretion) were plotted in shades of red and areas of negative change (erosion) were plotted in shades of blue. To be clear, the “accretion” and “erosion” terminology used is for convenience and does not necessarily reflect particular processes involved in apparent gains and losses of sediment volume. One very important factor in evaluating these differences pertains to sediment density. Because the bathymetric analyses are restricted to comparisons of acoustically detected sediment surfaces, no information is available to distinguish between bulked or consolidated sediments.

Larger, higher resolution versions of each of the three images in Figure 2 are provided in Appendix B to allow the reader more detailed examination. M&A has not been tasked with evaluating the quality of the data or adjusting the data to remove survey related noise. There appear to be some linear artifacts in the survey records (visible in Appendix B) that are related to the survey boat tracks rather than true bathymetric features, though the effects of these artifacts on the overall change analysis are believed to be minor.

The ACOE also provided M&A point data from a bathymetric survey performed in 2006 prior to the initiation of dredging for the restoration project, which began that year. This survey is presented in Figure 4 next to the first complete post-restoration bathymetric survey performed by ACOE in

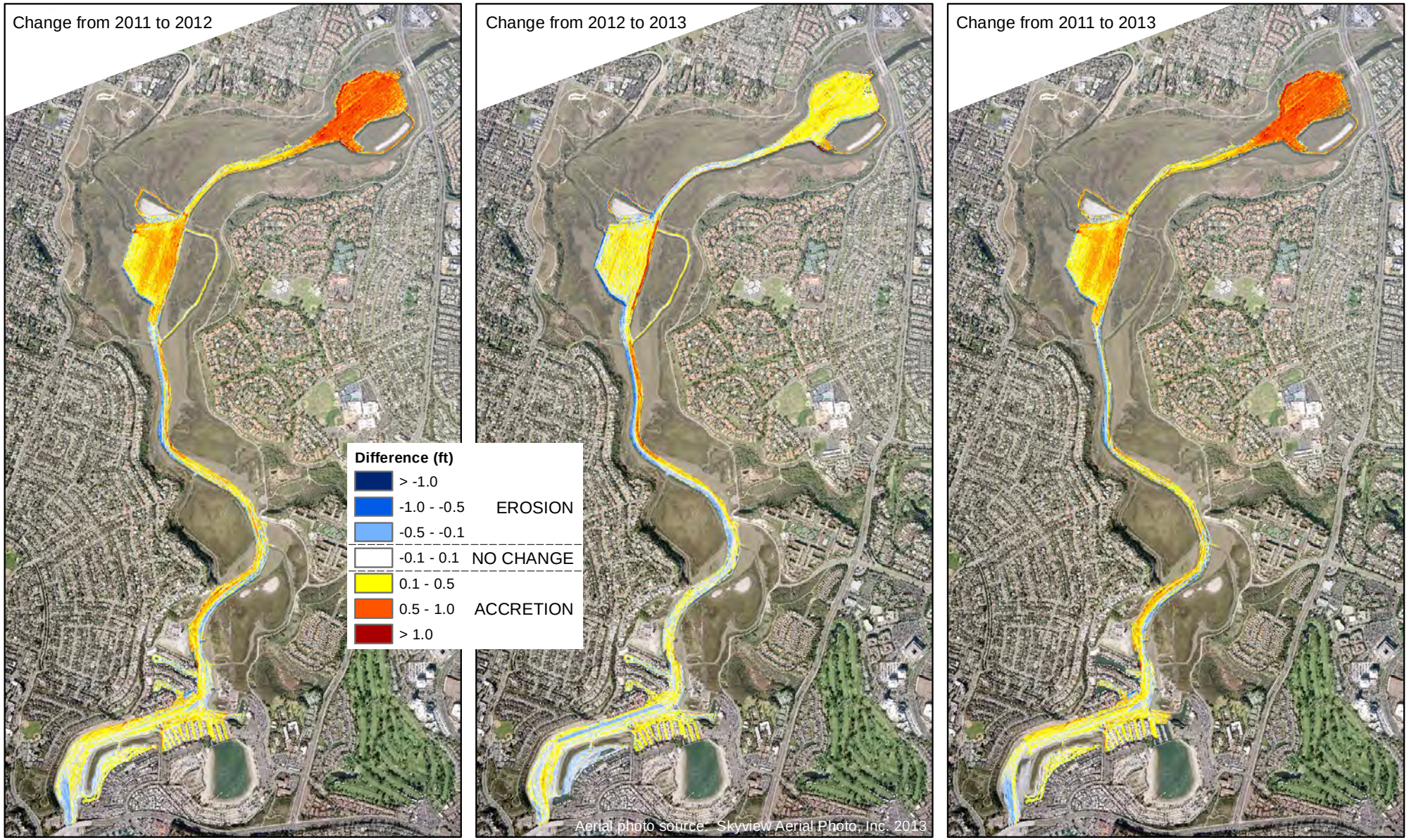


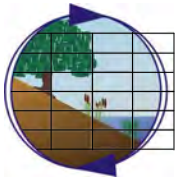


2011, 2012, and 2013 Bathymetry

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 3

Figure 2



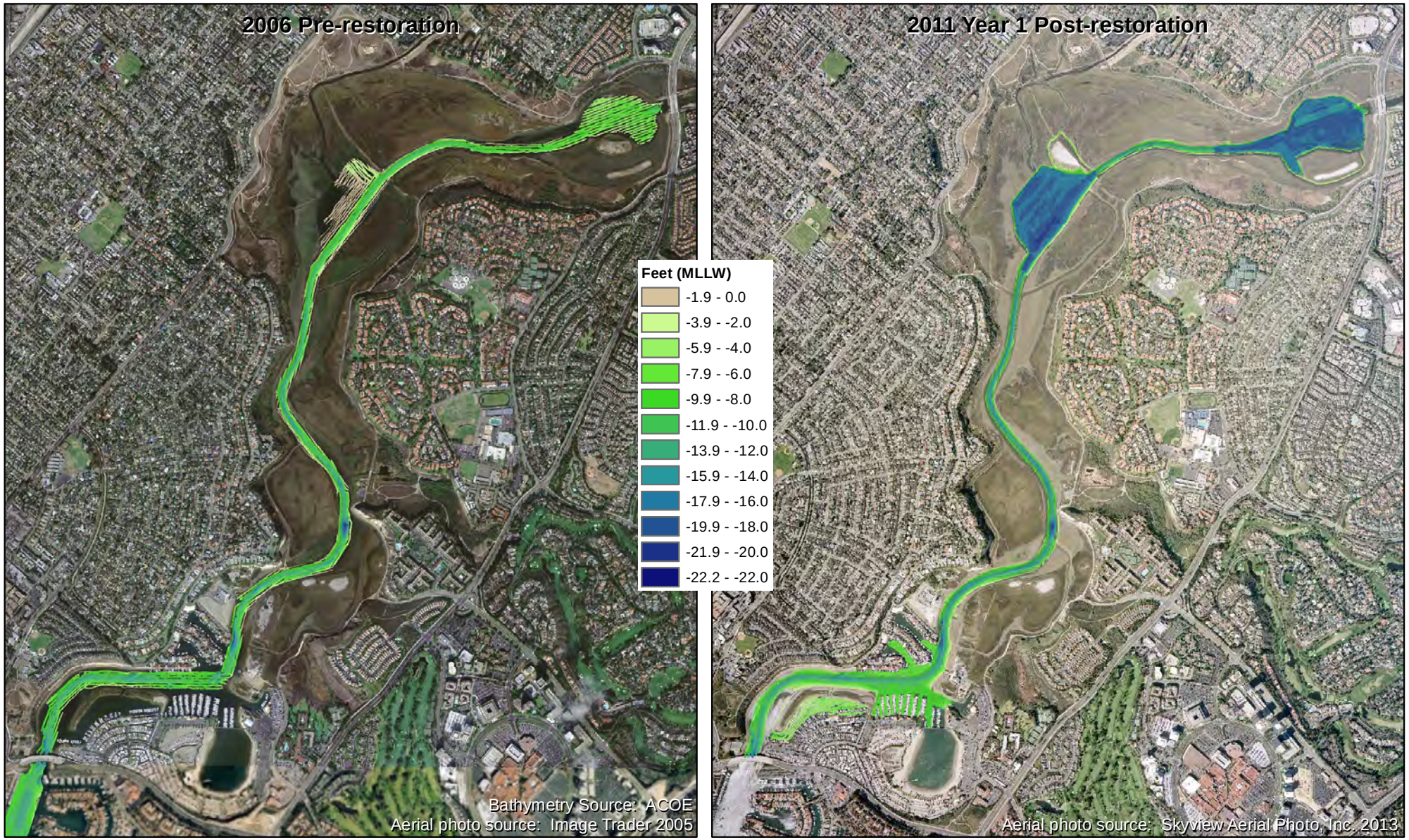


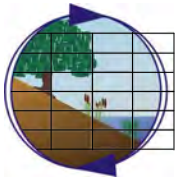
2011, 2012, and 2013 Bathymetry Change Analysis

Upper Newport Bay Ecosystem Restoration Project

Post-restoration Monitoring Program - Year 3

Figure 3





Pre-restoration (2006) and Post-restoration (2011) Bathymetry

Upper Newport Bay Ecosystem Restoration Project

Post-restoration Monitoring Program - Year 3

Figure 4

January, February, and March 2011, roughly four months after completion of dredging in September 2010 (referred to above as the Year 1 2011 survey). The figure illustrates very well the bathymetric features created by the restoration project, however, due to differences in survey extent and methodologies, it is not possible to utilize these data for change calculations.

Results

When examining the change between 2012 (Year 2) and 2013 (Year 3), there was considerably less surface change than was observed and reported on between 2011 and 2012 in the Year 2 report. Between the January 2012 survey and the February 2013 survey, total accretion throughout the surveyed area was approximately 72,405 cubic yards (55,358 cubic meters). Total erosion was 44,303 cubic yards (33,872 cubic meters), for a net change of 28,102 cubic yards (21,486 cubic meters) of accretion.

