Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Project Information

1. **Proposal Title:**

   Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

2. **Proposal applicants:**

   Jeff Hart, H.A.R.T., Inc.

3. **Corresponding Contact Person:**

   Jeff Hart
   H.A.R.T., Inc.
   13737 Grand Island Road Walnut Grove, CA 95690
   916 775-4021
   jeffhart@citlink.net

4. **Project Keywords:**

   Habitat Restoration, Estuarine shallow water
   Habitat Restoration, Instream
   Habitat Restoration, Riparian

5. **Type of project:**

   Implementation_Full

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Shallow Water, Tidal and Marsh Habitat

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

Latitude:	38.165
Longitude:	-121.695
Datum:	

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

Georgiana Slough, Tyler Island south of Walnut Grove (5,000 linear feet); Steamboat Slough, Grand Island, west of Walnut Grove (1,000 linear feet); Sutter Slough (500 feet) Miner Slough (500 feet), Sacramento River near Courtland (1320 ft.); the Sacramento River on Andrus Island, southwest of Walnut Grove (5,000 linear feet); Suisun Marsh, Joice Island, south of Suisun City (1000 feet); and Sacramento River west Rio Vista (5500) feet).

10. **Location - Ecozone:**

    1.1 North Delta, 1.2 East Delta, 1.4 Central and West Delta, 2.1 Suisun Bay & Marsh

11. **Location - County:**

    Sacramento, Sonoma, Yolo

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    3, 11

15. **Location:**

    California State Senate District Number: 4, 5

    California Assembly District Number: 8, 10

16. **How many years of funding are you requesting?**

    3

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       No

       If no, list single overhead rate and total requested funds:

Single Overhead Rate:	10%
Total Requested Funds:	$1,800,000

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CALFED program.

97-N13 Tyler Island Levee Protection & Habitat Restoration Project

99-106 East Delta Habitat Corridor (Georgiana Slough)

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

No

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

Steve Greco UC Davis (530) 752-9199 segreco@ucdavis.edu

Geofrey Schladow UC Davis (530) 752-6932 schladow@mailbox.ucdavis.edu

Hollis Allen US. COE (601) 634-3845 hallen@netdoor.com

21. **Comments:**

Environmental Compliance Checklist

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      Yes
   b) Will this project require compliance with NEPA?

      Yes
   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   CEQA Lead Agency: State Reclamation Board
   NEPA Lead Agency (or co-lead:) U.S. Army Corps of Engineers
   NEPA Co-Lead Agency (if applicable):

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   XCategorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   -none

   NEPA
   XCategorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   -none

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

   Passive restoration is considered to be maintenance.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      No

      If the CEQA/NEPA process is not complete, please describe the dates for completing draft and/or final CEQA/NEPA documents.

Within two months of receiving contract.

b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03 Required

CWA 401 certification Required

Coastal Development Permit

Reclamation Board Approval Required

Notification of DPC or BCDC Required

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation Required

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404 Required

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land. Agency Name:	
Permission to access state land. Agency Name:	
Permission to access federal land. Agency Name:	
Permission to access private land. Landowner Name: McCormack	Required

6. **Comments.**

Permission to access sites has been given by local reclamation districts.

Land Use Checklist

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   passive restoration...planting only

4. **Comments.**

Conflict of Interest Checklist

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Jeff Hart, H.A.R.T., Inc.

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Ellyn Davis	Davis Environmental
None	None
None	None
None	None
None	None

Helped with proposal development:

Are there persons who helped with proposal development?

No

Comments:

Budget Summary

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

State Funds

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Project Management		60,000							60000.0		60000.00
2	Materials/equipment					150,000				150000.0		150000.00
3	Implementation/construction		350,000							350000.0		350000.00
4	Project planning/design		30,000				10,000			40000.0		40000.00
		0	440000.00	0.00	0.00	150000.00	10000.00	0.00	0.00	600000.00	0.00	600000.00

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Project Management		60,000							60000.0		60000.00
2	Materials/Equipment					100,000				100000.0		100000.00
3	Implementation/Construction		400,000				15,000			415000.0		415000.00
4	Monitoring		40,000							40000.0		40000.00
		0	500000.00	0.00	0.00	100000.00	15000.00	0.00	0.00	615000.00	0.00	615000.00

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Project Management		60,000							60000.0		60000.00
2	Materials/Equipment					100,000				100000.0		100000.00
3	Implementation/Construction		400,000				15,000			415000.0		415000.00
4	Monitoring		40,000							40000.0		40000.00
		0	500000.00	0.00	0.00	100000.00	15000.00	0.00	0.00	615000.00	0.00	615000.00

Grand Total=1830000.00

Comments.

Budget Justification

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Direct Labor Hours. Provide estimated hours proposed for each individual.

Labor: 2080 hrs/year for 12-15 laborers

Salary. Provide estimated rate of compensation proposed for each individual.

Labor: ave. $25,000

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

About 25%

Travel. Provide purpose and estimate costs for all non-local travel.

none

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Office, laboratory, computing: abot $25,000 Field materials (plants, posts, supplies): $325,000

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Planning/permitting: $10,000

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

NA at present time.

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

For tasks as described above, est. $60,000/year

Other Direct Costs. Provide any other direct costs not already covered.

NA at present time.

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

10% overhead rate for surcharge of specific costs.

Executive Summary

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

This research and restoration project builds upon the experiences of H.A.R.T., Inc. along the North Fork Mokelumne River and Georgiana Slough in the Sacramento San Joaquin Delta. Under the auspices of two CalFed funded programs (#97-N13, Tyler Island Levee Protectin & Habitat Restoration Plan; #99-B106, East Delta Habitat Corridor (Georgiana Slough), we have prtotected more than 11,000 linear feet of bank using wildlife friendly biotechnical techniques and several miles of tidal marsh restoration using specialized planting methods. These methods are low-tech and cost-effective. They have the advantage of involving minimal planning effort and permitting time, thus ensuring a quick turn-around of on-the-ground habitat restoration. The results of these efforts serve to protect levees while at the same time restoring valuable riparian and tidal marsh habitat. There is a great urgency to continue this work. In some parts of the Delta, only a small fraction of natural (non-riprap) levees and embankments remain. Without this effort, these embankments would continue to be lost to environmentally unfriendly bank treatments. Already on Georgiana Slough, our efforts have resulted in the immediate protection of natural, earthen embankments and obviating the need for the placement of riprap for the foreseeable future. Our techniques are gaining acceptance. We have been asked by several reclamation districts and landowners to apply these techniques to new areas under their jurisdiction. We propose to continue these successfully proven methods along Georgiana Slough, as well as to initiate new, efforts on the Sacramento River, (BrannanAndrus Island; below Rio Vista at the base of Montezuma Hills, near Courtland); Steamboat Slough (Grand Island); Sutter Slough and Miner Slough (Reclamation District 999), and Suisun Marsh

Proposal

H.A.R.T., Inc.

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Jeff Hart, H.A.R.T., Inc.

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat

Jeff Hart
Habitat Assessment & Restoration Team, Inc.
13737 Grand Island Road
Walnut Grove, CA 95690

A. Project Description

1. Problem. The Sacramento – San Joaquin Delta was once a vast labyrinth of biologically productive aquatic, tidal wetland and riparian habitat. It is now a greatly diminished resource due to water diversions and channelization, changes in flow regime, flood protection, placement of rock for shore and levee protection, wave and wake erosion, pollution, invasion by exotic species, and various land uses. Seasonal and daily tidal flows that once spread across hundreds of thousands of low elevation islands now inundate only a fraction of this historic area. Fine sediment that once nourished the development of seasonal wetlands is now reduced due to the presence of large dams upriver that block off the natural transport of sediment to the Delta. Without the natural suspension of sediment, cleaner dam-released ("hungry") waters tend to pick and erode downstream banks and habitats. Furthermore, the effect of boat-waves in resuspending sediment also tears away at embankments, islands and habitat.

Under the auspices of current CALFED Bay-Delta Program (CALFED) funding (#97-N13, "Tyler Island Levee Protection & Habitat Restoration Plan"; #99-B106, ""East Delta Habitat Corridor (Georgiana Slough"), and various Department of Water Resources (DWR) and U.S. Army Corps of Engineers (Corps) contracts, Habitat Assessment & Restoration Team, Inc. (H.A.R.T.) has implemented successful riparian and tidal marsh habitat restorations using innovative biotechnical means of erosion control and bank protection. These methods are "low-tech" and cost-effective. They have the advantage of involving minimal planning effort and permitting time, thus ensuring a quick turn-around of on-the-ground habitat restoration. In the last 3 years, H.A.R.T. has installed several linear miles of various shoreline restoration and "soft" bank protection measures in the Delta, especially along Georgiana Slough.

There is a great urgency to continue this work. In some parts of the Delta, only a small fraction of natural (non-riprap) levees and embankments remain. Without this effort, these embankments would continue to be lost to environmentally unfriendly bank treatments. Already on Georgiana Slough, our efforts have resulted in the immediate protection of natural, earthen embankments and obviating the need for the placement of riprap for the foreseeable future. Our techniques are gaining acceptance, and the approach taken by our team bridges concerns of local farmers, reclamation districts, professional engineers, and resource agencies regarding levee stability, flood control, and environmental restoration. We have been asked by several reclamation districts and landowners to apply these techniques to new areas in the Delta and Suisun Marsh under their jurisdiction.

