Memorandum

8 April 2013

To: Marilyn Latta, Project Manager, State Coastal Conservancy

From: Max Busnardo and Gavin Archbald

Subject: Lessons Learned from Construction of California Clapper Rail Earthen High Tide Refuge Islands

H. T Harvey & Associates (HTH) monitored construction of 6 pilot earthen high tide refuge islands (hereafter “earthen islands”) built to enhance California clapper rail (Rallus longirostris obsoletus) habitat. One pilot earthen island was constructed at each of the following locations: (1) Cooley Landing, (2) Belmont Slough South, (3) Belmont Slough North, (4) Bird Island, (5) Bair Island northwest, and (6) MLK/New Marsh (Geographic coordinates provided in Table 1, Appendix A). In this memorandum, we provide a record of construction methods, as-built topographic data, a summary of lessons learned during pilot earthen island construction and illustrative photos (Appendix A). In addition, we include the following products on the CD submitted with this memorandum:

- Photos from fixed photo-point locations with directions to re-occupy photo-points.
- An Excel file with as-built topographic data of earthen islands and excavation areas.
- An Excel file with gumplant (Grindelia stricta) planting measurements.
- A Google Earth KMZ file with earthen island, excavation and elevation control point locations.

Future monitoring will be used to determine gumplant planting success and measure changes in earthen island and excavation area topography.

Construction Timing and Personnel

Construction was carried out between 18 December 2012 and 18 January 2013 by Hanford ARC and Aquatic Resources. The contractors utilized the conceptual design and associated notes provided in Invasive Spartina Project Pilot Earthen Island Construction Notes to Contactors (H. T. Harvey & Associates 2012) as a guide during construction. HTH restoration ecologists M. Busnardo, M.S. and G. Archbald, M.S. monitored the entirety of
the construction effort. HTH’s ecologists were accompanied by at least one ISP biologist, with project-specific clapper rail construction monitoring approval from the U. S. Fish and Wildlife Service.

**As-Built Topography and Settlement**

We measured the topography of earthen islands following construction and found that islands were constructed per the guidelines developed for contractors (H. T. Harvey & Associates 2012) and that settlement (i.e., compaction and sinking) began to occur shortly after island construction at one site. Contractors measured island heights via laser level during and immediately following island construction and HTH restoration ecologists G. Archbald and B. Busnardo observed that islands were built within approximately 0.1 feet (ft) of design elevations (+1.0 ft above MHHW).

To set up a baseline for future monitoring, HTH restoration ecologists measured the topography of constructed islands by taking spot elevations every 3 ft along a transect centered across the long axis of each island. In addition, the depths of excavation areas were measured via laser level. These data were collected within 1-3 days of construction at all sites except for Belmont Slough South. Baseline topography data were collected at this site 13 days following construction due to rains which rendered the laser level inoperable. Baseline elevations were comparable to the design (within approximately 0.1 ft) for the Cooley Landing, Belmont Slough North, Bird Island, Bair Island and MLK Marsh sites. Belmont Slough South measurably settled shortly after construction (Table 1). Belmont Slough South was measured 13 days after construction and had settled nearly -0.5 ft.

### Table 1. Pilot Earthen Island Design and As-built Dimensions

<table>
<thead>
<tr>
<th>Site</th>
<th>Island Height (ft ± standard error) above MHHW</th>
<th>Excavation Depth (ft ± standard error) below MHHW</th>
<th>Impact of Island and Excavation Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
<td>As-built</td>
<td>Design</td>
</tr>
<tr>
<td>Cooley Landing</td>
<td>+1.0</td>
<td>+0.98 ± 0.03</td>
<td>-3.05</td>
</tr>
<tr>
<td>Belmont South</td>
<td>+1.0</td>
<td>+0.48 ± 0.05</td>
<td>-2.99</td>
</tr>
<tr>
<td>Belmont North</td>
<td>+1.0</td>
<td>+1.00 ± 0.03</td>
<td>-2.99</td>
</tr>
<tr>
<td>Bird Island</td>
<td>+1.0</td>
<td>+0.90 ± 0.05</td>
<td>-3.42</td>
</tr>
<tr>
<td>Bair Island NW</td>
<td>+1.0</td>
<td>+0.88 ± 0.06</td>
<td>-3.08</td>
</tr>
<tr>
<td>MLK/ New Marsh</td>
<td>+1.0</td>
<td>+0.87 ± 0.05</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Belmont South topography survey was measured 13 days after island construction.

