Feather River Levee Repair Project
Levee Segment 2
Construction Completion Report
Addendum No. 2
Vegetated Wave Buffer
January 2012
Prepared for:
Three Rivers Levee Improvement Authority
Prepared By:
Planted By:
River Partners
Feather River Levee Repair Project
Levee Segment 2

Construction Completion Report

Addendum No. 2
Vegetated Wave Buffer

Planted by: River Partners

Prepared for: Three Rivers Levee Improvement Authority
Prepared by: MBK Engineers

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Figure 1 – Location and Extent of the Vegetated Wave Buffer

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1.0 Introduction

1.1 Summary

This addendum summarizes the activities for Three Rivers Levee Improvement Authority’s (TRLIA) Phase 4 Feather River Levee Repair Project, Segment 2 – Vegetated Wave Buffer, between Station 70+00 and 300+00. This design feature was implemented subsequent to completion of the Phase 4 Feather River Levee Repair Project Levee Segment 2, which is referred to as the “Project.” Thus, this document has been prepared as an addendum to the Feather River Levee Repair Project; Levee Segment 2 Construction Completion Report dated May 2010. Please refer to the May 2010 Construction Completion Report for information regarding the original levee construction work completed for the Project.

This addendum refers to plantings at the waterside levee toe of a 23,000-foot-long reach between Stations 70+00 and 300+00 as the “Vegetated Wave Buffer”, see Figure 1. This addendum provides (1) a general background and overview of the Vegetated Wave Buffer (2) implementation approach and methodologies, (3) implementation costs, (4) a photographic record of the final plantings, and (5) planting schematics. Vegetated Wave Buffer implementation, in general, consisted of planting 6 rows of varied riparian vegetation in a 100 foot wide strip beginning 70 feet from the waterside levee toe to provide erosion protection to the waterside levee slope from wind generated waves. Implementation efforts included (1) preparation of ground for planting, (2) installation of irrigation system (3) planting of vegetation, and (4) irrigation and maintenance of plantings for 3 years to establish vegetation (ongoing). A contract for the planting of the Vegetated Wave Buffer was awarded to River Partners of Chico, California on July 27, 2010. Contract work started April 11, 2011 and planting was completed June 17, 2011. Establishment maintenance and irrigation will continue until September 30, 2013. River Partners was the Vegetated Wave Buffer designer. Handen Company of Rancho Cordova, California was the Owner’s Engineer providing planting management and contract administration.

1.2 Background

Trees and thick brush growing in the floodplain (waterside of the levee) have a mitigating effect on the wave action on the levee. Typical riparian vegetation and orchards in the vicinity of the Feather and Bear River levees have a thick canopy that extends at and above the water surface. The trees and tall vegetation buffer wave action by obstructing and impeding wave travel and dissipating wave energy. These effects result in smaller-than-calculated waves reaching the levee and consequently a smaller-than-calculated wave runup and less wave erosion. The calculation of wave runup comes into play in determining freeboard requirements and final levee height. Waves breaking on a levee slope can cause erosion damage that has to be repaired after the storm.
There is no theoretical guidance in the technical literature for a vegetation correction factor to reduce the calculated wave runup, but recent project studies in the Sacramento River watershed have made empirical corrections to account for this effect:

- The Sacramento District of the U.S. Army Corps of Engineers (Natomas General Re-Evaluation Report Wave Runup Analysis, Draft Revised May 2006) estimated vegetation correction factors based on field inspection at the various points of analysis. Factors used ranged from 1.0 (no correction) to 0.2 for areas where the vegetation growing on the levee is so dense that wave action along the fetch will have little effect. The average of the 17 values of the correction factor used in this study was 0.66.
- Mead & Hunt (Wind Setup and Wave Runup Analysis for Natomas Levee Improvement Program, prepared for SAFCA, Draft May 2007) performed a visual evaluation of aerial images of the levees and classified vegetal cover into three categories – none, normal, and high – and assigned corresponding reduction factors of 1.0, 0.75, and 0.6. The average of the 31 values of the correction factor used in their study was 0.75.
- GEI Consultants and HDR (Feather River Setback Levee Design Report, Appendix C, prepared for TRLIA, January 2008) estimated a vegetation correction factor of 0.5 based on field observations of wind wave action along the Feather and Bear River levees during the high-water event of January 1, 2006.

In designing the Feather River Setback Levee, a correction factor was applied to the wave runup to account for the beneficial existence of current floodplain vegetation. The design assumed that there would be trees waterside of the levee (such as the existing orchards, or vegetation similar to the riparian vegetation that grows along the levee in Segment 1) and incorporated a vegetation correction factor, leading to lower freeboard requirements and levee height than would have been required otherwise. The average vegetation correction factor of 0.66 used by the Corps of Engineers in Natomas was adopted for the Feather River Setback Levee design (Feather River Setback Levee Design Report, Appendix C, prepared for TRLIA, January 2008).