The highly innovative methods outlined in this proposal are the most feasible approaches to easily and inexpensively develop habitat in the Delta. While created berms and setback levees are highly desirable, they are very expensive, require lengthy planning efforts, and can lead to loss of farmlands which may not always be economically or politically acceptable. Since much of the plantings will consist of fast growing herbaceous species, benefits to fisheries should be evident within one to two years.

We propose to continue these successfully proven methods along Georgiana Slough, as well as to initiate new, efforts on the Sacramento River (Brannan–Andrus Island; below Rio Vista at the base of Montezuma Hills, near Courtland); Steamboat Slough (Grand Island); Sutter Slough and Miner Slough (Reclamation District 999, near Courtland), and Suisun Marsh (Figures 1-7).

This project includes the following goals:

- Protecting natural embankment from further erosion through the use of biotechnical measures, thereby affording protection to existing Delta levees, embankments and habitats.

- Reconstructing natural berm environments through passive recruitment of new sediment (thereby reconstructing new floodplains and marshlands using natural means) to create new riparian and shaded riverine aquatic habitat.

- Developing new freshwater tidal marsh habitat through (1) direct planting and (2) facilitating natural recruitment by means of providing calm environments behind breakwater structures.

- Applying innovative technologies for habitat development on riprap levee and bank slopes in a variety of Delta environments.

- Removing non-native invasive weeds, such as <u>Arundo</u> <u>donax</u> and <u>Lepidium</u> <u>latifolium</u>, and replanting with native species.

- Monitoring the effectiveness of different restoration technologies for sediment recruitment, habitat development, and deterring colonization by non-native species.

The underlying premise for this project is that well-vegetated riverbank and tidal marsh environments, assisted with biotechnical features to deter erosion from current and wave action, provide protective, "safe harbor" conditions. This facilitates the recruitment and retention of new sediment, necessary precursors to habitat protection and development, as well as levee protection. This concept applies to the protection and restoration of remaining earthen embankments, as well as the softening of hard, rocked embankments. Mature vegetated sites not only provide maximal habitat values; they are also generally less vulnerable than open, poorly vegetated environments to invasion by exotic plants.

The approach of this project is the application of biotechnical (or bioengineering) techniques and materials that include structural elements, including organic materials (and occasionally rock features). They provide immediate bank protection until the vegetation matures sufficiently to effectively protect the river bank and tidal marsh environment. The recognition that protective, biotechnical features can add to site stability and habitat enhancement is gaining increased attention. The relationship of vegetation to riverbank stability has been well documented in the literature (Rosen, 1980; Schiechtl, 1980; Gray, 1989a; Coppin, 1990; Gray, 1996b), although the benefits to levee maintenance and erosion control generally are not appreciated among flood control professionals. Likewise, wetland and aquatic plants exert a strong influence on the hydrodynamics of waves (Leonard, 1995; Coops, 1991; Coops, 1994; Coops, 1996a**;** Coops, 1996b**;** Chambers, 1991; Foote, 1988). Various interactive relationships between plants, hydraulic dynamics, and sediment have been described in the literature, including: (1) the role of sediment in riparian plant recruitment (McBride, l984; Malanson, 1993); (2) plants as agents in flow resistance (Hickin, l984; Watson, l987); (3) the role of plants in reducing erosion, both surficial and from bank failure (Gray, 1996; Coppin, l990; Schiechtl, 1994; Gray, l989; Gregory, l988; Kondolf, l981; Smith, l976); (4) plants as a nuclei for sedimentation (McBride, l984; Malanson, 1993); and (5) the influence of plant architecture and vegetation characteristics on the occurrence of erosion and sedimentation (Coppin, l990).

We aim to test several hypotheses regarding: 1) sediment recruitment, utilizing several biotechnical and planting features; 2) plant survival of various installed plant species at various depths; 3) natural recruitment of native plants; and 4) competitive interactions with invasive, non-native species. Research level monitoring will form an integral part of the project. Site-specific restorations, laid out as formal experimental designs (with replication), will permit quantitative comparisons of the effectiveness of the different strategies (treatments) on erosion control and plant survival and growth. Non-treated (control) sites will be included within the experimental designs to permit comparison to a “do-nothing” strategy. The experimental design will include areas examined across a variety of sites and conditions, possibly including: location in Delta, reach position, orientation to wind, level of ambient wave action with respect to boating, initial vegetation characteristics, texture of embankment materials, bank slope, and presence of recreational access.

Through past and ongoing CALFED, Corps and DWR funding in the Delta, H.A.R.T. has successfully applied innovative techniques that demonstrate the positive relationship between the use of biotechnical features, bank protection, sediment recruitment and retention, and plant establishment. Various methods using passive efforts have been used to successfully reconstruct original berms through the recruitment of up to 2 feet of sediment during a single winter. Native sedges, tules and rushes have been planted on the newly constructed floodplain; ultimately, riparian trees will be installed. These efforts have been favorably received by the local farming community, reclamation districts, landowners and engineers.

The success of this project has been reported in numerous CALFED quarterly reports and annual monitoring and restoration reports. The results were also orally presented at the CALFED 2000 Science Conference (see abstract for further details). This project has also been described at local universities (e.g., UCD) and numerous field trips given to CALFED staff.

The reversal of the current erosional processes to a more stable depositional one should be of great interest to CALFED goals. Loss of habitat is one of the primary reasons for diminishing populations of wildlife and plants. The conversion of sites to more stable ones enhances wildlife values. Many species of wildlife would benefit from this program: among fish, Delta smelt, longfin smelt, Sacramento splittail, Chinook salmon, striped bass, green sturgeon, anadromous lampreys, and steelhead; for birds, neotropical migratory species, waterfowl and other wetland dependent species; and plants, Suisun marsh aster, Mason's lilaeopsis and rose mallow. Several organisms are listed as threatened and/or endangered species of special concern. Numerous CALFED documents have pointed out the importance of nearshore wetland and riparian habitats to the well-being of these species and their overriding importance as the basis of the Delta food chain. Moreover, the application of these methods offer a practical alternative to riprap. Already, our efforts are having a ripple effect in that new reclamation districts and landowners are asking us for assistance using our methods.

2. Justification. Historically, the Delta was a comparatively low-energy, distributary system, marked by long periods of bank stability with occasional periods of channel migration or "avulsion." The bank configuration probably was a relatively stable mantle of vegetation. Increased channelization and other land and water use changes have increased erosion in the Delta waterways compared to historical conditions. Increased erosion rates also are coupled with reduced amounts of sediment transport (due to dam construction upstream), which historically served as the basis for natural levee and bank accretion and stability. Excessively eroding banks is, therefore, an unnatural condition (in the Delta) and leads to loss of riparian habitat, including shaded riverine aquatic environments. Our program has a proven track record of successful efforts in combating erosion and habitat loss in the Delta. The original CALFED 97-N13 expires this fall and while another year of funding currently exists under CALFED Project 99-N03, we seek additional funding with the CALFED 2002 package to avoid a gap in the restoration program, including ongoing monitoring efforts. Without further action, continued rip-rapping of these environments would likely occur. Moreover, as our efforts have become widely recognized, we have been asked by other reclamation districts (e.g. Suisun Marsh Resource Conservation District, Reclamation District 999) and landowners (e.g, McCormacks, Montezuma Hills) to apply our techniques to new areas outside of the original (1997, 1999) CALFED site locations on Georgiana Slough.

<u>Erosion/Degradation Model.</u> Bank erosion processes include the following sequence of events. Initially, a thick stand of riparian or marsh vegetation functions to protect levees and banks. With continued erosional effect of waves and current affecting the shoreline environment, an opening or break eventually is created in the vegetative armor. The presence of shoreline irregularities, including small breaks or indentations, provides a focal point for the concentration of wave energy. Thus begins the formation of the semi-circular embayments or "scallops" characteristic of areas experiencing wave-induced shoreline erosion (Figure 8). With time, wave energies enlarge the size of the scallop within the berm, eventually extending to the levee itself. This process is compounded by bank failure processes in which the over steepened bank slopes fail after winter flood flows. With erosion occurring dangerously close to the levee toe, reclamation districts and flood control agencies are compelled to place riprap along the base of the levees for protection (Figures 3, 4). Once this occurs, the softbank is irretrievably lost, along with the habitat conditions. Once riprap is in place, the physical effect of the waves is increased due to wave reflection from riprap, leading to a spiraling effect of sediment and habitat loss.