The areas of greatest sedimentation were the two basins, as anticipated by the project design, and in the channel between them (see Figure 1 for basin and landmark names). Between 2012 and 2013 the average depth in the Unit I/III Basin changed from approximately –17.8 feet (-5.4 m) MLLW to –17.5 feet (-5.3 m) MLLW. The Unit II Basin maintained an approximate average depth of –18 feet (-5.4 m) MLLW between 2012 and 2013. Both were excavated by the restoration project to –19.0 feet (-5.8 m) MLLW. Erosional areas occurred primarily on the west shoreline of the Unit II Basin and on the western shore of the main channel. Based on the scale and characteristics of the exhibited erosional features, some of the quantified erosion is likely related to alignment noise at the edges of the multibeam sonar datasets rather than true areas of erosion, however some of the change is likely related to winnowing of the fines and deposition of the material resuspended from the shallows into the deeper basins.

In comparison, the total accretion between 2011 (Year 1) and 2012 (Year 2) was 113,102 cubic yards (86,472 cubic meters) and total erosion was roughly half as much as the present comparison, at 22,080 cubic yards (16,881 cubic meters). The net change between 2011 and 2012 was 91,022 cubic yards (69,591 cubic meters) of accretion, more than three times more than the change between 2012 and 2013.

Comparisons of surfaces between 2011 (Year 1) and 2013 (Year 3) find a total accretion of 138,010 cubic yards (105,516 cubic meters) and total erosion of 24,639 cubic yards (18,838 cubic meters), for a net accretion of 110,371 cubic yards (84,385 cubic meters) (Figure 3). Note that the change calculations for Years 1 to 2 and Years 2 to 3 do not sum to the change reported between Years 1 and 3 because the calculations are based on the areas of intersection between two survey surfaces and each annual surface is a slightly different shape, so the points of intersection are different for each calculation. This is evident in Figure 3, where missing data prevented the change calculations in some areas in some years.

Discussion

The monitoring work was intended to answer Question 1 posed in Section 1.3 above: *Are the sediment basins performing according to the design goals?* More specifically, do the basins have enough capacity such that maintenance dredging will not be required for 20+ years (given the rate of sediment accumulation within the basins) and are the basins trapping the majority of the

sediment that enters the upper bay, and thus minimizing sediment accumulation in the tidal channels and the lower portions of the bay?

The January 2011 Design Documentation Report (ACOE 2011) describes the design goals as follows. The two existing Unit II and Unit I/III sediment basins were configured to trap sediment coming from San Diego Creek. The project design called for expanding and deepening these basins to –17.3 feet (5.26 m) MLLW, with the final constructed basin depths being generally –19.0 feet (-5.8 m) MLLW with maximum depths of –19.7 feet (-6.0 m) MLLW. The previously maintained depth was -10.6 feet (–3.43 m) MLLW. The basins were sized to accommodate average annual sediment loading for a period of 21 years before requiring maintenance. The 21-year maintenance cycle was based upon historic annual sediment inflows into UNB from San Diego Creek ranging from 6,000 cubic yards (4,600 cubic meters) to nearly 700,000 cubic yards (535,000 cubic meters) during the 1972 to 1996 period. Modeling for the project design used an annual average of 164,000 cubic yards (125,000 cubic meters), though the Design Documentation Report notes there is updated sediment loading information available in the Newport Bay Watershed Sediment TMDL Annual Reports prepared by the County of Orange.

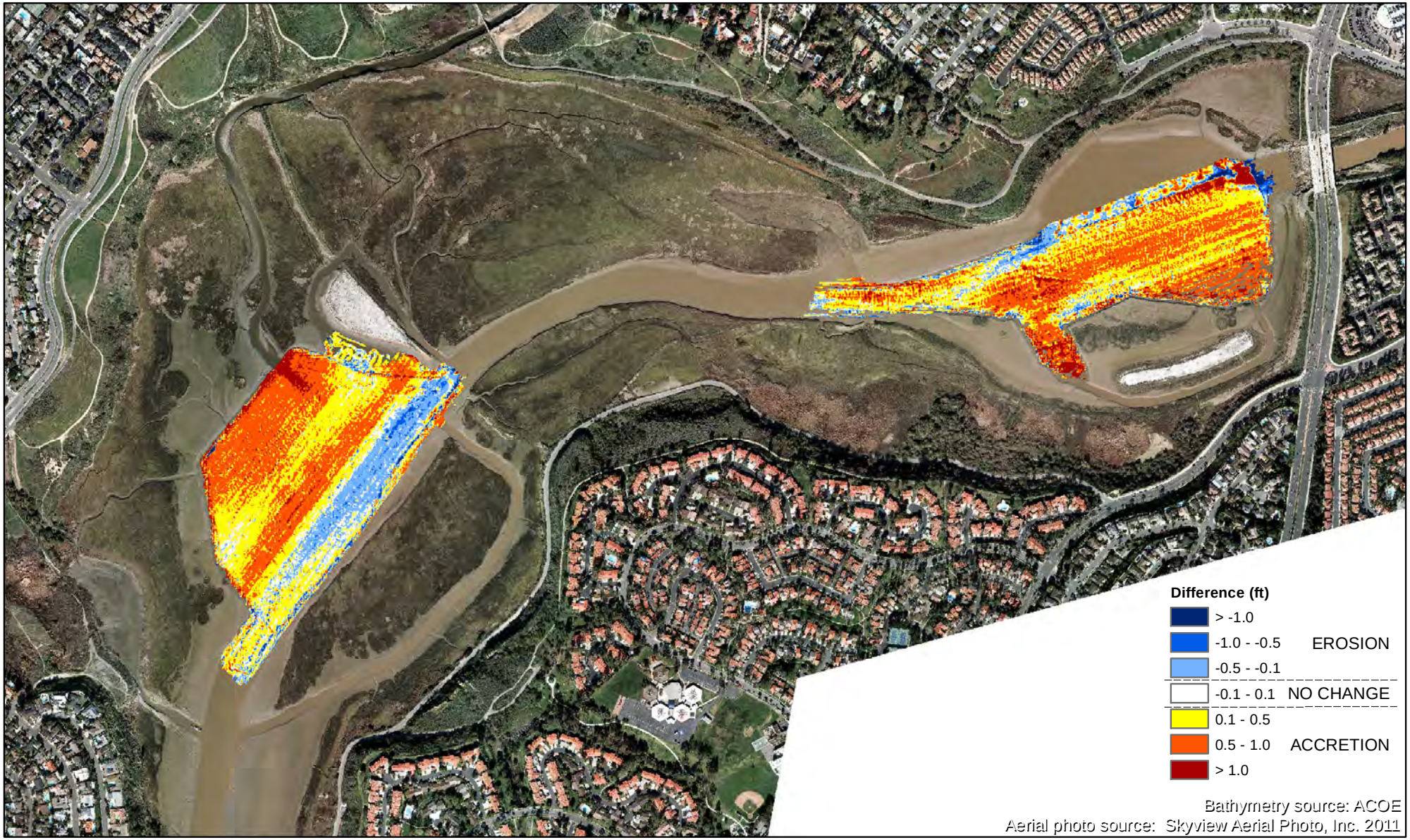
The total accretion of 138,010 cubic yards (105,516 cubic meters) between Year 1 and Year 3 is consistent with the above design projections and would suggest that the 21-year maintenance cycle is reasonable. It is critical to note that the analyses of accreted volume are based on unconsolidated surface-to-surface comparisons between the years. With time and accumulation of greater sediment depths, the lower strata of the trapped sediment will consolidate, resulting in reduced sediment volume and increased density, thus returning some of the basin capacity as porewater is released through self-weight consolidation. Notwithstanding the early monitoring results, it is important to note that the three rainy seasons captured by these data (January 2011 to February 2013) were notably drier than most and also lacked significant high rainfall periods, therefore it is not appropriate to draw long-term conclusions based on sub-average rainfall conditions. To truly understand the likely frequency of maintenance required, it will be necessary to collect data over periods of average and above average storm conditions. This bathymetric analysis is scheduled to be performed again in monitoring Years 5 (2015) and 8 (2018).

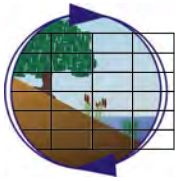
The analysis of the three bathymetric surveys confirms that sediment is being trapped in the basins. When the distribution of sediment trapping is examined, it is clear that the degree of sediment capture decreased from the upper to lower portions of the UNB study area. Most of the sediment was trapped above Unit II basin. Sediment trapping within the basins undoubtedly serves to reduce the availability of source sediment for deposition in smaller tidal channels, however, transportable fine sediments will continue to be available and thus tidal channel infill is expected to continue to a point of tidal flow based cross-section stability. Where channels were over-excavated by the restoration project to isolate islands, the velocities of tidal flow will typically be inadequate to keep sediment in suspension or re-suspend sediment once it is deposited in the channel. As a result, these channels will accrete sediment at a more rapid rate than channels that are naturally sized by the flows they convey. The rate of deposition within the excavated channels will diminish as the sectional area is reduced to a point at which flow velocities are adequate to prevent deposition and stimulate export of deposited sediments.

An estimate of the sediment input into UNB from the surrounding watershed is generated annually by the County of Orange in the Newport Bay Watershed Sediment TMDL annual reports. Using suspended sediment samples and hydrographic data, the monitoring estimated that freshwater tributaries input approximately 116,000 cubic yards into UNB during the 2010/2011 wet weather season, 4,000 cubic yards in the 2011/2012 season, and 1,709 cubic yards in the 2012/2013 season (County of Orange 2012, 2013, and 2014). Cubic yards were estimated from the reported tons of sediment discharged using a conversion of 1 cubic yard = 1.215 tons of sediment. The disparity between the sediment input estimates and the volume changes estimated from the bathymetric surveys illustrates the differences in what is being measured by the two methods. As discussed above the bathymetric surveys simply report the vertical position of the seafloor and the analysis of accreted volume is based on an unconsolidated surface-to-surface comparison between years. It does not truly measure the volume of sediment added to UNB because the sediment below that surface has a large porewater component and over time will consolidate under self-weight. Therefore, for example, a drought year without input of large volumes of sediment could register as a net loss of sediment from the system based on the bathymetric data, while, in fact, there was simply a change in the density of the sediment as porewater was forced out and the seafloor surface moved deeper.