At the time of the design it was assumed that at a minimum a linear strip of the existing orchards would be left in front of the setback levee. As acquisition negotiations proceeded with some land owners, some of these orchards were completely removed to reduce concern with agricultural pests that can infest non-maintained orchards. The complete removal of the orchards changed the original design assumption for wave runup. Fortunately the walnut trees in the southern third of the setback levee are in active orchards and were left in place. The need for buffering floodplain vegetation is most critical along the southernmost half of the levee, which is exposed to a larger fetch, has less freeboard, and is aligned at a more unfavorable angle with respect to the fetch than the northern half of the levee.

The vegetated wave buffer is a project design feature intended to reduce the overall wave action and erosion that could potentially occur on the waterside of the new setback levee. The design includes a 100-foot-wide buffer of plantings beginning at the edge of the 70-foot waterside toe access corridor of the new levee. The buffer would exist all along the setback levee for a length of approximately 30,000 feet. It is estimated that this design feature will include 70 acres of plantings within the setback area. Ultimate tree density is determined by a planting matrix of six
rows (20-feet apart) with plant spacing of 10 feet between plants in the rows. Not all 70 acres will need to be planted, since currently about one half of the buffer zone is currently planted in orchards. While the plantings could consist of any large canopy trees and associated shrubs, the buffer does offer the opportunity to restore some riparian habitat in this stretch of floodway.

Proposed riparian plant species and density per acre consist of the following (*scientific name*):

- **Box Elder** (*Acer negundo*) 26 per acre
- **Coyote Bush** (*Baccharis pilularis*) 26 per acre
- **Fremont Cottonwood** (*Populus fremontii*) 39 per acre
- **Oregon Ash** (*Fraxinus latifolia*) 22 per acre
- **Western Sycamore** (*Platanus racemosa*) 30 per acre
- **Wild Rose** (*Rosa californica*) 35 per acre
- **Arroyo willow** (*Salix lasiolepis*) 30 per acre
- **Black willow** (*Salix nigra*) 26 per acre
- **Sandbar willow** (*Salix exigua*) 26 per acre

Total of 260 Plants per acre

A typical planting tile and cross section is shown on Figure 2.

After planting, the vegetation will be maintained for at least three years to ensure establishment of the plants. Maintenance will consist of fertilizing and watering and the control of invasive plant species. In some cases, replanting of the described species may be required due to high mortality of the initial plantings. The planting could occur any time that flood flows are not present in the newly established floodway, but some plantings are best done in the fall and spring during the dormant period for some plants. Where orchards currently exist, no vegetated wave buffer was planted. Should these orchards die or be removed in the future, the buffer will have to be extended to cover these newly exposed reaches.

### 2.0 Environmental, Regulatory and Right of Way Requirements

Project planting activities for the Vegetated Wave Buffer required compliance with several environmental and regulatory permits and property owner agreements described in the May 2010 Construction Completion Report, as well as one additional permit issued by the Central Valley Flood Protection Board.

The following additional permit was issued for the Vegetated Wave Buffer:

Encroachment Permit No. 18556 BD was issued on March 4, 2011 by the Central Valley Flood Protection Board. This permit provided several conditions for implementation and maintenance to minimize the impacts of the Vegetated Wave Buffer on the adjacent levee and surrounding floodway.
3.0 Planting Summary

3.1 Planting Materials

Plants for the Vegetated Wave Buffer were obtained by collecting local seeds and propagating in the River Partners’ nursery, collecting cuttings from local plants and preparing them for planting, and from other local nurseries that specialize in native plant species.

3.2 Plant Quantities

The quantity of each plant placed in the Vegetated Wave Buffer is given in the following table:

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Planted</th>
<th>Survived</th>
<th>% Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box Elder (Acer negundo)</td>
<td>1,308</td>
<td>1,293</td>
<td>99%</td>
</tr>
<tr>
<td>Coyote Bush (Baccharis pilularis)</td>
<td>1,025</td>
<td>851</td>
<td>83%</td>
</tr>
<tr>
<td>Fremont Cottonwood (Populus fremontii)</td>
<td>1,935</td>
<td>981</td>
<td>51%</td>
</tr>
<tr>
<td>Oregon Ash (Fraxinus latifolia)</td>
<td>1,170</td>
<td>1,156</td>
<td>99%</td>
</tr>
<tr>
<td>Western Sycamore (Platanus racemosa)</td>
<td>1,525</td>
<td>1,351</td>
<td>89%</td>
</tr>
<tr>
<td>Wild Rose (Rosa californica)</td>
<td>1,359</td>
<td>1,313</td>
<td>97%</td>
</tr>
<tr>
<td>Arroyo Willow (Salix lasiolepis)</td>
<td>1,298</td>
<td>1,017</td>
<td>78%</td>
</tr>
<tr>
<td>Black willow (Salix nigra)</td>
<td>1,127</td>
<td>849</td>
<td>75%</td>
</tr>
<tr>
<td>Sandbar willow (Salix exigua)</td>
<td>1,103</td>
<td>804</td>
<td>79%</td>
</tr>
</tbody>
</table>

Totals 11,760 9,615 82%

The survivorship is based on a total plant survey taken in August 2011. Survivorship exceeds success criteria for planting establishment.