<u>Sediment Recruitment/Habitat Facilitation Model</u>. H.A.R.T.'s innovative technologies function to reverse the degradational process described above and create a depositional model in its place. Techniques involve the construction of a multiple of structures such as brush boxes, brush bundles, coir biologs, and ballast bucket plantings that function as semi-permeable membranes (see description in later section and accompanying figures). These structures combine to dampen wave energy during the summer boating season (and/or are sufficiently weighted to resist being knocked over), and then function to trap sediment during the winter. As sediment accumulates during the winter flood season and then is protected during the spring and summer season, suitable environments are created that foster tidal marsh and riparian habitat development (Figures 10-17). The techniques already developed by H.A.R.T. will be expanded upon with new techniques (see Figures 18-25) in order to accommodate a greater diversity of erosional situations to new locations in the Delta.

Our scientific monitoring program of past and ongoing work has documented positive results of these restoration efforts in sediment recruitment and enhancement of wildlife values. We initially hypothesized that (1) winter sediment transport would result in sediment deposition at restoration sites and (2) biotechnical structures would prevent its loss during the summer boating season. This scenario was evaluated through a factorial experiment involving 50 sites for the CALFED 97 treatment sites. The factors were scallop type and treatment. Using multivariate statistics, sites were classified on the basis of various morphometric variables, reach location, and bendway position. Of the 50 sites, 2/3 were treated with biotechnical methods, and the remaining 1/3 left as control or do-nothing sites. To measure the relative deposition and erosion at the sites, more than 1800 erosion pins were randomly placed at both treatment and control sites. During the winter of 1999-2000, sediment accumulated at both control and treated sites. Mean sediment depth in April 2000 was 14 cm at control sites ($N = 19$) and 17 cm at treated sites ($N = 31$). By June 2000, however, control and treated sites differed significantly in the retention of this sediment ($P < .0001$). By June 2000, 70 % of sediment had been lost from control sites (June mean 4 ± 1 cm) while treated sites gained several mm of additional sediment. The treated mudflat sites averaged 19.2 cm gain in sediment, compared to controls which only had 0.3 cm gain. The treated bank sites showed a 0.3 cm gain, whereas the controls showed a loss of 4 cm.

Our efforts led to enhanced vegetation and habitat values. The treatment sites were planted with sedges in the summer of 1998, while the control sites were left unplanted. It was also anticipated that the protected treatment sites would provide conditions that would foster the recruitment of plants. In fall, 2000, the sites were evaluated for percent cover of several variables, including plant cover and woody debris. The treatment sites averaged 23% plant cover. Of this cover, the treatment sites showed a recruitment of 14 plant species, whereas the control showed a 9% cover. Also, the woody debris cover was higher in the treated scallops (20%) compared to the control sites (11%).

We demonstrated that the biotechnical structures physically dampened wave energy. Working with geomorphologists from the University of Southern California, we measured the hydraulic forces that undermine bank stability and habitat values. USC scientists placed current meters, pressure transducers, and optical back scatterance meters in our experimental installations to determine the benefit to bank protection. They demonstrated that our brush box structures reduced wave height by 40% and energy by 60%. This figure compares favorably with other studies of the effect of wave energy reduction through organic structures. Boumans et al. (1997) showed that intertidal fences caused a 50% reduction of boat wake energy. Roberts (1992) showed that coral reefs caused a 72-97% reduction. Massel et al. (1999) showed a 99% reduction through thick, mangrove forests.

Results are currently being analyzed for 2001, after which we intend to submit a manuscript for publication in a peer-reviewed journal.

Our tidal marsh restoration techniques have proven highly successful. Initial ballast bucket plantings of tules along 5,000 linear feet of the North Fork Mokelumne River and about 8,000 linear feet of Georgiana Slough have been very successful. The sites now support a nearly continuous coverage of bulrushes and rushes (Figures 16, 17)

These results demonstrate the effectiveness of biotechnical measures for sediment and plant recruitment, and bank and levee protection in this setting.

Given this success, we propose to extend these efforts to: (1) complete bank protection/habitat restoration work and monitoring on Georgiana Slough; and (2) initiate new work on the Sacramento River on Brannan–Andrus Island (Brannan – Andrus Island Levee Maintenance District, RD 556), Steamboat

Slough on Grand Island (RD 3); and Sutter Slough, Miner Slough, and Sacramento River (RD 999); Sacramento River below Rio Vista (McCormack Ranch); and Suisun Marsh (Suisun Marsh Resource Conservation District (Figures 1-2) . All projects are in the Delta Ecozone. Centroids are: (1) Sacramento River, between Isleton and Walnut Grove, Isleton Quad: 38° 12'30"/121° 33' ; (2) Georgiana Slough: Isleton Quad: 38° 12'30"/121° 32'; (3) Steamboat Slough, Rio Vista Quad: 38° 11'/121o 138'. Miner Slough, Sutter Slough, Sacramento River, Courtland Quad: 38° 17' 30"/121° 37' 30"; Suisun Marsh (Joice Island), Fairfield South Quad, 38° 10'/122° 5'.

The areas selected for repair and restoration are located in critical areas in the Bay – Delta region. The ERP (Chapter 9) identified the importance of several of these in the Delta and eastside tributaries (e.g. Georgiana Slough, Sacramento River, Miner Slough and Steamboat Slough) that serve as important habitat corridors.

An area with tremendous habitat development potential exists along the Sacramento River below Rio Vista at the base of the Montezuma Hills. It is one of the few areas where riparian vegetation can be developed along this reach of the Sacramento River (in the west, central Delta) due to the presence of an elevated, non-leveed berm at the base of the Montezuma Hills. Most other elevated landforms in this part of the Delta are narrow levees, where tree planting is precluded by the reclamation districts.

A final area of bank protection/restoration is proposed along Suisun Slough in Suisun Marsh. Suisun Marsh plays an important part in "X2" zone, is an important migration corridor, and serves as a nursery area for many aquatic species (ERP, CALFED, 2001). The Suisun Resource Conservation District has asked H.A.RT. to apply biotechnical bank protection measures around Joice Island. The techniques now proposed are attractive to agencies involved, especially due to special conditions of the Marsh-wide U.S. Army Corps of Engineers Regional General Permit that prohibit dredging from exterior islands and the placement of rip-rap on levees where previously no riprap existed. The District sees the benefits of biotechnical erosion control to include: "1) re-establish high marsh vegetation in bare areas; 2) reduce or eliminate levee erosion; 3) minimize levee maintenance; 4) reduce or eliminate the risk of levee breaching; 5) exploit natural patterns of sediment deposition; 6) reduce populations of <u>Phragmites</u> in the Marsh by harvesting it for biotechnical erosion control/levee restoration; 7) satisfy special condition of the USACE RGP that requires the development of alternative levee erosion control methods" (Bruce Wickland, SRCD).

We consider this work to be urgent since a finite number of softbanks remain in many parts of the Delta. With no further intervention, these sites will continue to erode to the base of the levee, at which time they would be riprapped by local flood control districts or the Corps (Figures 3-4). In some areas of the Delta, riprap cannot be applied until an emergency situation develops. By then, habitat values would have eroded away with the embankment. We propose to extend the use of environmentally friendly techniques already successfully developed by H.A.R.T., as well as to experiment with other combinations of approaches that have been used elsewhere. Because we have successfully applied these concepts to previous or ongoing restoration efforts, we believe that some components of this project would constitute a full-scale implementation project (e.g., Georgiana Slough), while other components would still fall under the category of a pilot project (e.g., Suisun Marsh).

As with currently funded CALFED projects, H.A.R.T. will deploy adaptive management strategies. Because we are a "design build" team, we have a rapid response feedback loop between the design team and the installation crews. With the projects already in process, we have altered installation techniques, the nature and size of the materials used, and the timing of installation. These new projects will benefit from these "lessons learned".

Since we are expanding efforts into some new tributaries (e.g., Sacramento River, Steamboat Slough, Suisun Marsh, Sutter Slough and Miner Slough) with potentially new conditions, we will need to adapt, expand, and/or alter our current palette of materials and methods. For example, wave and current energies on the Sacramento River are potentially greater than on the other tributaries. Accordingly, we propose to make judicious use of more resistant, or hard, biotechnical materials. Some of the embankments are steeper than those on Georgiana Slough so that entirely different methods, such as crib walls and gabion structures (Figures 24, 25), may need to be used. Suisun Marsh presents an equally challenging environment to apply these techniques. Each of these new methods will require adaptive management at the installation phase of the project. "Pilot" installations of materials initially will test implementation timing, construction techniques, durability, sustainability, and function. Methods and techniques that don't work will be discarded, while those that do will be modified, if necessary, and applied on a larger scale. Adaptive management also will come into play on a long-term basis as the knowledge of the successes and failures of the various deployed techniques can be used to direct future restoration projects in the Delta.

Rigorous hypothesis testing regarding sediment recruitment and retention, installation success/failure, natural recruitment, and sustainability will be used as a positive feedback loop to constructive adaptive management practices.

3. Approach (Design). For the several locations proposed (Figures 1, 2), approximately 20,000 linear feet of eroded scallops and embankments and/or habitat have been identified for enhancement. These include, along Georgiana Slough (5,000 linear feet), Steamboat Slough (1,000 linear feet), Sutter Slough (500 feet) Miner Slough (500 feet), Sacramento River near Courtland (1320 ft.), and the Sacramento River on Andrus Island (5,000 linear feet), Suisun Marsh (1000 feet), and Sacramento River below Rio Vista (5500) feet). The approach will involve: (1) mapping in detail the erosion sites to be treated, (2) developing a restoration/monitoring plan, (3) applying for permits, (4) obtaining peer review of the plan and revising the plan as needed, (5) implementing the project, (6) monitoring the project, and (7) applying the principles of adaptive management based on monitoring results.