Keeping in mind the key purpose of the bathymetric monitoring, which is to determine the condition of the sediment basins and their capacity to capture future sediment inputs, it is less important to track the volumes calculated by the annual surface to surface comparisons and more important to track the available basin volume below the adjacent channel elevations. As the bottoms of the two basins approach the channel elevations, the basins will become less effective at trapping and sequestering sediment and debris. This calculation of available basin space remaining could be used in conjunction with the County estimates of sediment input to predict the remaining lifespan of the basins and to serve as the trigger for future maintenance dredging of the basins.

As a follow-up to comments generated by the Year 2 monitoring report, additional bathymetric data were examined. It was pointed out that the majority of the sediment influx into UNB in the past three years occurred during a major storm event from December 20 to 22, 2010, during which nearly nine inches of rain fell in the watershed. This storm occurred prior to the collection of the Year 1 bathymetric data in January through March 2011. To investigate the degree of sediment infill that may have occurred in the basins prior to the “baseline” post-restoration survey in 2011, the September 2010 post-dredge performance surveys from the basins were obtained from ACOE and compared to the January through March 2011 survey points from overlapping areas. The comparison is presented in Figure 5 and shows roughly a range of 0.1 to 1.0-foot loss of depth in the basins and an estimated net accretion of 44,676 cubic yards (though the northern portion of Unit I/III Basin was not surveyed in the September 2010 survey). Unfortunately, the missing area in the northern portion of the Unit I/III Basin is an important element of the total measured volume. It is also important to keep in mind that rapidly discharged fine fluvial sediment would be expected to deposit in a highly bulked form that would be subjected to substantial subsequent redistribution from shallow areas and consolidation in deeper areas. These post-deposition changes in sediment distribution and density make it very difficult to make use a short-term deposition event as a tool in assessment of trends or an indicator of either rates or patterns of infill.





Bathymetric Change in Sediment Basins Between Post-dredge Surveys (September 2010) and the First Full Post-restoration Survey (January 2011)

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 3

Figure 5

2.2. Least Tern Island Elevations

The Monitoring Program calls for an assessment of New Least Tern Island, the nesting site created by the restoration project near the old salt dike (Figure 1) in Years 1, 2, 3, 5, 8, and 10. Since its construction in 2007 and 2008, least terns and western snowy plovers have not been observed nesting on the New Least Tern Island. Prior to the 2013 nesting season, an assessment of the island was made on January 10, 2013. Notes were taken on the condition of the surface, photos were collected, and elevation data were collected with a total station. In addition to checking the elevation of three permanent control points, multiple elevations were recorded along six representative transects crossing the island from edge to edge to document the range of elevations present.

At the time of the survey New Least Tern Island had not yet been prepared for nesting season, however vegetative cover was low, and estimated at 10% cover of live vegetation and 30% cover of dead plant material from the prior year. There was adequate space for tern nesting and the island appeared to be in good physical condition, with limited erosion and a generally sloping surface. The main surface of the nesting area slopes downward from north to south, with the higher northern edge averaging around +9.7 feet (+2.9 meters) MLLW and the lower southern edge around +8.5 feet (+2.6 meters) MLLW in 2013. The design elevation of the island was +3.0 ± 0.2 meters. Elevations were lower at the eastern end of the island where it slopes down to the access ramp on the east point. There are three existing elevated control points on the nesting site (NLTI 1, NLTI 2, NLTI 3), installed and initially surveyed by ACOE in May 2009, roughly one year after the island was completed in March 2008. Table 2 presents the original 2009 measurements, a single measurement taken at NLTI 2 in 2011, the 2012 measurements, and the current 2013 measurements. Note that although the 2011, 2012, and 2013 measurements were taken during the Years 1, 2, and 3 post-restoration monitoring program, they actually represent conditions three, four, and five years since the completion of the island in March 2008, midway through the restoration process. Also note that the control point monuments are elevated above the surface of the island and should therefore not be compared to the stated design elevations.

Table 2. Elevation (feet MLLW, 83-01 epoch) of three control points at New Least Tern Island.

Control Point ID	May 2009* ACOE	January 25, 2011 M&A	April 26, 2012 M&A	January 10, 2013 M&A
NLTI 1	9.96		9.52	9.50
NLTI 2	10.77	10.38	10.35	10.27
NLTI 3	9.95		9.36	9.35

* 14 months after island was completed

These data suggest the ground near the control points may have settled by between 0.42 and 0.59 feet (0.12 and 0.17 meters) between the first measurements in 2009 and 2012. Between 2012 and 2013 additional settling was minimal: less than 0.1 feet (0.03 meters) at each control point. No evidence of land bridges to the main marsh was detected and the channel around the island was still fully subtidal.

An assessment was also made of the cordgrass that was transplanted in November 2009 on the windward (south) and west shores of New Least Tern Island. The purpose of the transplant effort was to mitigate for the estimated 500 square meters of cordgrass impacts that resulted from the excavation of the channel around New Least Tern Island. The mitigation obligation for the project included the creation of 1,500 square meters of new cordgrass beds. In 2013, the largest persisting planted patches were on the west slope of the island, where the sandy shoreline has eroded to expose a mud base more suitable for cordgrass growth than the other shorelines of the island. Field measurements of the cordgrass patch dimensions estimated a total area of approximately 40 square meters, growing at elevations between 2.8 and 3.5 feet MLLW. Sparse remnants of the transplants on the south shore that had been observed in Year 2 were not evident during the January 2013 survey of the island. It is possible that later in the growing season this cordgrass reemerged to some degree. However it is unlikely that cordgrass on this shoreline will ever expand to a form dense stand around the island; more likely, it will persist or spread to particular areas along the island shoreline where substrate and wave exposure are most opportune. The other limited areas of sandy substrate in UNB also do not support dense cordgrass.

Although the goal of 1,500 square meters of cordgrass restoration will not be met on New Least Tern Island, well over this amount of cordgrass habitat has been created further east on the Bullnose Wetland Restoration Area excavated during the restoration project (see feature map in Appendix A). This expansion of cordgrass is discussed further in the vegetation chapter below.

3.0 BIOLOGICAL MONITORING

3.1. Vegetation Monitoring

The distribution, composition, and evolution of vegetation communities and unvegetated habitats are being monitored through the use of aerial photography and quantitative transect methods. The Monitoring Program calls for collection of aerial photographs in Years 1, 2, 3, 5, and 8 and surveys of transects in Years 2, 5, and 8. Therefore Year 3 monitoring was limited to aerial image collection and habitat mapping.

Methods

To map vegetated and non-vegetated habitats during Year 3 (2013), the UNB study area was contract flown on March 11, 2013 to photograph the site from true vertical position on full-color film. The site was broken into a series of ten tiles, collected at a scale of 1 inch = 666 feet. A single higher elevation spot shot of the entire UNB area was collected at a scale of 1 inch = 2000 feet. The photos were taken between 1550 and 1603 hours at roughly a 0 foot MLLW tidal elevation. This allowed photography of as much exposed intertidal habitat as possible while lighting and weather conditions were suitable for the work. Collection of aerial imagery in subsequent years should be conducted as close to the same tidal elevation as practical.

Because of the scale of the study area, full registration of the image tiles was not directly possible due to lens distortion. To rectify this issue, the tiles were broken into multiple smaller tiles and then rectified by aligning physical features within each of the smaller tiles with the same features present in orthorectified imagery originally flown for the site in 2010. The smaller tiles were rubber sheeted to the rectified image such that error generated by image distortion could be substantially reduced. By clipping the spot image multiple times with differing tile centers and repeating the process, the rectification was substantially improved. Digitization from the rectified tiles rather than a single mosaic was then performed. When a static feature used for alignment (sign, utility pole, road shoulder, small tidal channel, or single shrub) began to diverge in alignment between the known rectified image and the rubber sheeted tiles, differing tiles would be used in the mapping to maintain tighter horizontal control.

To establish a consistent study area, a boundary was established during Year 1 at the extreme high water line, which is 7.8 feet (2.4 meters) MLLW for UNB, and corresponds to the upper boundary of salt marsh habitat. All areas extending from that outer boundary toward the channel were included, including raised areas above 7.8 feet (2.4 meters), such as the least tern islands. The geographic position of the 7.8 feet line was determined using topographic data collected by ACOE in 2011. It was not possible to also evaluate just the habitat occurring within the UNB Ecological Reserve because a GIS-based reserve boundary was not available at the time of analysis. In addition, some portions of the reserve extend outside the boundary of the restoration and monitoring program.

Heads-up digitization of vegetation boundaries visible in the imagery was performed using ArcGIS 10. Mapped vegetation generally following the Holland (1986) and Oberbauer (2008) classification system where appropriate, with other non-vegetated habitat types being assigned as needed.

Because it is not feasible to distinguish between low, middle, and high salt marsh vegetation using the true color aerial imagery, all zones of coastal salt marsh were mapped as a single habitat. Eelgrass (*Zostera marina*) visible in the aerial image was delineated, though it is likely that the lower edges of the eelgrass extend to depths below what can be mapped from aerial images.