3.3 Major Planting Components

3.3.1 Ground Preparation

The Contractor cleared, ripped, and disked the planting area. Large roots from existing trees were grubbed and removed from the planting area. Berms were created for the planting rows.

3.3.2 Irrigation Installation

Trenches were dug, mainline pipe placed in the trenches, and the pipe covered. Irrigation drip lines were trenched into the planting rows. The irrigation mainline was connected to an operating well located in the Elderberry Mitigation Area.
3.3.3 Planting
A planting database reflecting the planting tile was created for the Wind Wave Buffer. Plant labels were created and printed for planting. Labels were placed at appropriate locations in the planting area and the area was planted. Not all areas were planted. In some areas existing orchards exist to an extent such that no plantings were necessary or only a partial width (less than 100 feet) of the buffer was planted. These existing orchards serve as the wave buffer. The vegetated wave buffer is to extend from station 6+00 to station 300+00 of the setback levee. The following table shows the reaches planted under this effort.

<table>
<thead>
<tr>
<th>Station Range</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>6+00 to 32+00</td>
<td>Existing orchard, no planting</td>
</tr>
<tr>
<td>32+00 to 46+00</td>
<td>Planted full width</td>
</tr>
<tr>
<td>46+00 to 70+00</td>
<td>Existing orchard, no planting</td>
</tr>
<tr>
<td>70+00 to 226+00</td>
<td>Planted full width</td>
</tr>
<tr>
<td>226+00 to 246+00</td>
<td>Existing orchard, partial width planting</td>
</tr>
<tr>
<td>246+00 to 300+00</td>
<td>Planted full width</td>
</tr>
</tbody>
</table>

Future monitoring of reaches with no plantings or partial plantings will occur to verify that the current orchard conditions condition. Should these orchards be removed or allowed to die, then additional plantings similar to what was done for this effort will have to occur to replace the vegetation necessary to serve as a wave buffer.

3.3.4 Establishment
After planting, weeds are controlled through mowing and placement of herbicide. The plants are irrigated for the first three years to provide enough growth so that the plants can survive on their own.

3.4 Implementation Issues
The low establishment of cottonwoods is most likely due to the delay in obtaining the encroachment permit. This delay caused River Partners to have to hold the native cuttings in cold storage for an extended period of time. During the extended cold storage, many of the cuttings began to bud and/or produce leaves. As budding and leaf growth occurred before they were planted, many of the cuttings died because they were unable to root. As a result, they were unable to intake sufficient nutrients needed for growth and establishment. For optimal results, cuttings should be installed in the early spring before budding occurs in order to ensure that the cuttings can set root. The low survival of cottonwoods will still provide enough of a large tree component in the barrier to act as an effective wave buffer. In addition, cottonwoods frequently recruit on their own in floodways and the number of cottonwoods in the Vegetated Wave Barrier is expected to increase.
4.0 Quality Control / Quality Assurance

Quality control and quality assurance was provided by the planting contractor. Success in the planting implementation is shown by the survivorship of the plantings over time. Should survivorship drop below 67%, additional plantings will be done to provide the plant density needed to act as a successful barrier to wind generated waves.

5.0 Cost Summary

The Vegetated Wave Buffer was awarded as an amendment to other planting activities being accomplished by River Partners in the Feather River Setback Area in 2010 and 2011. The final cost for implementation of the Vegetated Wave Buffer is $634,456.

6.0 Conclusion

Based on the observations and plant surveys conducted for the Project, it is our opinion that the Vegetated Wave buffer was implemented in accordance with the Contract Plans and Specifications and once established will provide the function for which it was designed.

Figure 3 provides photos of the planted Vegetation Wave Buffer as of October 2011.
Figure 1

Source: Data Provided by EDAW and GEI 2007
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arroyo Willow</td>
<td>AW</td>
</tr>
<tr>
<td>Black Willow</td>
<td>BW</td>
</tr>
<tr>
<td>Box Elder</td>
<td>BE</td>
</tr>
<tr>
<td>Coyote Bush</td>
<td>CB</td>
</tr>
<tr>
<td>Fremont Cottonwood</td>
<td>CO</td>
</tr>
<tr>
<td>Oregon Ash</td>
<td>AS</td>
</tr>
<tr>
<td>Sandbar Willow</td>
<td>SW</td>
</tr>
<tr>
<td>Western Sycamore</td>
<td>SY</td>
</tr>
<tr>
<td>Wild Rose</td>
<td>RO</td>
</tr>
</tbody>
</table>

Notes:
1. Plant on Existing Ground Elevation
2. Begin at Station 1+00 and Continue to Station 301+00 (30,000 Linear feet)
3. Repeat Planting Tile in 100 Foot Increments

Plan View - Planting Tile

Cross Section

Waterside Levee Toe

Waterside Edge of Toe Access Corridor
Figure 3
Vegetated Wave Buffer 2011 Photo Points

Photo Point 1

Photo Point 2

Photo Point 3

Photo Point 4