Restoration Technologies

The techniques and methods used in habitat restoration will be based on the successes and/or failures of previous treatments (adaptive management) and new design concepts. To ensure that a diversity of design concepts is considered, H.A.R.T. will contract with other bioengineering specialists to assist in augmenting a greater palette of methods. This process will provide a means of peer review of current designs and, if needed, new ideas. Some of these new techniques may include cribwalls, log revetment, gabion structures, and lunkers in steep bank areas and other breakwater structures to dampen wave energies affecting bank stability. Most of these methods are easily installed using hand labor, and many of the materials can be collected from Delta orchards. H.A.R.T. also has workboats and a barge for waterside installation. The treatment sites will be generously planted with sedges, and woody plants such as alders, willows, box elder, ash, cottonwoods, and oaks—all collected from local genetic stock. The design of these techniques has been based on geomorphic and hydraulic analyses and experience from the use of these materials in similar environments.

Bioengineering structures can serve many functions: wave and current energy reducers, surface or soil protection features, sediment trapping elements, ballasted or anchored materials that resist being swept away, and ground stabilization structures that protect the bank from mass failure. A particular structural element often may serve multiple functions. Ultimately, the plants installed with these features will mature and provide many of the same protective functions. The biotechnical features may be classified as follows: (1) breakwater structures; (2) soil protection techniques; (3) sediment recruitment and retention techniques; (4) plant-anchoring or weighting techniques; and (5) ground stabilization techniques.

Breakwater Structures. Several breakwater structures were considered for the ongoing projects (#97-N13; #99-B106), including floating logs, brush boxes, branch box breakwaters or brushwood fascines, wooden platforms, sand-filled geotubes, sandbags, peaked stone dikes or rock groins, coir geotextile rolls, plastic sheetpiles, and trees as revetment. The method that H.A.R.T. has successfully deployed is a branch box breakwater structure. This structure is constructed from long poles inserted vertically into the embankment, with bundles of small dead branches (called fascines) packed between the poles and secured with twine or cable. To attract sediment, the fascines may be enveloped in coconut fabric or similar material to further slow current and wave energy (Figures 5-8). Brush boxes or brushwood fascines have been used in Europe (Boumans, 1997; Ostendorp, 1995), the Louisiana delta (Boumans, 1997; Good, 1993), and locally on Georgiana Slough (Hart, 2001)—all with positive results. Boumans (1997) reported wave energy reductions of 50% across monitored fences and elevation increases up to 3.3 centimeters per year (cm/year), and Ellis (2001) showed a 40-60% reduction using H.A.R.T. installed brush boxes along Georgiana Slough.

Other possible breakwater structures may be fashioned. Stone or rock may be covered within nylon or wire (gabion) material to function as a breakwater. Geotextile tubes, constructed of synthetic material, may be filled with sand and placed along the shoreline to deflect waves. In Germany, coir geotextile rolls, rock berms, and rock rolls containing vegetative plantings are installed shoreward of the breakwater structures. In Michigan, Fuller (1997) reported the use of coir geotextile rolls, placed between the shoreline and a row of rocks, that function to dampen waves. Trees and logs can be floated into place, secured to each other and the substrate with cable. With time, the logs sink to the bottom, thereby serving a breakwater function. Geotextile bags and tubes have been used as breakwaters. Since they must be hydraulically filled with sand at the locations where they are to be constructed, their use is limited to areas where the appropriate substrate is found. In the Delta, this method has proven expensive for a project adjacent to Sherman Island, and was therefore not utilized.

Plants also can be used to dampen the energy of waves. The amount of dampening that occurs is related to the nature and the width of the vegetation. A study in the Chesapeake Bay determined that more than 50% of the energy associated with waves was dissipated by 2.5 meters of marsh habitat (Knutson, 1990; Knutson, 1982). Stem density and the size of the stems also influence wave energy. Greater numbers of small-diameter plants are more effective than fewer, larger diameter materials. Rosen (1980) found that fringe marshes reduced erosion rates by 20-50%, depending on the particular geomorphic setting. However, not all physical environments are suitable for the use of plants to dampen wave energies. In extremely exposed environments, emergent macrophytes may be limited. Hall (1975) reported the vegetative protection of shorelines to be limited due to high wave energy, winter icing, and fluctuating water levels.

<u>Soil Protection Techniques</u>. Various techniques are used to protect the ground surface from the erosive energies of water current, waves, and wind. The eventual establishment of a living ground cover, such as a dense sward or turf of graminoid plants, will protect the ground surface. Various kinds of inert, organic or synthetic materials are available for short-term protection until vegetation becomes thoroughly established. These materials include types of rolled erosion control blankets (for example, coir, jute, wood excelsior, straw, and coconut fibre [coir]), brush matting or mattresses, and synthetic products. Organic materials have the advantage of eventually decaying, whereas synthetic materials may remain in place for decades or more.

<u>Sediment Recruitment and Retention Techniques</u>. Increased deposition of sediment occurs with the reduction of wave energy and currents, assuming that suitable sediment loads exist. Gleason (1979) documented a positive relationship of sedimentation with increased stem density. The work by Hart and Holms (1998) similarly documented the positive relationship between roughness at a microscale and deposition. Materials must be sufficiently dense to slow current velocities in order to adequately recruit sediment and simultaneously prevent these materials from washing away. Materials that effectively recruit sediment include coir biologs, coir mattresses, log brush barriers (Figure 9) brush boxes,

and other dense matted or branched materials. With sufficient sediment established in these structures, plants then can become established. Boumans (1997) reported surface elevation increases up to 3.3 cm/year using silt fences made from piles and Christmas trees. Boumans concluded that silt fences will produce land more quickly if they are placed in the shallowest water available. On the Kenilworth Marsh in the District of Columbia, Bowers (1995) used brush bundles as sediment containment enclosures for dredged materials. Bowers found that the structures were too porous to retain sediment, and that straw bales were more efficient. Sediment recruitment and retention structures should be designed to permit sediment-laden waters to pass through the outer perimeter layers and to deposit in the interior zones. This can be accomplished by locating more porous structures outboard and placing more dense structures in interior areas.

<u>Plant-Anchoring or Weighting Techniques</u>. Plants are naturally anchored by the presence of extensive root systems. However, establishing plants in high-energy wave environments may require the imaginative use of anchored planting techniques in the early phases of plant establishment. Many of the commonly used bioengineering products, such as mats and rolls or live willow wattling, are anchored to the shore with stakes, rebar, or anchoring pins. Other specialized methods include planting structures with anchor rods, plants fixed to concrete rings and cast onto the shore bottom, and roots of aquatic plants fixed to packing wire inserted into the soil. Fonseca (1994) deployed three different planting methods: (1) fixing plants to the bottom with large staples (U-shaped metal rods, approximately 2 millimeters in diameter, with the leg of each rod being about 20 cm long; (2) the coring method (10-cm-diameter PVC core tubes used to extract sediment from the shorebottom, after which plugged plants are installed in the hole; and (3) the plug/peatpot method (a 7.6- x 7.6-cm Jiffy Pot made of compressed peat that is installed with a sod plugger).

Another strategy is the placement of heavily weighted planting materials with a soil medium resistant to erosion. These materials must be sufficiently heavy to prevent being washed away, and their soil structure must resist erosion. H.A.R.T.'s ballast buckets are made of an organic, biodegradable bucket, filled with a clayey loam and grown with plants capable of forming dense roots and living through long periods of inundation (Figures 16, 17). Logs and rootwads can be attached to the shore with earth anchors or duckbill structures. These consist of cable attached to the midsection of a flange of metal, which is driven into the embankment. As the cable tightens, the metal flange is pulled perpendicular to the embankment, thus resisting being pulled out.

<u>Ground Stabilization Techniques</u>. These methods reduce the mechanical forces active in the deeper soil mantle. Deeper structures or roots can be very effective in stabilizing the soil, thereby reducing mass slippage. Bioengineering techniques include the use of live cuttings, earth-filled brush works, branch packing, brush layering, wattle fence and wattles (or fascines), layer construction, vegetated geogrids, rock rolls, lunkers, dormant posts, vegetated live crib walls, biologs, root wads, live slope grating, gabion walls, bank crib with cover log, and

log revetments (Figures 10-16). In streambank environments, these structures often are placed at the base of the slope for toe protection.

Hypothesis Testing

The following hypotheses will be tested with monitoring data from a formal experiment.

- Wave Energy: During a period in the middle of the low-flow season, average cumulative wave energy per scallop (erosion site) as measured by wake gauges will be lower in the treatment sites than in the do-nothing control sites.

- Erosion, Deposition, Soil Retention. For the first 2 years, by the end of the low-flow season, the average of net sediment deposition/soil retention within each year will be at least 3 cm greater in the treatment sites than in the do-nothing control sites.