The only habitats that were not mapped strictly from the aerial were intertidal mudflat and open water. The upper edge of the mudflat was determined based on inspection of the aerial image, where the mudflat met the salt marsh, regardless of elevation. However, during the project planning process, the existing acreage of mudflat was calculated in 2004 based on both bathymetry and aerial photos. To capture comparable mudflat expanses during the Year 1 (2011) mapping effort, the lower edge of the mudflat was extended from the 0 MLLW line (visible in the aerial image) down to the -1.54 feet (-0.47 meter) MLLW contour (used in 2004 mudflat mapping), based on the bathymetric data provided by the ACOE. This approach became problematic in Year 2 (2012), however, because in many cases the bathymetric data for 2012 did not extend up as shallow as the –1.54-ft MLLW contour, so it could not be used to delineate the lower boundary of the mudflat (and upper edge of open water). This same problem occurred in Year 3 (2013), again due to an incomplete bathymetric dataset in the shallower areas. In these cases, attempts were made to estimate the position of the –1.54-ft MLLW contour by joining the ends where the contour line broke off, by examining the aerial photo, or through comparison with the Years 1 and 2 contours. Bathymetric data were not collected in the Newport Dunes basin and a few others areas within the southern portion of the habitat mapping boundary (data gaps visible in Figure 2). In these areas, the lower edge of the mudflat was also approximated. Another exception to this habitat method occurred in most of the side channels of UNB, where ACOE bathymetric data were not collected in Years 2 and 3 (it was collected in Year 1, but is not presented in this report). Therefore the open water/mudflat boundary in these channels had to be mapped from the aerial image, which reflected conditions at a 0 MLLW tide. The areas in which this had to be done can be seen by comparing the available bathymetric data in Figure 3 with mapped habitat in Figure 6. For example, the Santa Ana Delhi Channel (see Appendix A for feature map) was not included in the bathymetric survey, therefore the open water and emerging mudflat was mapped exclusively from the aerial photographs.

The approximation of boundaries where bathymetric data were not available, and the inherent error associated with overlaying consecutive annual images, reduced the level of accuracy and precision of the mapping process. Small changes in habitat coverage year to year will, therefore, be difficult to distinguish from imprecision arising from these mapping issues. This can be seen particularly in comparisons of habitats that are linear or near the edge of the survey area, such as the road along the east shoreline of UNB. A very slight shift of the photo position from year to year, while the survey boundary remains geographically fixed, can, for example, result in a small sliver of the road falling within the survey boundary, when it had previously been excluded. These mapping errors are most distinct along the urban transition as it is the periphery of the project and exhibited the greatest amount of photographic distortion in the mapping process. We assume that changes in habitat coverage of less than one percent of the mapped habitat types from survey to survey could be due to the mapping technique used and cannot be viewed with certainty as a true change on the ground.

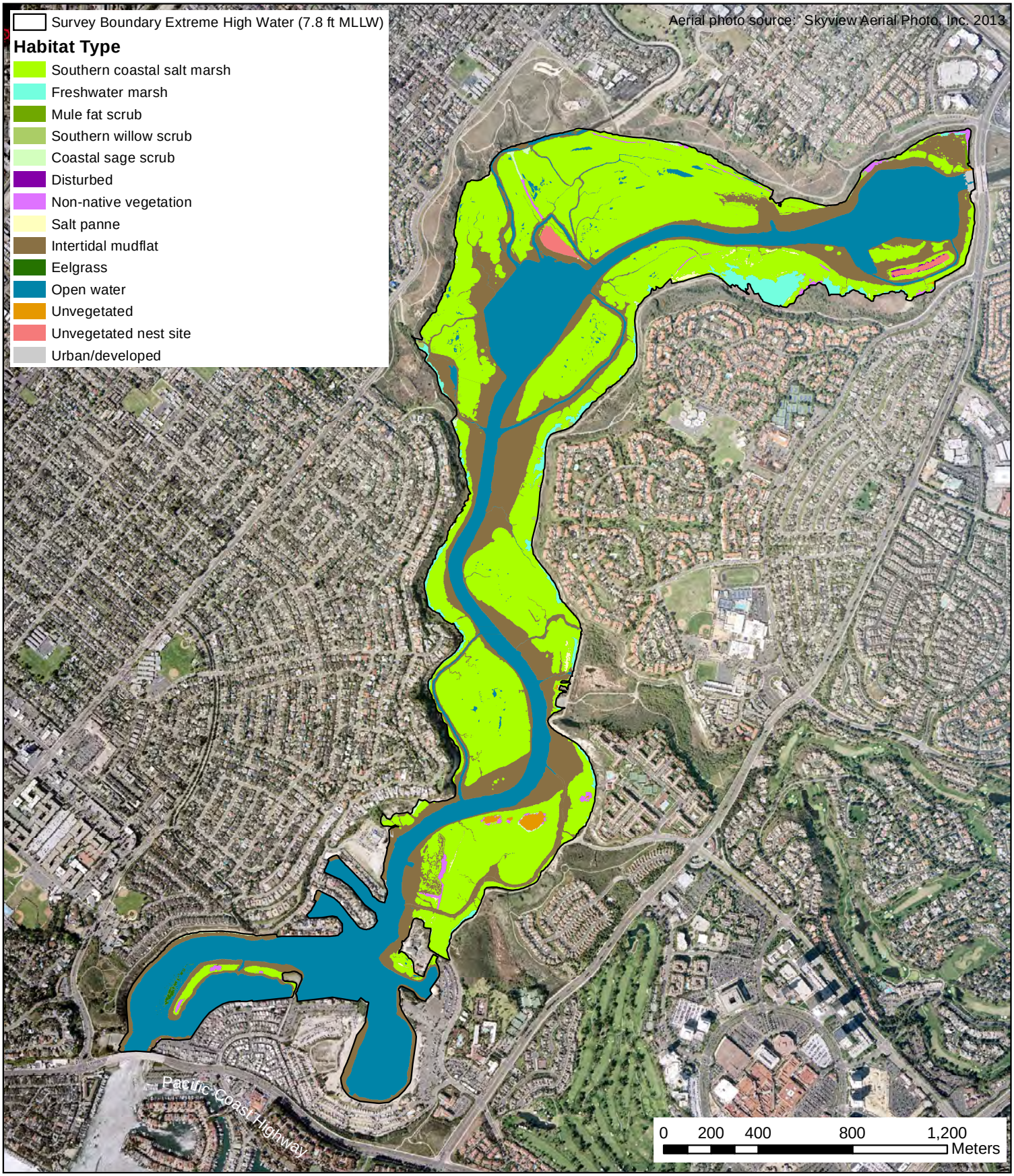
The draft digitized habitat maps were printed and taken into the field for ground-truthing from various vantage points along the shoreline and from the water. The habitat maps were updated and map products and summary statistics of habitat acreage and distribution were generated. Comparisons were made to the Year 2 habitat data.

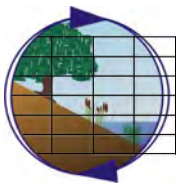
Results

Based on the March 2013 imagery, thirteen habitats were mapped within the study area. Figure 6 presents the distribution of habitats on-site and Table 3 summarizes the extent of each.

Table 3. Area of habitats within the UNB study area (March 2013).

Habitat	Hectares	Acres
Southern coastal salt marsh	145.5	359.6
Freshwater marsh	5.7	14.1
Mule fat scrub	0.2	0.4
Southern willow scrub	0.6	1.4
Coastal sage scrub	1.6	3.9
Disturbed	0.2	0.4
Non-native vegetation	2.3	5.8
Salt panne	0.7	1.8
Intertidal mudflat	68.3	168.8
Eelgrass	0.2	0.6
Open water	100.5	248.4
Unvegetated	1.1	2.6
Unvegetated nest site	1.6	3.8
Urban/developed	0.5	1.1





Habitat Map - April 2013

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 6

Merkel & Associates, Inc.

Southern coastal salt marsh is the most abundant habitat in UNB, with 145.5 hectares (359.6 acres) mapped in 2013. As mentioned above, without infrared photography it was not possible to distinguish from the imagery the delineations between low, middle, and high marsh. The species that made up each of these marsh communities were reported on in the Year 2 annual report, which included vegetation transect surveys (M&A 2014).

The 68.3 hectares (168.8 acres) mapped as mudflat reflect the amount of mudflat that occurs between the lower edge of the salt marsh and the open water, which was set at -1.54 feet (-0.47 meter) MLLW for this project by ACOE for prior habitat mapping efforts. The exception as detailed above is in the side channels where bathymetric data were not available and the mudflat extended only down to the 0 MLLW line visible in the aerial image. The 100.5 hectares (248.4 acres) mapped as open water include all waters below -1.54 feet (-0.47 meter) MLLW and those between -1.54 feet and 0 MLLW in the side channels. Pools of ponded water fed by small channels on the salt marsh plain were also mapped as open water.

Areas identified in the field as brackish marsh and coastal and valley freshwater marsh were grouped together as freshwater marsh, and tended to be dominated by cattails (*Typha latifolia, T. domingensis,* and *T. angustifolia*) and bulrush (*Bolboschoenus maritimus*). This habitat expanded slightly in 2013 in a few areas on the eastern boundary of UNB where perennial freshwater input supports freshwater marsh vegetation. Other emergent wetland habitats occurring between the salt marsh and the upper edge of the survey boundary included southern willow scrub and mule fat scrub. These generally constituted small groupings of arroyo willow (*Salix lasiolepis*) and mule fat (*Baccharis salicifolia*) growing along Back Bay Drive at the upper edge of the marsh, and in the northern corner of the bay.

Small areas of coastal sage scrub dominated by goldenbush (*Isocoma menziesii*) occurred on elevated areas in the salt marsh and at the upper edge of the marsh. Other species within this habitat included California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), coyote brush (*Baccharis pilularis*), bladder pod (*Isomeris arborea*), and four-wing saltbush (*Atriplex canescens*). The steep slopes on either side of UNB, which support extensive expanses of coastal sage scrub, were generally outside of the survey area for this monitoring program. In a few cases, coastal sage scrub that lies outside of the intended study boundary was actually included in the acreage calculations due to the minor geographic shifts of the aerial image in relation to the fixed geographic boundary established by the topographic data in 2011. This resulted in a small increase in coverage values each year that is not reflective of true gains in coastal sage scrub in the system.