**Project Impacts**

Project permits require that total tidal marsh impacts within the footprints of excavation and island fill be no more than 504 square feet (ft²) per island (or 3028 ft² for 6 pilot islands). The total impacts of the 6 pilot islands (fill and excavation areas) totaled 2600 ft², less than the permitted amount of 3028 ft² (Table 2).
Lesson Learned

We evaluated the efficiency of construction of earthen islands via manual and mechanized equipment; and noted a number of opportunities to reduce marsh impacts during construction and to increase successful vegetation establishment on earthen islands. We recommend that these lessons learned be incorporated into a revised version of the Invasive *Spartina* Project Pilot Earthen Island Construction Notes to Contractors (H. T. Harvey & Associates 2012).

Efficiency of Construction Methods- Manual versus Mechanized Equipment

Both contractors used shovels to remove marsh sod from the excavation and island fill sites (Appendix A, Photos A-1 and A-2); however, Hanford ARC excavated fill for island construction using shovels and manual labor while Aquatic resources excavated fill for island construction using a mechanized Marsh Master (Table 2; Photos A-3 and A-4). During excavation, both contractors used wheel barrows to transport excavated mud to the island fill locations and both contractors built islands via manual shovel work (Photos A-5 and A-6). At MLK/New Marsh, soil was not excavated; soil was brought in by truck (Photo A-7). Both contractors placed marsh sod on earthen islands by hand (Photo A-8) and planted the earthen islands with gumplant (*Grindelia stricta*) and saltgrass (*Distichlis spicata*) on the second day of island construction (Photo A-9). The Marsh Master was limited to excavation only because Olofson Environmental, HTH and the Coastal Conservancy agreed that the marsh plain would be severely damaged if the vehicle repeatedly maneuvered between the excavation and island fill areas.

To help the Coastal Conservancy compare the efficiency of the construction methods used, we recorded in the field the time each contractor spent per island excavating sediment relative to the island fill height (Table 2). Island fill height provides a rough relative approximation of the amount of sediment required to build each earthen island. The Marsh Master took longer (4.1 hours) than manual labor (3.2 hours) to excavate a similar average volume of sediment (Table 2).

Moreover, mobilization primarily in the transportation of the Marsh Master to and from the sites took additional time not shown in Table 2 and was constrained by the tides. Aquatic Environments deployed the Marsh Master during the peak of the higher high tides to facilitate access to the marsh plain. Even with higher high tide deployment, at the Bair Island site, Aquatic Environments had difficulty getting the Marsh Master across the steep side slope of a large slough channel and up onto the marsh plain. Aquatic Environments had to expend extra time and effort using an airboat and rope to pull the Marsh Master onto the marsh plain at this site (Drew Kerr, pers. comm. 2013).

Given the above observations, we recommend the use of manual labor for subsequent earthen island construction.
Table 2. Pilot Earthen Island Construction Details