- Mass Wasting. By the end of the high-flow storm season each year, average centimeters of horizontal bank movement through mass wasting will be lower in the treatment sites than in the do-nothing control sites.

- Diversity of Natural Recruitment. The mean number of native plant species that established through natural recruitment will differ significantly between the treatment sites and the do-nothing control sites.

We will select control and treatment sites through initial site surveys, followed by measurement of extent of erosion, documentation of various site physical features and biological attributes. This information will form the basis of statistical ordination leading to a classification of the sites. The methods will be detailed in a restoration and monitoring plan, as was done for the previous CALFED Projects. Data collecting methods include the use of erosion pins placed at randomly determined locations within treatment and control sites. Using these pins as points of pretreatment land surface elevations, data collected will determine the amount of loss, retention, and/or gain of sediment at specific locations. Percent survival of installed plants and vegetation recruitment and growth will be determined using standard plant ecological methods. An analysis of variance (ANOVA) will be used to determine significant differences for hypotheses being tested.

4. Feasibility. To date, H.A.R.T. has successfully applied most of the elements of the structures described above, including brush boxes, coir biologs, ballast buckets, and brush bundles. Biotechnical structures have been applied in similar environments (Allen and Leech, 1997; Boumans et al., 1997; Lee et al., 1997; Chen, 1998) to successfully reduce wave energies. The practical feasibility of the approach outlined above has already been demonstrated through previous CALFED funding (#97-N13; #99-B106; see following figures) and Corps and DWR projects.

Several Reclamation Districts and landowners affected all have given their support for the project. These include Reclamation District 563, RD 556, Brannan – Andrus Island Maintenance District, RD 3, RD 999, the McCormack family, and the Suisun Resource Conservation District. To date, project planning and permitting has not proven to be insurmountable. From a planning and regulatory perspective, reconstructing the original bank and planting riparian vegetation will not negatively affect hydraulic conveyance, and has not raised concerns from local Reclamation Districts or the State Reclamation Board. Virtually no land transformations requiring engineering are proposed at this stage; hence, these activities would not appear controversial to potentially affected parties. Minimal regulatory planning is required for these treatments, since they are implemented with hand labor and passive, natural processes.

Several regulatory and planning issues need attention before work could begin. At the beginning of the project, a meeting will be held with representatives of the U.S. Fish and Wildlife Service (USFWS) and the Corps. As with past projects, a Nationwide Permit Number 13 (NW-13) will be secured to satisfy Clean Water Act Section 401 water quality certification. A general condition (#9) of the NW-13 requires state water quality certification from the Central Valley Regional Water Quality Control Board (CVRWQCB). A California Department of Fish and Game (DFG) Streambed Alteration Agreement also is required for streambed work. Because this project is considered to be part of ongoing maintenance, it qualifies for categorical exemption under the California Environmental Quality Act (CEQA). Under Title 7 of the U.S. Endangered Species Act, consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service will be solicited.

5. Performance Measures. The research/monitoring program will include testing a variety of scientific hypotheses and general areas of interest, such as erosion/deposition relationships, boat-wake energies, instream shade, plant survival and cover between control and treatment sites, and control techniques for non-native invasive weeds. The completed restoration/monitoring plan will include the following chapter topics: (1) project goals and objectives; (2) hydraulic, geomorphic, and biological description of the sites; (3) statement of hypotheses; (4) sampling or censusing designs and methods for depositional/erosional patterns; (5) data management and quality control; (6) data evaluation protocols; and (7) procedures for utilizing monitoring results in adaptive management of the project. This project will not monitor faunal use of the sites. We feel that CALFED, perhaps under the auspices of CMARP, should develop standard sampling techniques that would be applied across numerous restoration projects.

6. Data Handling and Storage. Data will be captured and stored in various formats, including GIS data (ArcView), photo monitoring (JPEG or other format), tabular format (Excel), and/or relational database (Access). The data will be analyzed using ANOVA statistical methods and will be presented in written, chart, and pictoral formats.

7. Expected Products/Outcomes. In addition to CALFED quarterly reports, information will be distributed through publications in referred journals, popular magazines, and seminars and visually through web site development and/or Powerpoint presentations. Additional information, including onsite tours, will be provided upon request.

8. Work Schedule. The work is divided into several distinct, but somewhat overlapping phases that will occur over a 3-year period: (1) plan development and permitting in first several months after funding, (2) project construction years 2 and 3; (3) project monitoring and adaptive management years 2 and 3.

B. **Applicability to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities**.

1. ERP, Science Program and CVPIA Priorities. This project supports several of the CALFED Program objectives in improving ecosystem quality, water quality, and levee system integrity. The project also supports several goals of the ERP in improving aquatic and terrestrial habitats. Specifically, implementing this project will aid several of CALFED ERP and Science Program goals, implementation plan and CVPIA priorities. As described in the ERP, several goals are addressed with this project:

- Tidal marsh and riparian habitat restoration (**Goal 4, ERP**).
- Control of non-native invasive species (**Goal 5**).
- Ecosystem processes, trapping of sediment that fosters wetland development (**Goal 2).**
- Water Quality improvements (**Goal 6)**.
- Improved habitat conditions for at-risk species (e.g., splittail, smelt, Chinook salmon), (**Goal 1**) and harvestable species (striped bass, salmon) (**Goal 3**).
- Levee stability. The approach taken by this team also contributes to levee stability (Levee System Integrity Program Plan, CALFED 2000) and water quality enhancement (Water Quality Program Plan, CALFED 2000).

This project also strives to build a body of knowledge that contributes to the CALFED science program. These include experiments and experiences leading to adaptive management (e.g., improved use of technologies in biotechnical bank protection); comparing relative effectiveness of different restoration strategies in different locations; advance process understanding (e.g., relationship of physical forces and plant establishment); establish integrated science in complicated field settings (e.g., rigorous use of control and treatment sites/statistical analysis); advance science of regulatory activities (e.g., use of riprap vs. softer features and relative habitat values). The general habitat goals of the CVPIA are also addressed, e.g., "improved physical habitat"; riparian and aquatic habitat.

2. Relationship to Other Ecosystem Restoration Projects. This project builds on several other current projects in the Delta and broadens the experimental design already underway by H.A.R.T. for several projects in the Delta, such as #97-N13 and #99-B106 on Georgiana Slough and the North Fork of the Mokelumne River, an AB 360 project on the North Fork of the Mokelumne River, and a Corps demonstration project on Steamboat Slough.

3. Request for Next-Phase Funding. Not applicable.

4. Previous Recipients of CALFED or CVPIA Funding. Two other CALFED projects have been awarded to HART: #97-N13 and #99-B106.

5. System-Wide Ecosystem Benefits. The implementation of this project will result in the enhancement of nearly 20,000 linear feet of critical shoreline riparian environments, habitat that will benefit the principal native fish species that either migrate through or reside in the Delta. Moreover, the application of these innovative methods can serve as a model for continued work of this nature.

C. Qualifications

H.A.R.T. This project will be delivered by the Habitat Assessment & Restoration Team, Inc. (H.A.R.T.), located near Walnut Grove, CA. H.A.R.T. specializes in natural resource surveys and habitat analyses, restoration design, propagation of native wetland plants, and restoration implementation. Located along Steamboat Slough on Grand Island (in the Delta), H.A.R.T. 's 10-acre facility includes a plant nursery stocked with native wetland and riparian plants, a potting barn, greenhouse and shadehouse; storage and tool sheds, several vehicles, two workboats and 1 barge; office facilities including four computer work stations with GIS and graphics capabilities, and considerable room for growth. Jeffrey A. Hart, Ph.D., will serve as overall project manager. Dr. Hart has had considerable success in designing and implementing restoration projects (e.g., Stone Lakes National Wildlife Refuge, Twitchell Island, Decker Island), bioengineering projects (e.g., Dry Creek, Lower American River, North Fork of the Mokelumne River, Georgiana Slough, Steamboat Slough), and resource studies (e.g., Cosumnes River and Lower American River). His clients include mostly government agencies and non-profit companies such as the Sacramento Area Flood Control Agency, California Department of Water Resources, Turlock Irrigation District, Sacramento County Water Resources Division, Ducks Unlimited, and The Nature Conservancy. H.A.R.T. has successfully completed restoration contracts with Ducks Unlimited. Since moving to Grand Island in July 1998, H.A.R.T. has successfully established a native plant nursery where a large inventory of native plants are already under propagation. Many of the tasks for the project will be performed by Jeff Hart and H.A.R.T. employees. Other tasks will be performed by the following subcontractors.

Davis Environmental Consulting. Davis Environmental Consulting provides professional consulting services in biological resources regulatory compliance, habitat restoration and mitigation planning, performance monitoring, and construction oversight. Davis Environmental Consulting has particular expertise in handling wetland regulatory compliance issues and threatened and endangered species issues. Davis Environmental Consulting will assist H.A.R.T. with regulatory agency coordination and consultation; produce permit application packages; and coordinate wetland delineations and other biological studies for wetland and endangered species regulatory compliance. Ellyn Miller Davis, principal of Davis Environmental Consulting, has in-depth experience in and knowledge of natural resources planning and regulatory compliance. Her 14 years experience as an environmental consultant has provided her with a solid working knowledge of environmental resource laws and regulations including Sections 404 and 401 of the federal Clean Water Act, Section 10 of the Rivers and Harbors Act, National Environmental Policy Act, Fish and Wildlife Coordination Act, Endangered Species Act, California Environmental Quality Act, and Section 1600 et seq. of the California Fish and Game Code.