Habitats mapped as non-native vegetation were well-established stands of exotic species including castorbean (*Ricinus communis*), tree tobacco (*Nicotiana glauca*), hottentot fig, white sweetclover (*Melilotus albus*), large Brazilian pepper trees (*Schinus terebinthifolius*), pampas grass (*Cortaderia selloana*), giant reed (*Arundo donax*), and Canary Island date palms (*Phoenix canariensis*). Only a small portion of the non-native vegetation on the margins of UNB fell within the survey boundary (extreme high tide line: +7.8 feet MLLW), with additional ornamental exotic species occurring higher in the adjacent upland between the marsh and Back Bay Drive or northern trail system.

Disturbed habitat was mapped in areas that had a growth of opportunistic weedy species as a result of human action. The dominant vegetation in these small areas was telegraph weed (*Heterotheca grandiflora*), with some wild radish (*Raphanus sativus*).

Areas mapped as urban/developed had been constructed upon or otherwise physically altered to an extent that native vegetation was no longer supported. Within the survey area at UNB this included riprap and concrete, particularly where San Diego Creek enters the Unit I/III basin and on the south shore of the Newport Aquatic Center across from Shellmaker Island. Again small shifts in the position of the aerial photo captured portions of Back Bay Drive that were not intended to be within the survey area but fell within the geographically fixed project boundary. There was no true change in the extent of urban/developed areas since 2011.

Several other habitats devoid of vegetation were distinguished due to the variable origins of their unvegetated condition. The bare sand portions of the created tern islands were called out as "unvegetated nest site" in order to track the extent of habitat available for nesting over time. This excluded the small portions of the tern islands that were vegetated to a degree that nesting by tern species or plovers would be unlikely. Areas mapped as salt panne collect rainwater or seawater at extreme high tides and remain ponded due to the microtopography of the area. Evaporation of the ponded water leads to hypersaline conditions and depressed oxidation-reduction potential that are inhospitable to most vascular plants. The expansion of pickleweed into salt panne areas is variable year to year; therefore, variations in the extent of salt panne present each year is to be expected. Finally, areas with no vegetation, but apparently unaltered by human action, were mapped as simply "unvegetated". These were generally raised areas on Shellmaker Island made up of unstable sands that may preclude the establishment of most plant species. These raised areas were generally ringed by hottentot fig and goldenbush. Once established these species can expand into shifting sands and some reduction in the extent of unvegetated habitat may occur in future years due to stabilization by invasives or opportunistic natives.

Approximately 2,307 square meters (0.57 acre) of eelgrass was mapped on the western shoreline of the DeAnza Peninsula, the arm of land that parallels the main channel just north of Pacific Coast Highway. This is believed to be an underestimate due to mapping methodologies as discussed above as well as limitation with aerial mapping of submerged habitats at deeper depths. A survey conducted using sidescan sonar would be needed to fully map the complete distribution of eelgrass within UNB. The extent of this particular eelgrass bed is known to vary annually, and improvements in water clarity envisioned by the restoration project were projected to improve the vigor and extent of this bed. An eelgrass restoration project was undertaken in June 2012 by the Orange County Coast Keeper near the eelgrass bed described above. A total of 200 square meters (0.05 acre) of eelgrass was transplanted using three methods: bare root bundles, units of eelgrass tied to wire frames, and flowering stalks is bags that drop seed as it ripens.

Discussion

Question 9 posed in Section 1.3 above asks if the restoration project has resulted in a 10 percent gain or loss of any habitat. This question, and the difficulty of answering it without appropriate pre-restoration habitat mapping, was discussed at length in the Year 1 report (M&A 2013). Aside from a question specifically about eelgrass, there were no other habitat goals identified by the Monitoring Program.

The habitats of primary interest in relation to the effect of the restoration work were salt marsh, mudflat, and open water. Changes in the distribution of these habitats before and after the restoration were discussed in the Year 1 report. The following discussion examines changes in these three habitats in post-restoration Years 1 (2011), 2 (2012), and 3 (2013). Table 4 and Figure 7 compare their coverage and distribution between years. Much of the change year to year is small and close to the accepted less than one percent mapping-related error, making it difficult to distinguish quantitatively between mapping error and true habitat change. However an examination of Figure 7 reveals some true changes in habitat distribution.

Table 4. Comparison of key habitats (ha.) within the UNB study area during Years 1, 2, and 3.

Habitat	2011	2012	2013
Southern coastal salt marsh	141.6	144.4	145.5
Intertidal mudflat	74.3	72.0	68.3
Open water	99.2	98.8	100.5

Year 3 found a continued reduction in the amount of mudflat. This was due primarily to the expansion of salt marsh onto the mudflat in two areas. The Bullnose Wetland Restoration Area was excavated during the restoration project to create intertidal mudflat. Portions of the mudflat, however, are at elevations too high to preclude the growth of low marsh vegetation; and in the three years since its creation cordgrass and pickleweed had expanded onto the mudflat. It is anticipated that the higher areas of the Bullnose mudflat will continue to convert to low salt marsh as the established patches of cordgrass expand, with the lower areas remaining mudflat. The second area of mudflat loss was the Shellmaker Island mudflat. This mudflat was also created during the restoration project. It was also excavated to elevations that are too high to maintain an open mudflat and was very rapidly colonized by both low and mid marsh species, nearly filling in completely with marsh between 2011 and 2013 (Figure 7). There were also smaller marginal losses of mudflat throughout UNB as the salt marsh expanded down to a slightly lower elevation on the mudflat. Finally, there was continued expansion of isolated cordgrass tussocks by radial clonal growth across the mudflat. This expansion can be seen by examination of the mudflats in consecutive years in Figure 7.

Inter-annual variations in mudflat coverage values were also caused by the photo georeferencing issues described previously. Minor shifts or distortions of the image can have widespread affects on the width of the linear shoreline mudflat. Additionally, the gaps in the –1.54-foot MLLW contour data in Years 2 and 3 added another factor of imprecision to the delineation and quantification of mudflat.

The expansion of salt marsh described above is somewhat masked in the total coverage values presented in Table 4 (increasing by only 1.1 hectare from 2012 to 2013) by two main factors. In some locations, the freshwater marsh that intrudes into the salt marsh on the outer boundaries of UNB expanded in 2013. This habitat will expand and contract annually based on the degree and reach of freshwater from various minor sources in the surrounding watershed. Secondly, the problems with georeferencing have distorted the boundaries of some salt marsh polygons in 2013 in comparison to 2012. For example, an examination of two areas where this effect was detected found a 0.5-hectare (1.3-acre) variation in salt marsh coverage between 2012 and 2013 that was due solely to the distortion of the photographs.

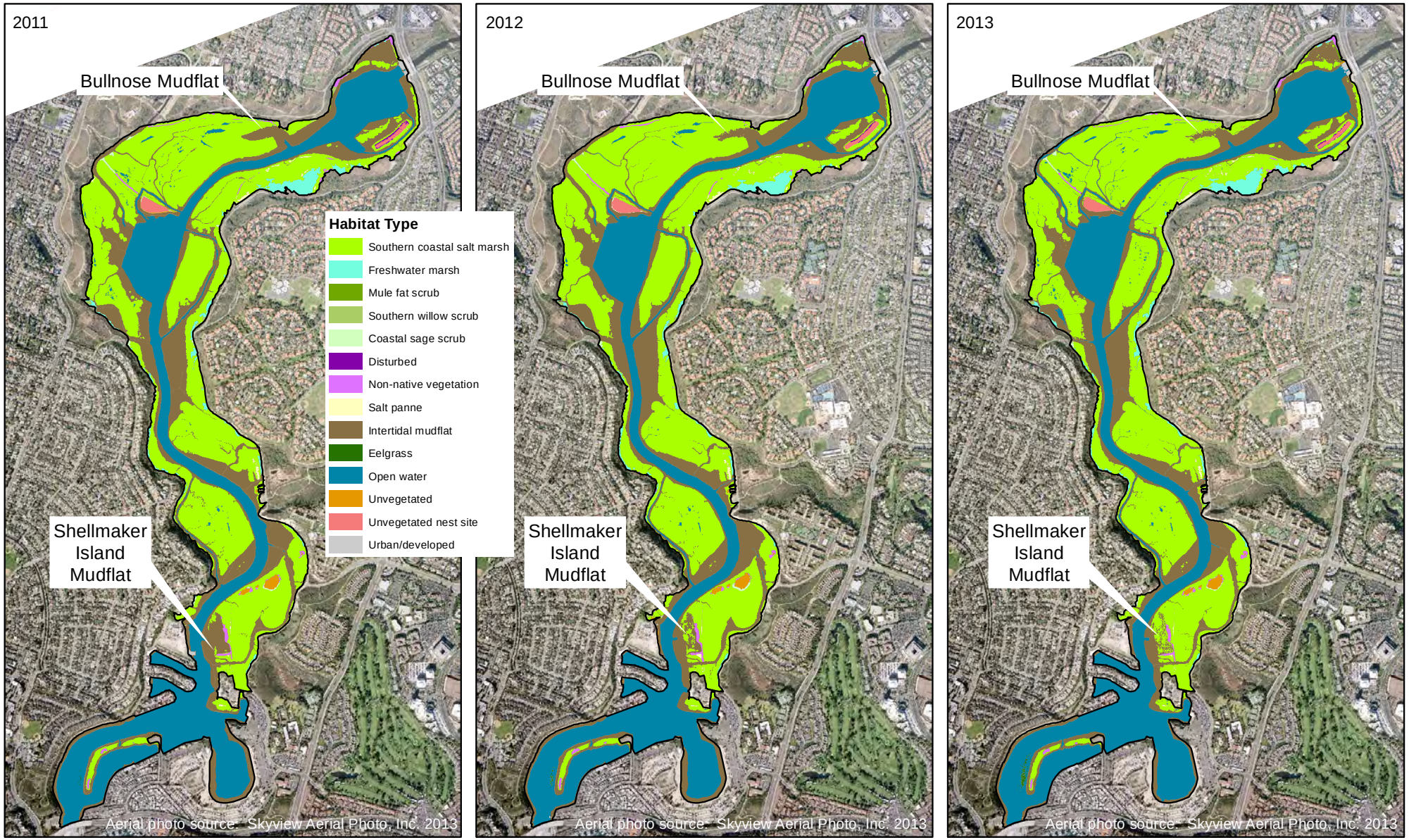
The minor changes in open water each year are most likely due to the limitations of the methodology used to the map the upper edge of the open water from the provided bathymetry, as described in the methods section above. True losses of open water would happen largely as a result of expansion of mudflat from upstream sediment influxes, and there was no evidence of such mudflat expansion.