<table>
<thead>
<tr>
<th>Site</th>
<th>Construction Dates</th>
<th>Contractor</th>
<th>Crew Size</th>
<th>Excavation Method</th>
<th>Excavation Time (hours)</th>
<th>Island Fill Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooley Landing</td>
<td>18, 19 Dec 2012</td>
<td>Hanford AR</td>
<td>6</td>
<td>Manual</td>
<td>3.25</td>
<td>1.55</td>
</tr>
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<td>Belmont South</td>
<td>20, 21 Dec 2012</td>
<td>Hanford ARC</td>
<td>6</td>
<td>Manual</td>
<td>2.75</td>
<td>2.00</td>
</tr>
<tr>
<td>Belmont North</td>
<td>3, 4 Jan 2013</td>
<td>Hanford ARC</td>
<td>6</td>
<td>Manual</td>
<td>3.50</td>
<td>1.99</td>
</tr>
<tr>
<td>Bird Island</td>
<td>7, 10 Jan 2013</td>
<td>Aquatic Resource</td>
<td>7</td>
<td>Marsh Master</td>
<td>4.00</td>
<td>1.73</td>
</tr>
<tr>
<td>Bair Island NW</td>
<td>8, 9 Jan 2013</td>
<td>Aquatic Resources</td>
<td>6</td>
<td>Marsh Master</td>
<td>4.25</td>
<td>1.99</td>
</tr>
<tr>
<td>MLK/ New Marsh</td>
<td>17, 18 Jan 2013</td>
<td>Hanford ARC</td>
<td>4</td>
<td>Soil trucked in</td>
<td>NA (2.0 to fill)</td>
<td>1.96</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td>Manual</td>
<td>3.2</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Marsh Master</td>
<td>4.1</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Efficiency of Construction Methods: Access by Boat versus by Land

Earthen Island construction mobilization times differed by whether sites required access via boat or were accessible by land. It took Hanford ARC about 1.5 days to construct and plant earthen islands at Cooley Island, Belmont Slough South, Belmont Slough North and Cooley Landing. These sites were accessible from land and were accessed by walking through the marsh. It took Aquatic Resources about 2 days per earthen island at the Bird Island and Bair Island Northwest sites, which required transport of crew and equipment to and from construction sites via boat. Additional mobilization time associated with transporting the Marsh Master to, from and between sites was not observed by HTH and is not included in this comparison.

Protect Existing Marsh Vegetation

More care should be taken to protect existing marsh vegetation during construction of earthen islands. Workers and ecologists caused damage to vegetation by trampling during construction. In some locations, particularly in the areas immediately around earthen islands and excavation areas, marsh vegetation root structure was damaged when walking punctured the marsh surface (Photo A-10). Damage to existing vegetation also occurred where the treaded truck made sharp turns during soil delivery to the island site at MLK/ New Marsh (Photo A-11).

Marsh vegetation was effectively protected when contractors placed plywood over vegetation prior to construction. Contractors should place plywood or functionally equivalent material in all areas of repeated foot traffic including the entire perimeter of the island fill and excavation sites. If plywood is used, the plywood surface should be modified to improve traction for workers (e.g., by securing lathe via screws to plywood). Plywood or an equivalent material should be placed in areas where vehicles turn around (Photo A-12) and where materials are staged and/or stockpiled.

Additionally, care should be taken to stay outside of the fill and excavation areas to protect marsh sod prior to and during sod harvest.
**Consider Adjusting Island Design Elevations**

It is anticipated that island elevations will decrease due to settlement. Island elevations were designed to account for some settlement and still provide sufficient high tide refugia cover during peak high tides. As settlement is monitored, the design elevation should be reconsidered if settlement is likely to reduce island heights to MHHW or lower. Assuming planted gumplant grows 3 ft tall on island tops, if island tops are below MHHW, gumplant would likely be covered by water during an estimated 100 year tide (US Army Corps of Engineers 1984). However, building islands too high may result in acidic soils and/or ecotone weed invasions. These trade-offs should be considered following monitoring of pilot island topography and prior to construction of the remaining earthen islands.

**Select Well-Drained Areas for Construction Close to Channel Edges**

We recommend constructing future earthen island sites from and on well-drained marsh sediments to enhance island stability. At Belmont Slough South, for example, both the island fill site and the excavation area were quite wet and less consolidated that at other sites (Photo A-13). This may lead to greater settlement of excavated material and sinking into marsh sediments under the weight of the constructed island. In addition, marsh islands should be placed as close to channel edges as possible to mimic locations of natural high elevation gumplant lined marsh channels, while still allowing access to the island for construction.

**Access Marsh Sites via Boat**

Marsh vegetation was disturbed least when sites were accessed by airboat. Walking to and from earthen island sites, particularly in saturated areas, lead to incised trails. This could be avoided by transporting crew and equipment (including plywood or equivalent) via airboat to construction sites. This, however, would limit construction to sites readily accessible via airboat (i.e., sites with large channels or extensive mudflat adjacent to the construction location). If sites are accessed by foot, channels were affectively crossed via the construction of temporary bridges using joined 2’ x 12’ planks anchored in place with metal rods (Photo A-14).