Gilbert Cosio. MBK Engineers. Mr. Cosio is a principal engineer and vice president of Murray, Burns & Kienlen. Mr. Cosio has experience in flood control, hydrology, hydraulics, water resource planning, drainage water supply, surveying, and levee maintenance. Mr. Cosio is currently principal-in-charge of all Delta levee reclamation district work for Murray, Burns & Kienlen. **Kjeldsen, Sinnock & Neudeck, Inc. (KSN).** KSN will provide survey, mapping, and planning functions. This firm is a full service civil engineering and land surveying firm specializing in the surveying, mapping, planning, design and construction of municipal, public works and water resources related projects. The firm currently serves as consultants to over thirty communities, special districts, and local public agencies in the San Joaquin County and foothill areas. **Robert Miller & Associates and DCI Engineering.** These two engineering firms represent Brannan – Andrus Island.

D. Cost

1. Budget. Table I gives a cost breakdown for the budget. The total cost for the project is $1,830,000 for 20,000 linear feet of biotechnical bank protection and habitat restoration. As can be seen from the task breakdown, this includes 1) planning and permitting; 2) restoration and monitoring plan, plant propagation, materials, restoration implementation, monitoring, and project management. Most of the work will be done by H.A.R.T. employees, with outside consultants supplying specialty services such as planning and permitting, and engineering services. Overhead is included in the project management component, and includes time spent in contract administration as well as normal project oversight duties.

2. Cost-Sharing. Not applicable.

E. Local Involvement. This project is fully supported by the local reclamation districts and landowners.

F. Compliance with Standard Terms and Conditions. H.A.R.T. can comply with all terms and conditions described in Attachment D of the PSP (Terms and Conditions for State Proposition 204 Funds).

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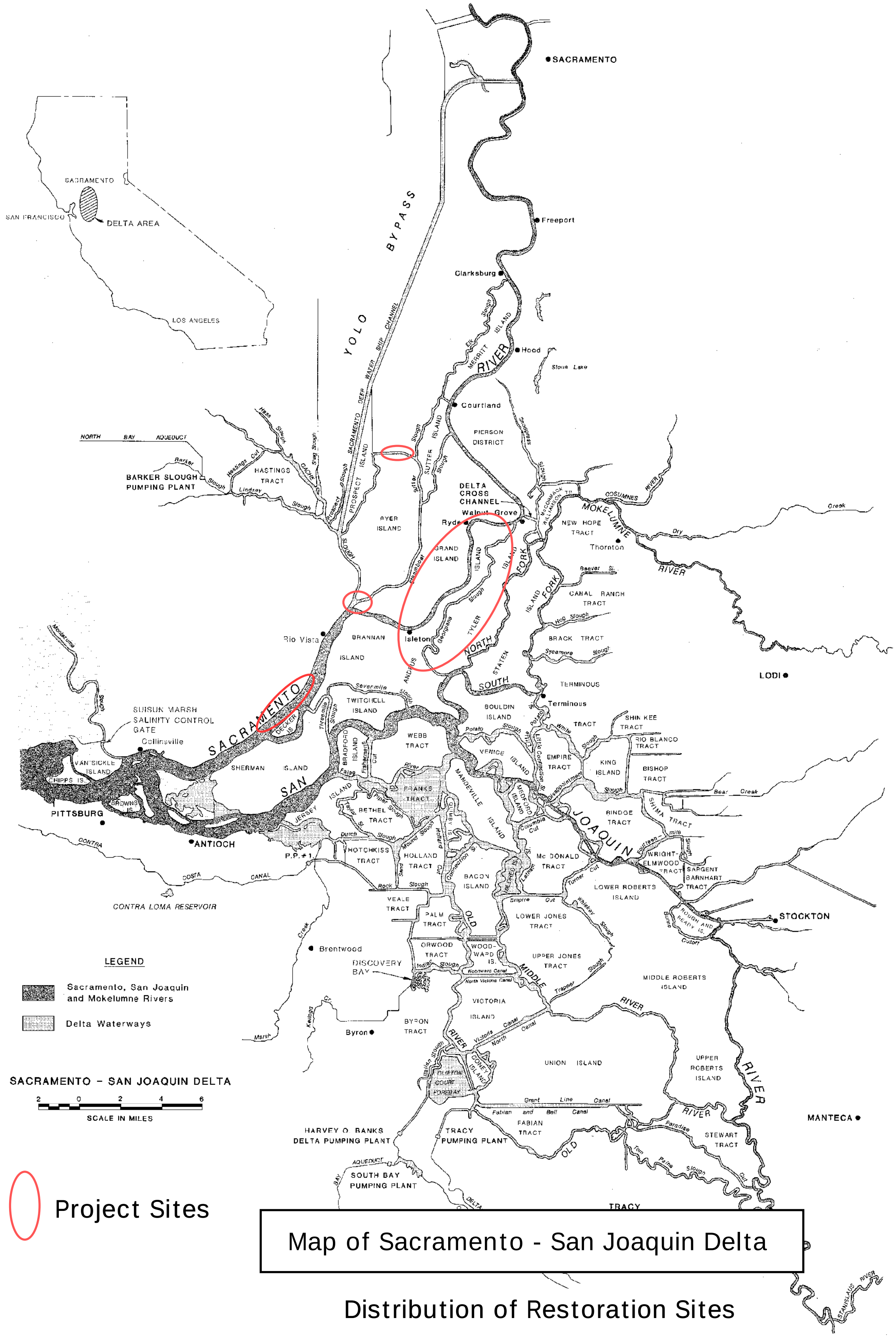
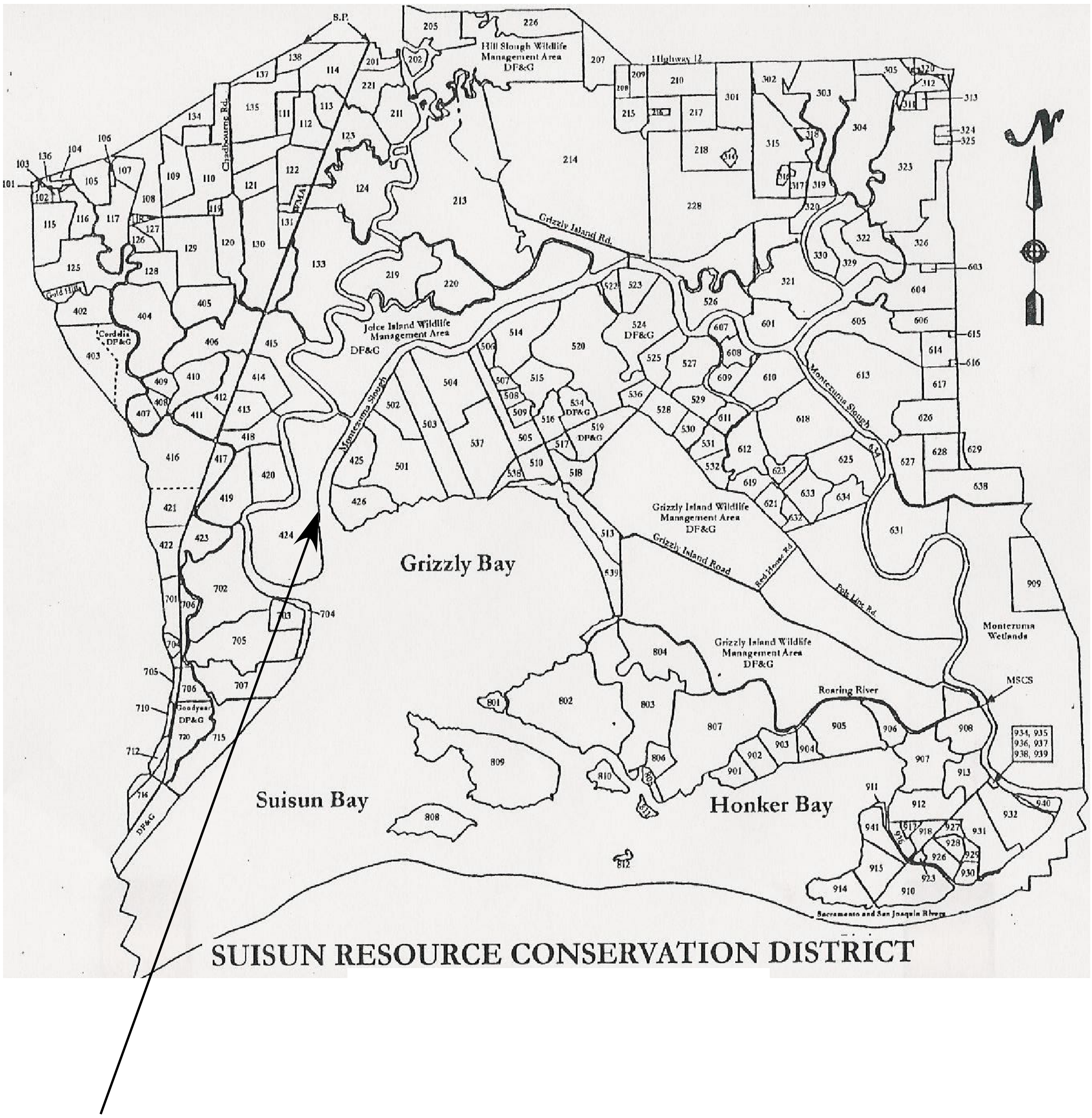
Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat