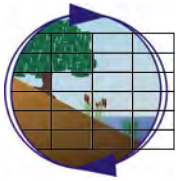
After the first three years of monitoring it is clear that near term annual shifts in habitat distribution will be subtle and on a small scale, but will be useful to track as indicators of change in physical conditions. Due to the issues that have arisen from manually georeferencing the aerial photo tiles in Years 2 and 3 (an orthophoto was collected in Year 1), it is recommended that the aerial imagery collected in Years 5 and 8 be orthophotos. The effort comes at additional cost, but may be necessary to track small-scale habitat changes within UNB. The rectification process used to create an orthophoto removes the effects of camera tilt, terrain relief, and lens distortion, providing an image with uniform scale from which highly accurate area measurements can be made.

Question #4 posed in Section 1.3 was as follows: *Has the project resulted in increased eelgrass survival in the upper bay?* The only persistent eelgrass bed in UNB, described above off of DeAnza Peninsula, appeared to have expanded from 2010 to 2012. A sidescan sonar survey conducted in September 2010 mapped approximately 160 square meters (0.04 acre) (M&A 2010), while the Year 2 (2012) survey, using an aerial mapping technique, known to underestimate eelgrass bed size, found more than three times as much (544 square meters) eelgrass present (M&A 2014). An estimated 2,307 square meters (0.57 acre) of eelgrass was mapped in 2013 from the aerial, reflecting a considerable expansion of the bed following the 2012 transplant work. The transplant complicates efforts to link the expansion of the eelgrass bed to improvements in water quality associated with the restoration.

To achieve accurate and efficient surveillance for eelgrass elsewhere in UNB, a more sophisticated survey technique would need to be employed. If such a program were implemented, Question #4 could be more precisely addressed.

The other peripheral habitats presented in Table 3 were largely unchanged between 2011 and 2013. As described above, very small changes in coverage are largely attributable to the slight shifts in the aerial image under the geographically fixed survey boundary.





Comparison of Habitat Distributions Between Year 1 (2011), Year 2 (2012), and Year 3 (2013)

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 3

Figure 7

4.0 RECOMMENDATIONS

The following recommendations are made based on the monitoring work reported on above and are intended to improve the continuity of data collection as the monitoring is transferred to CDFW and the County of Orange in Year 4 for initiation of monitoring in Year 5. More comprehensive recommendations relating to the more expansive monitoring program tasks performed in Year 2 were provided in the Year 2 annual report (M&A 2014).

- Future aerial imagery for vegetation monitoring should be collected as orthophotos to allow more precise tracking of the small-scale shifts observed in the distribution of habitats in UNB.
- The Year 5 and 8 vegetation monitoring should incorporate the GIS files developed to date into the continuing habitat mapping process, including the survey boundary polygon, annual habitat shape files, and vegetation transect point files.
- For consistency, the lower edge of the mudflat should continue to be delineated using the bathymetric contour (–1.54-foot MLLW) methodologies applied previously. Although the designation is unconventional, it was the basis for developing restoration objectives and for generating the only baseline data on mudflat distribution available. The bathymetry should be adequately expansive to capture this contour in future monitoring years.
- To accurately map the extent of the eelgrass bed off DeAnza Peninsula and to detect any additional eelgrass that may have become established elsewhere in UNB as a result of water quality improvements from the restoration, a sidescan sonar survey of the UNB channel could be performed. Interferometric sidescan sonar may be used to accomplish both the eelgrass and the bathymetric data collection, or multibeam sonar coupled with conventional sidescan sonar may be used to achieve these two goals.

5.0 SUMMARY

Year 3 post-restoration monitoring was limited primarily to bathymetric and habitat investigations, which found that the basins continue to function as designed to trap incoming sediment and organic debris. The two least tern nesting islands remain protected from mammalian predators by the channels around them. The most significant habitat change was the infill of two created mudflats by salt marsh and the minor expansion of the lower edge of the salt marsh to a slightly lower elevation, resulting in more salt marsh and less mudflat in UNB.

The more expansive monitoring effort undertaken in Year 2 will be repeated in Year 5 (2015) by the County of Orange in partnership with CDFW, with more limited monitoring in Years 8 (2018) and 10 (2020), to continue tracking the condition of UNB and its resources post-restoration.

6.0 REFERENCES

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Appendix A

Upper Newport Bay Ecosystem Restoration Project Features and Summary

Retrieved from http://www.newportbeachca.gov/index.aspx?page=115

Document entitled Project Completion Summary Report 11/2010

Upper Newport Bay Ecosystem Restoration
Project Features

Upper Newport Bay Ecosystem Restoration

14 October 2010 Project Summary

- Period of Contractual Construction: November 2005 to October 2010
- Period of Dredging Construction: April 2006 to September 2010
- 2.35 million cubic yards (mcy) dredged, 2.2 mcy removed from the bay and 0.15 placed in-bay
- Constructed the following:
    - Widened and deepened 2 Sediment Control Basins (Unit II and Unit I/III)
    - Deepened 5 shallow island restoration channels (Shellmaker Island, Middle Island, New Island, Hotdog Tern Island, and New Least Tern Island)
    - Created 3 mudflats (Shellmaker, 23rd Street, Bullnose West)
    - Relocated 1 tern nesting island
    - Provided maintenance access to 2 nesting islands (New Least Tern and Hotdog)
    - Provided interpretive signs and buoys
- Phase 1 Contractor was DD-M Crane and Rigging dredged 1.737 mcy from April 2006 to July 2009
- Phase 2 Contractor was RDA, Contracting Inc. dredged 613 kcy from January 2010 to September 2010
- 1.05 mcy removed from Unit II Basin (DD-M Phase 1 removed 865 kcy; RDA Phase 2 removed 186 kcy)
- 905 kcy removed from Unit I/III Basin (DD-M Phase 1 removed 494 kcy; RDA Phase 2 removed 411 kcy)
- 92% disposed offshore at LA3 and 1% nearshore at Newport Beach
- 7% disposed in-bay for construction of nesting islands
- Approximately 5,000 tug and scow trips passed underneath PCH without incident (from 1,685 DD-M tug and scow trips to LA3, 680 RDA tug and scow trips to LA3 and numerous tug and scow maneuvers)
- 2 to 4 scows were in use at any one time for construction, 7 different scows ranging from 1000 cy capacity to 3000 cy capacity
- 2 tugs
- Staging areas were Lower Castaways and Northstar Beach
- 1,558,000 cy were disposed at LA3 under Phase 1, 565 days of actual dredging for an average production of 2,750 cy per dredge day, over a period of 1,183 days. Primary dredge was a 5 cy clamshell bucket mounted on the CB-3 Crane Barge, with some of the dredging performed by 10-inch hydraulic dredge “Pelican”.
- 613,000 cy were disposed at LA3 under Phase 2, 175 days of actual dredging for an average production of 3,500 cy per dredge day, over a period of 240 days. Primary dredge was a Cat 385 excavator mounted on the CB-3 Crane Barge, with a minor amount of dredging performed by 10-inch hydraulic dredge “Pelican”.
- An amphibious excavator was used to: complete the shallow dredging at Middle Island and Shellmaker Island Restoration Channels; construct the maintenance access ramps at New Least Tern Island and Hotdog Tern Island; and excavate the Skimmer Island to mudflat elevation. In December 2009 there was an incident where the excavator, while being parked on the mudflat for the day, turned over into the bay. No injuries and no environmental damage occurred. It took a few days to bring the excavator upright.

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
April 2006 to September 2010
TOTAL

FEATURE	START	FINISH	Volume Removed CM	Placed LA-3 CM	Placed Nearshore CM	Placed NLTI/Pit CM	Hotdog Tern Island	Scow Volume CM	e-trac report
Access Channel Between PCH and Unit II Basin	Apr-06	Sep-10	5,800	5,800				15,467	
Northstar Beach Wetland Restoration	Feature not built per County request		na						
Shellmaker Island Wetland Restoration	Feb-07	May-08	39,400	0		33,700	5,700		
Shellmaker Island Restoration Channel	May-06	Jun-06	9,700	9,700				8,318	
Middle Island Restoration Channel	May-06	May-06	9,600	9,600				11,148	
Access Channel to 23rd Street Wetland Restoration	Apr-07	Apr-07	4,600	4,600				4,752	
23rd Street Wetland Restoration	Aug-07	Mar-08	98,200	20,000		62,200		38,305	
Rev A Nearshore	Mar-08	Apr-08			15,000			20,479	
Rev B Nearshore	May-08	May-08			1,000			1,270	
New Island Restoration Channel	Jun-06	Jul-06	16,800	16,800				9,230	
Unit II Basin	Jun-06	Sep-10	803,860	803,860				796,778	
Access Channel to New Least Tern Island Pit	Jun-06	Jun-06	3,000	3,000					
New Least Tern Island Pit	Jun-06	Feb-07	74,600	74,600				69,113	
New Least Tern Island	Feb-07	Mar-08	na						
Segment Main Dike	Jun-07	Oct-07	900			900			
Cordgrass Transplant	Nov-09	Nov-09	na						
New Least Tern Island Channel	Jan-10	Jan-10	11,000	11,000					
New Least Tern Island Ramp	Jan-10	Jan-10	na						
Access Channel Between Unit II and Unit I/III	Feb-07	Apr-07	1,060	1,060				part of Unit I/III S	
Bullnose Access	Apr-07	Apr-07	1,800	1,800				2,485	
Bullnose West Wetland Restoration	Feb-07	Nov-07	18,100			18,100			
Hotdog Tern Island Restoration Channel	Feb-07	Apr-07	6,400	6,400				7,552	
Hotdog Tern Island Sand/Shell Layer	Mar-07	Apr-07	na						
Hotdog Tern Island Maintenance Access Ramp	Mar-10	Mar-10	na						
Unit I/III Basin	Feb-07	Sep-10	691,680	691,680				661,698	
Cubic Meters			1,796,500	1,659,900	16,000	120,600	<-------	1,624,846	1,946,239
		check	1,796,500					1,632,098	
Cubic Yards	0.764555		2,349,733	2,171,067	20,927	157,739		2,125,218	2,545,584
			Volume Removed	LA-3	Nearshore	In-Bay		Scow	e-Trac
Cubic Yards, Rounded			2,349,700	2,171,100	20,900	157,700		2,125,200	2,545,600
Disposal Percentage of Total Removed				92%	1%	7%			8%