**Sod Excavation, Storage, and Placement**

Flat head spade (versus rounded) shovels were particularly effective at removing sod (Photo A-15). Workers using straight edged spades can (1) cut square pieces of sod and (2) harvest sod at a consistent depth. Uniform, straight edge sod pieces fit together more closely during placement on earthen islands, thereby improving the ability of sod to retain moisture. Sod should be temporarily stored on geotextile fabric to protect underlying, in-situ marsh vegetation. In addition, sod should be stacked no more than one sod piece deep during stockpiling prior to placement on an earthen island (Photo A-16). This prevents damage to sod vegetation. Sod should be handled with care transport from excavation areas to storage areas and from storage areas to placement areas.
Care should be taken fit sod pieces together tightly by hand. This works best with uniform size sod pieces. Small sod pieces should be used to fill all gaps between sod pieces following planting to help with moisture retention.

Sod should be placed at the top of the island first and then planted before placing sod on side slopes. During sod placement and planting on island tops, plywood can be used to protect the shape of earthen island side slopes. Material (e.g., wood strips) should be secured to plywood to increase grip. Once the top is covered with sod and planted, side slopes should be planted (Photo A-17).

**Planting**

Plants should be carefully transported to island sites (e.g., carried to the island site without holding plants by their stems). Plastic sleds were useful to transport plants to the site without damaging plant material. When planning 1-gallon containers, a post-hole digger is the appropriate width and shape to cut into marsh sod without damaging more sod vegetation then necessary. A wide shovel should not be used as this results in excess damage to marsh sod.

**References**


**Personal Communications**

Appendix A. Photos to Exemplify Lessons Learned

Photo A-1. Both contractors removed marsh sod by shovel (Photo from Belmont Slough South)

Photo A-2. After excavation, sod was temporarily stored for later use (Photo from Belmont Slough North)
Photo A-3. Aquatic Environments excavated sediment to build the earthen island using a mechanized Marsh Master (Photo from Bair Island North)

Photo A-4. Hanford ARC excavated sediment to build the earthen island using shovels (Photo from Belmont Slough South)
Photo A-5. Both contractors transported sediment from the excavation area to the earthen island fill site by wheelbarrow (Photo from Belmont Slough South)

Photo A-6. Both contractors formed and shaped earthen islands via manual shovel work (Photo from Belmont Slough South)
Photo A-7. Terrestrial soil was brought in to MLK/New Marsh via truck (Photo from MLK/New Marsh).

Photo A-8. Marsh sod was placed on earthen islands by hand (Photo from Belmont Slough South)
Photo A-9. Gumplant and saltgrass were planted on the tops and side slopes of earthen islands (Photo from Cooley Landing)

Photo A-10. Impact to marsh vegetation from walking around earthen islands were considerably greater in areas where plywood was not placed for protection (Photo from Belmont Slough North)
Photo A-11. Impacts to marsh vegetation of a tracked dump truck transporting soil to MLK/ New Marsh

Photo A-12. Impacts from tracked dump truck transport of soil could be reduced by placing plywood or equivalent material in locations where vehicles turn around (Photo from MLK/ New Marsh)
Photo A-13. Saturated sediment conditions at the earthen island fill location at Belmont Slough South made construction more difficult and may increase island settlement. Building with and on saturated sediments should be avoided.

Photo A-14. Wooden 2” x 12” wooden planks were effectively used to cross tidal channels (Photo from Belmont Slough North)
Photo A-15. Flat edged shovels allowed for square sod pieces to be cut which improved fit of sod pieces during placement on earthen islands (Photo from Belmont Slough South)

Photo A-16. Sod should not be stacked to avoid damage to sod vegetation (Photo from Bird Island)
Photo A-17. Sod should be placed and container plants planted at the top of the island prior to sod placement on earthen island side slopes to reduce trampling of sod during planting (Photo from Belmont Slough North)