Map of Sacramento - San Joaquin Delta

Distribution of Restoration Sites



Project Site on Joice Island

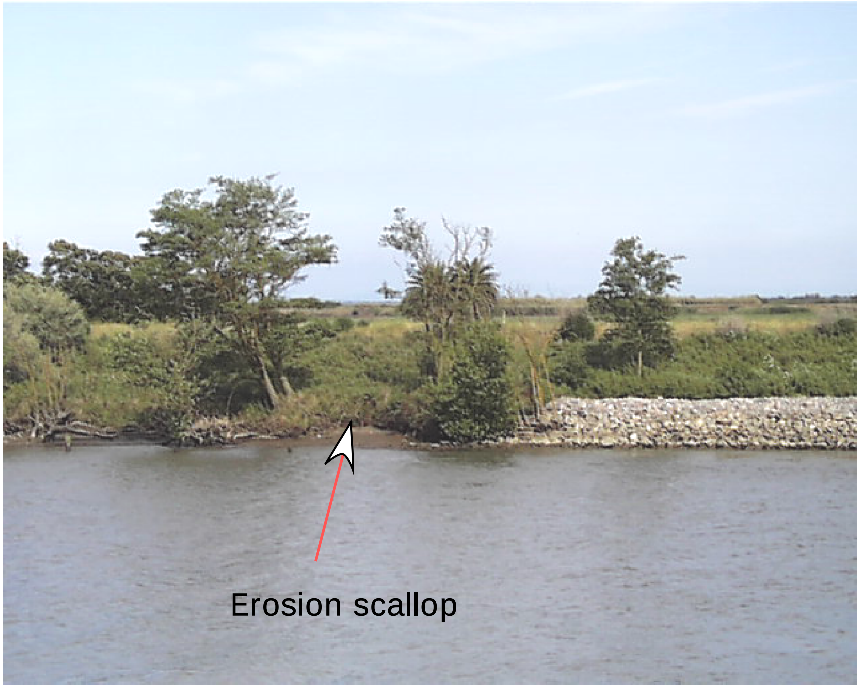
Figure 2

Note eroded semicircular scallops along bank of Georgiana Slough.

Placement of riprap in the scallops when erosion comes close to the levee toe.

Aerial Photograph of Erosion Scallops and Riprap Placement
on Georgiana Slough

Figure 3



Bank Erosion

Above: Bank erosion, leading to scallop formation, on the Sacramento River on upper Andrus Island. Note the placement of riprap on right. Below: Bank erosion on Grand Island. Toe of levee is being undercut by current and wave action.

Figure 4

Sacramento River at McCormack Ranch, base of Montezuma Hills. Opportunities abound for habitat development on low berm (above) and bank protection using biotechnical features and tidal marsh habitat development (below).

Figure 5

Sacramento River, McCoraick Ranch, at base of Montezuma Hills. In conjunction with habitat development, invasive weed control will be needed. Above photos show Arundo donax, Lepidium latifolium, and Rubus procerus that will be eradicated.

Figure 6

Erosion at Joice Island, Suisun Marsh. Erosional scallops are eroding base of levee.

Figure 7

Erosion

1. Wave-Energy Dissipation
   Problem: Boat wakes, especially during the summer months, cause erosion along the embankment.
   Solution: Structures outboard of the eroding banks need to be installed that break the waves and dissipate their energy. Recommended structures include floating log breakwater structures, fabric-encapsulated straw bales and brush bundles, and brush boxes.

2. Sediment Capture
   Problem: Considerable sediment passes through the Delta, especially during the winter months. Sediment is needed to build and maintain embankments.
   Solution: Sediment-capturing structures, such as brush fences, dense plantings, and coir biologs, will be placed in the waterways adjacent to the bank to induce accretion of fine materials.

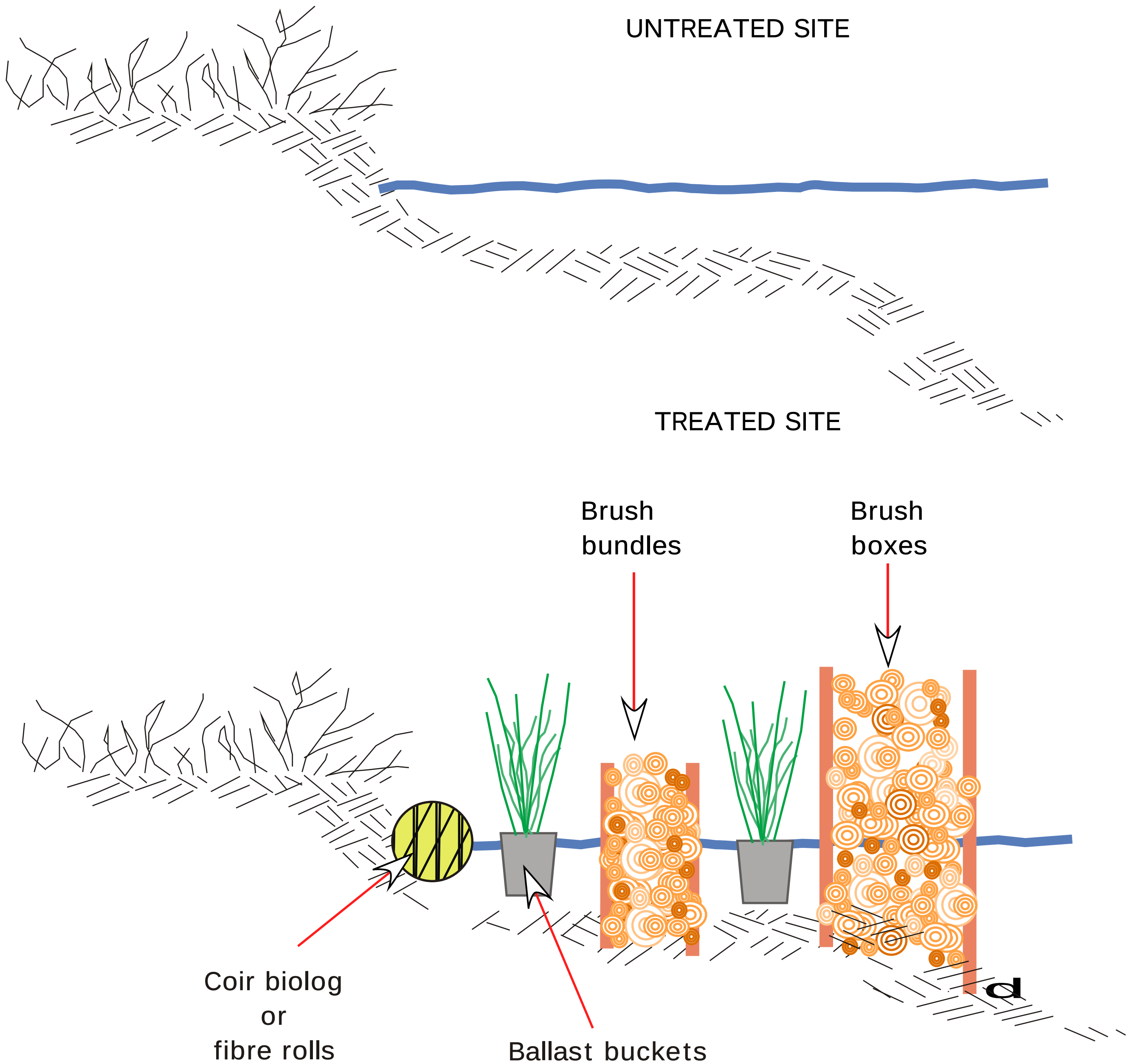
3. Ballast Plantings
   Problem: Erosive action of flowing water and boat wakes can erode habitat and vegetation plantings.
   Solution: In addition to the wave-attenuation structures, specialized ballast-bucket planting techniques will be applied.