Note: September 2000 Feasibility Study estimated the total volume of material to be dredged from the Upper Bay would be approximately 2.1 million cubic yards, and initial construction would take 2 years. The project was dredged in two phases, taking close to five years, and 2.35 million cubic yards were dredged and placed at LA3, Nearshore and In-Bay.
2,190,000 cubic yards were removed from the bay
158,000 cubic yards were placed in the bay

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
April 2006 to July 2009
PHASE 1

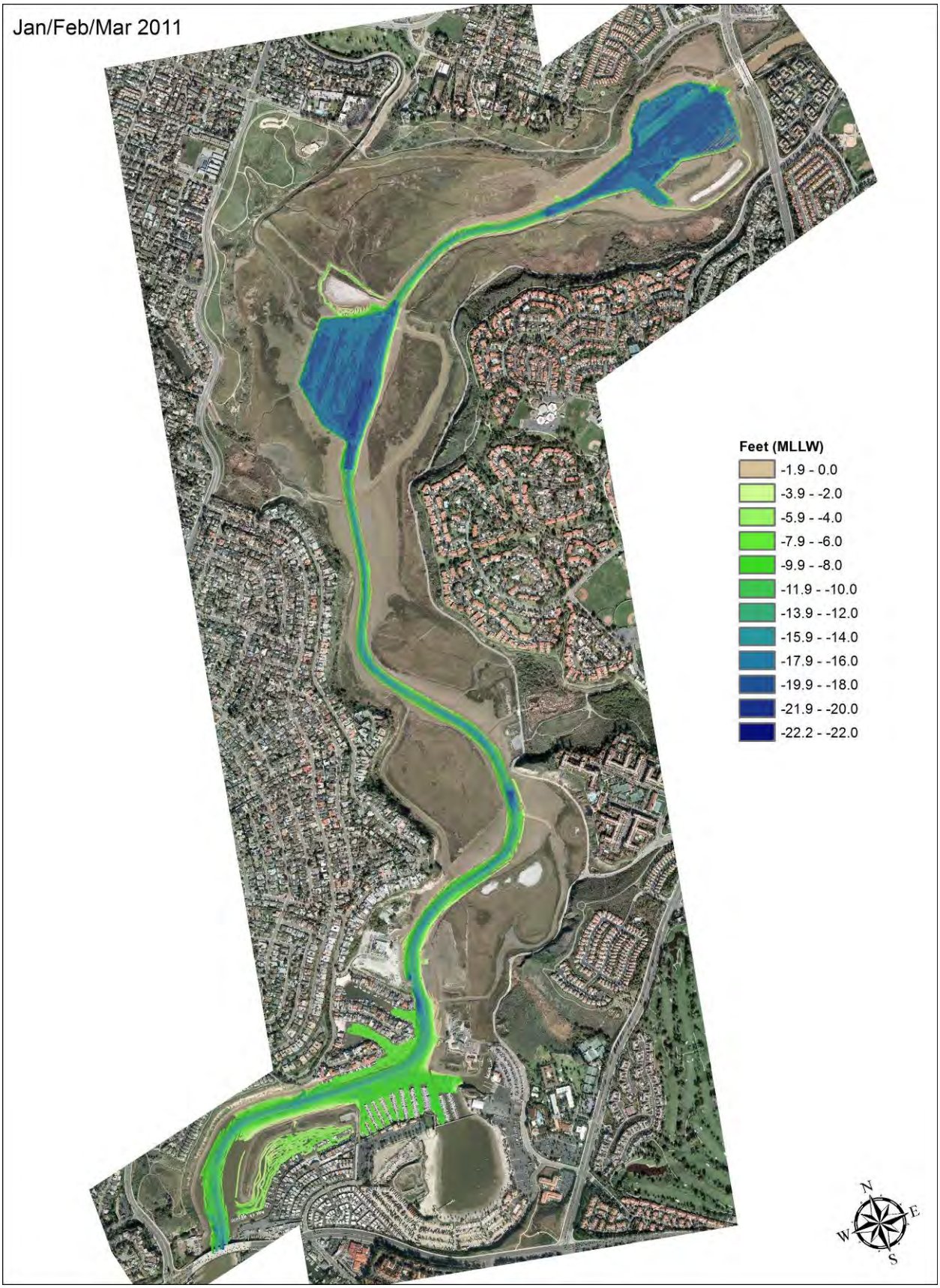
FEATURE	START	FINISH	Bid Volume CM	Volume Removed CM	Placed LA-3 CM	Placed Nearshore CM	Placed NLTI/Pit CM	Hotdog Tern Island	Scow Volume CM	e-Trac START	e-Trac FINISH	e-Trac Approx. Volume
Access Channel Between PCH and Unit II Basin	Apr-06	May-06	Lump Sum	5,800	5,800				15,467	Apr-06	Jul-06	89,720
Northstar Beach Wetland Restoration	Feature not built per County request		NA	NA	NA					Sep-06	Jun-07	515,050
Shellmaker Island Wetland Restoration	Feb-07	May-08	Lump Sum	39,400	0		33,700	5,700		Jun-07	Apr-08	500,400
Shellmaker Island Restoration Channel	May-06	Jun-06	Lump Sum	9,700	9,700				8,318	May-08	Aug-08	127,000
Middle Island Restoration Channel	May-06	May-06	Lump Sum	9,600	9,600				11,148	Mar-09	Jul-09	149,850
Access Channel to 23rd Street Wetland Restoration	Apr-07	Apr-07	Lump Sum	4,600	4,600				4,752			
23rd Street Wetland Restoration	Aug-07	Mar-08	124,906	98,200	20,000		62,200		38,305			
Rev A Nearshore	Mar-08	Apr-08				15,000			20,479			
Rev B Nearshore	May-08	May-08				1,000			1,270			
New Island Restoration Channel	Jun-06	Jul-06	Lump Sum	16,800	16,800				9,230			
Unit II Basin Base + Option + Santa Ana Delhi Channel	Jun-06	Jan-08	678,811	661,800	661,800				656,832			
Base			144,543	114,500					122,587			
Option 1			172,299	181,800					534,245			
Option 2			361,969	363,900								
Santa Ana Delhi Channel			part of Options	1,600								
Access Channel to New Least Tern Island Pit	Jun-06	Jun-06	Lump Sum	3,000	3,000							
New Least Tern Island Pit	Jun-06	Feb-07	74,626	74,600	74,600				69,113			
New Least Tern Island	Feb-07	Mar-08	NA	NA								
Segment Main Dike	Jun-07	Oct-07	part of Bullnose	900			900					
Access Channel Between Unit II and Unit I/III	Feb-07	Apr-07	Lump Sum	0	0							
Bullnose Access	Apr-07	Apr-07	part of Bullnose	1,800	1,800				2,485			
Bullnose West Wetland Restoration	Feb-07	Nov-07	19,994	18,100			18,100					
Hotdog Tern Island Restoration Channel	Feb-07	Apr-07	Lump Sum	6,400	6,400				7,552			
Hotdog Tern Island Sand/Shell Layer	Mar-07	Apr-07	part of Bullnose		0		NA					
Unit I/III Basin + Modifications	Feb-07	Jul-09	379,149	377,300	377,300				354,438			
Base			111,149	140,500								
Mod Phase 1			150,000	153,600								
Mod Phase 2			40,000	40,000								
Mod CLIN 42 & 43			78,000	43,200								
Cubic Meters			1,277,486	1,328,000	1,191,400	16,000	120,600	<-------	1,177,640			1,382,020
		check		1,328,000					1,177,639			
Cubic Yards	0.764555		1,670,888	1,736,958	1,558,292	20,927	157,739		1,540,295			1,807,614
			Bid Volume	Volume Removed	LA-3	Nearshore	In-Bay		Scow			e-Trac
Cubic Yards, Rounded			1,670,900	1,737,000	1,558,300	20,900	157,700		1,540,300			1,807,600
Disposal Percentage of Total Removed				100%	90%	1%	9%					4%