Alternative Bank-Protection Strategies

Figure 8

Sustainable Restoration Technologies for Bay/Delta Tidal Marsh
and Riparian Habitat

Design for low bank, moderate slope



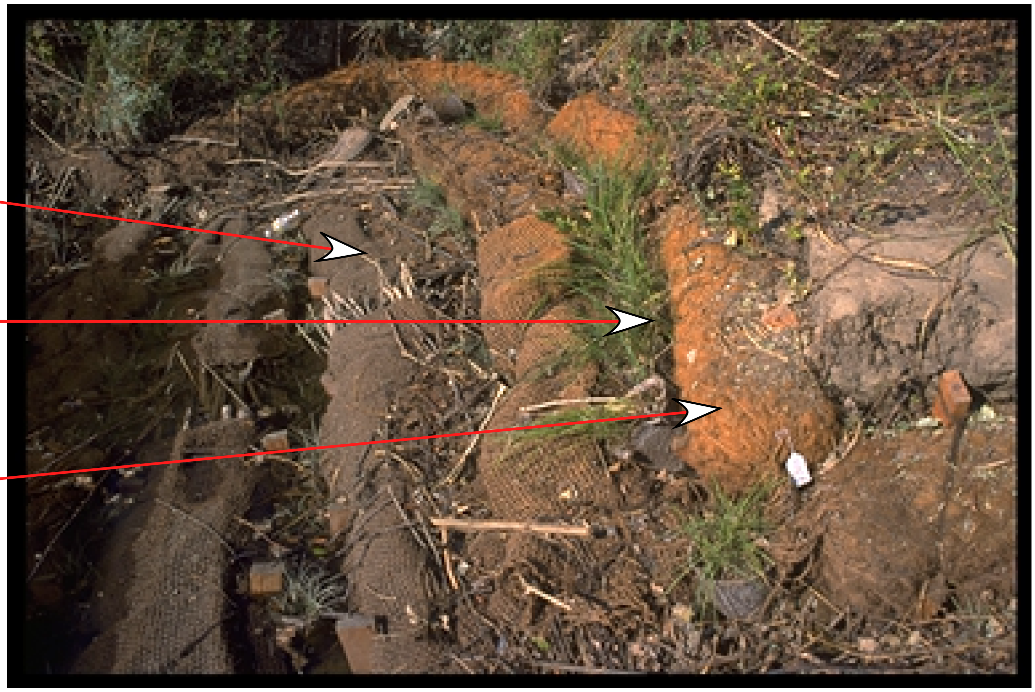
Composite Brush Works/Ballast Buckets

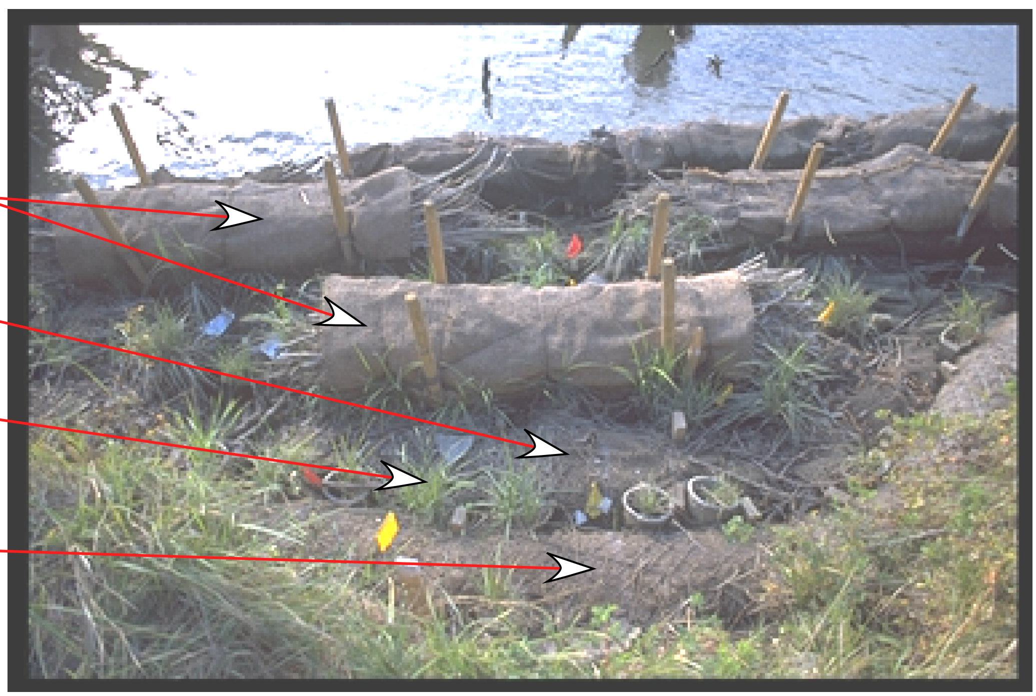
Composite protection and habitat enhancement techniques include brush boxes to serve as breakwaters, coir-wrapped brush bundles and coir biologs to capture sediment, and ballast-bucket plantings for habitat establishment.

Figure 9

Georgiana Slough, showing erosional scallop before treatment.
Site A6, prior to treatment.

Figure 10

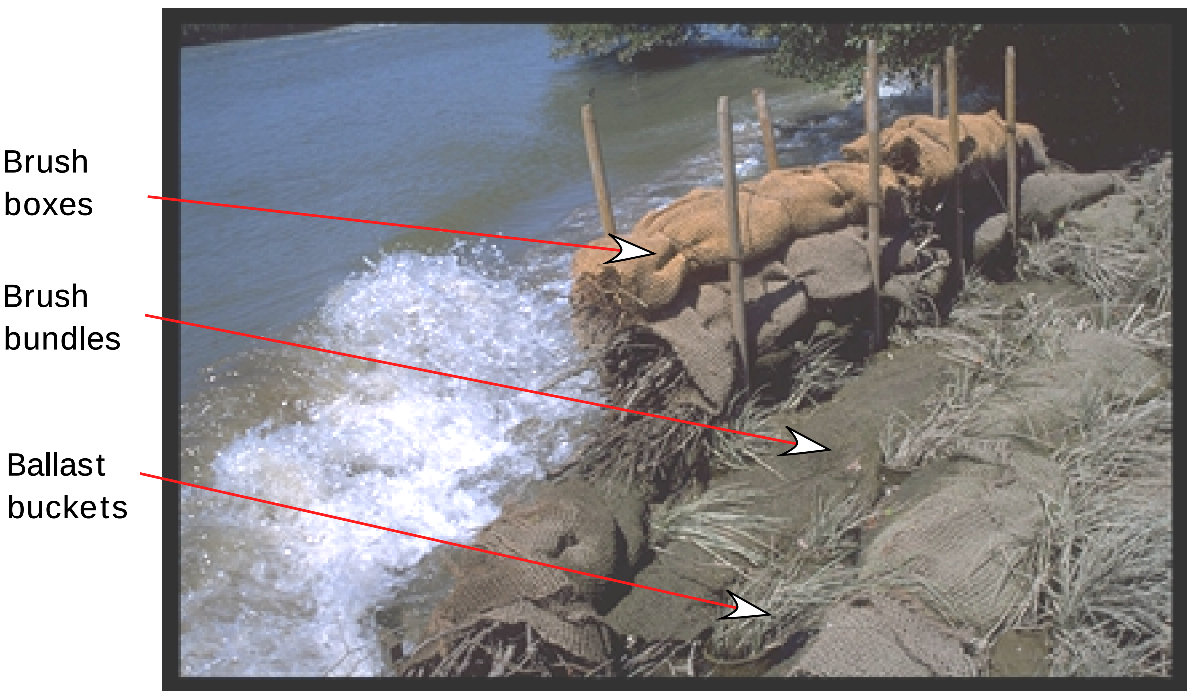




Sample Restoration Site on Georgiana Slough

Above: Scallop no. 4A before construction in spring 1999. Below: Same site after construction in fall 1999. More than 33 sites, totalling approximately 1,880 feet, were installed in the first field season.

Figure 11



Effect of Brush Works in Dampening Boat Wave Energy

Above: Boat waves approaching brush works. Below: Beneficial effect of brush works in deflecting boat waves; note that waves do not penetrate beyond brush boxes.

Figure 12

Submerged brush boxes

Brush boxes covered with sediment

Ballast-bucket plantings

Effect of Brush Works in Precipitating Sediment Deposition during Winter 2000 Flooding

Above: Winter flooding, with presumed deposition occurring. Below: After winter flooding. Note ample amounts of deposition (approximately 2 feet).

Figure 13

Calfed 97 treatment site A6 on Georgiana Slough. Above photo showing eroding, mudflat before treatment. Site was treated in 1999. Below photo shows restored berm capable of supporting riparian plant community. Trees will be planted this fall.

Figure 14

Treatment sites, Georgiana slough. Newer treatment techniques, showing outer enhanced brushbox, wetland plants, and rootwads, one year after treatment.

Experimental Tule (Scirpus californicus) and Rush (Juncus effusus)
Plantings on the North Fork of the Mokelumne River

This is an area being restored along an expanded mudflat on the North Fork of the Mokelumne River. These ballast-bucket plantings have withstood two seasons of boat waves and winter flooding. Above: Looking upstream, fall 1999. Below: September, 2001.

Figure 16

Experimental Tule (Scirpus californicus) and Rush (Juncus effusus)
Plantings on North Fork Mokelumne River

This area on the North Fork of the Mokelumne River is a moderately impacted site located with in a shallow water mudflat upstream of the outside bend of the river. The site was planted in the fall of 1998 with ballast bucket tules. Photo below shows establiished stand of tules.

Figure 17