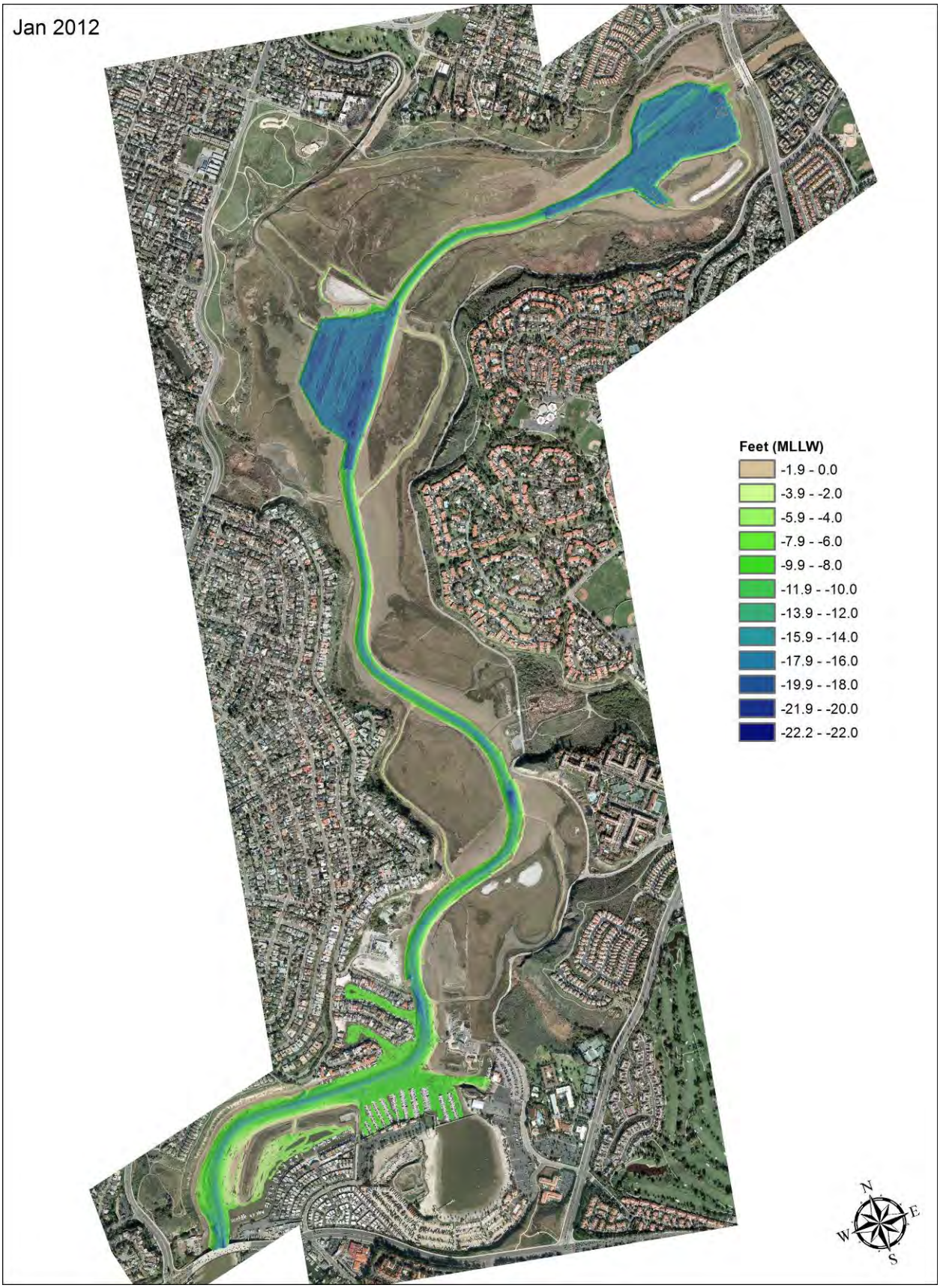
UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT 10/13/2010
September 2009 thru September 2010
PHASE 2

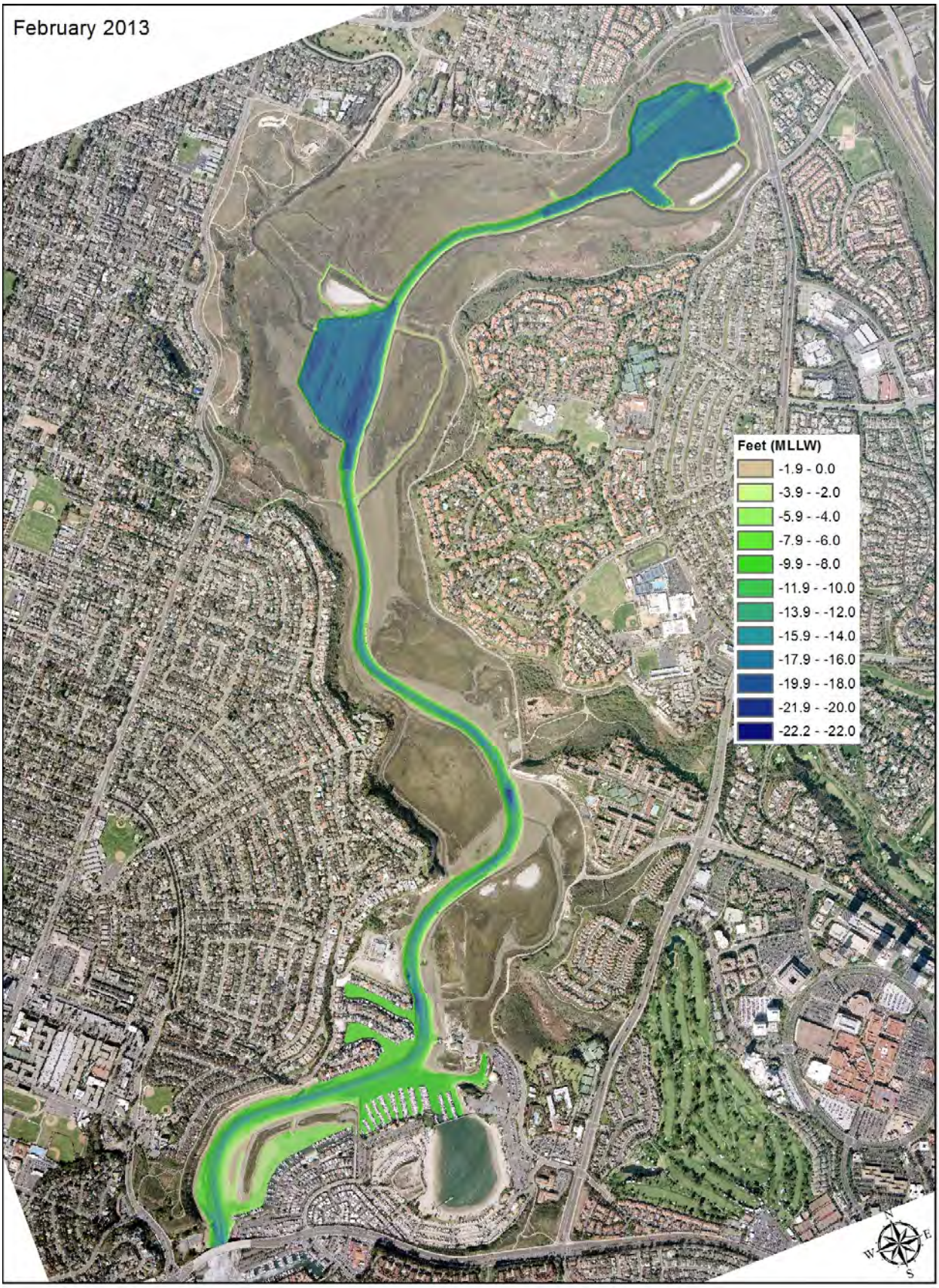
FEATURE	START	FINISH	Bid Volume CM	Approximate Volume Removed CM	Placed LA-3 CM	Scow Volume		
Access Channel Between PCH and Unit II Basin	na	na	na	na	na	na		
Cordgrass Transplant	Nov-10	Nov-10	na	na	na	na		
New Least Tern Island Channel	Jan-10	Jan-10	Lump Sum	11,000	11,000	7,252		
New Least Tern Island Ramp	Jan-10	Jan-10	na	na	na	na		
Top of Skimmer Island	Dec-10	Mar-10	10,600	10,600	10,600	part of Unit I/III S		
Southern Unit I/III Basin	Jan-10	Jun-10	225,000	235,836	235,836	256,788		
Additional Southern Unit I/III Basin, Closeout Phase 1	Jan-10	Feb-10	Phase 1	17,944	17,944	part of Unit I/III S		
Northern Unit I/III Basin	Jun-10	Jul-10	50,000	50,000	50,000	50,472		
Access Channel Between Unit II and Unit I/III	Mar-10	Mar-10	Lump Sum	1,060	1,060	part of Unit I/III S		
Unit II Basin	Jul-10	Aug-10	140,000	142,060	142,060	139,946		
Hotdog Tern Island Ramp	Mar-10	Mar-10	na	na	na	na		
Cubic Meters			425,600	468,500	468,500	454,458	564,219	
		check		468,500				
Cubic Yards	0.764555		556,664	612,775	612,775	594,409	737,970	
			Bid Volume	Volume Removed	LA-3	Scow	e-Trac	
Cubic Yards, Rounded				613,000	613,000	594,000	738,000	
Disposal Percentage of Total Removed					100%		20%	higher than actual

* Volume included in Phase 1

Appendix B
Bathymetric Plots Enlarged from Figure 2


Jan/Feb/Mar 2011
Feet (MLLW)
-1.9 - 0.0
-3.9 - -2.0
-5.9 - -4.0
-7.9 - -6.0
-9.9 - -8.0
-11.9 - -10.0
-13.9 - -12.0
-15.9 - -14.0
-17.9 - -16.0
-19.9 - -18.0
-21.9 - -20.0
-22.2 - -22.0
N
E
S
W


Jan 2012
Feet (MLLW)
-1.9 - 0.0
-3.9 - -2.0
-5.9 - -4.0
-7.9 - -6.0
-9.9 - -8.0
-11.9 - -10.0
-13.9 - -12.0
-15.9 - -14.0
-17.9 - -16.0
-19.9 - -18.0
-21.9 - -20.0
-22.2 - -22.0
N
E
S
W


February 2013
Feet (MLLW)
-1.9 - 0.0
-3.9 - -2.0
-5.9 - -4.0
-7.9 - -6.0
-9.9 - -8.0
-11.9 - -10.0
-13.9 - -12.0
-15.9 - -14.0
-17.9 - -16.0
-19.9 - -18.0
-21.9 - -20.0
-22.2 - -22.0
N
E
S
W