PIPER PARK MARSH, *a little-known 24-acre public tidal salt marsh within a 5-minute walk to downtown Larkspur, is located on the south side of Corte Madera Creek, adjacent to Piper Park, Hall Middle School and Boardwalk One – an additional 9.4 acres of privately owned marsh with homes on piers.*

Piper Park Marsh Resiliency Proposal

L A R K S P U R , C A L I F O R N I A

Special Thanks to the wonderful experts and community members who gave of their time and expertise to help make this proposal possible (see page 13).

Kathi deFremery, Elizabeth Clark, Alan Jones
Environmental Forum of Marin
May 6, 2017

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Piper Park Marsh Resiliency Proposal

Executive Summary

Piper Park Marsh has successfully co-existed with surrounding development for decades, providing a number of community benefits, including significant carbon sequestration and storage. But the marsh is now showing signs of stress. With the onset of more severe weather events and continued human activity within the watershed, it is in danger of losing its resiliency – its ability to adapt to these stressors. Without adequate stewardship the marsh could eventually downgrade to mudflat.[i] With input and support from community members, conservation and climate change organizations, and wetlands experts, we propose that the City of Larkspur undertake proactive stewardship of Piper Park Marsh to preserve this important community asset.

With little funding and minimal ongoing maintenance the City can achieve continued resiliency through the following actions:

1. **<u>Rezone Piper Park Marsh:</u>** Rezone marsh from R-1 ("Residential First") to OS (Open Space), per Larkspur's General Plan, Chapter 6, "Open Space Goals, Policies, Programs," *Shoreline & Marsh Conservation.* [ii]
2. **<u>Authorize a Resiliency Plan:</u>** Beginning with an existing conditions assessment, develop a long-term resiliency plan. It should include monitoring elevation change, tracking channel expansion, monitoring vegetation and coordinating with other agencies to monitor creek flow and dredging impacts. The cost effectiveness and benefits of such a plan are substantial and detailed on page 6.
3. **<u>Larkspur Climate Action Plan:</u>** Include Piper Park Marsh in the updated Larkspur Climate Action Plan, citing its cost effective contribution to sequestering CO_2 and reducing greenhouse gases.
4. **<u>Invasive Species:</u>** Remove current invasive plant species through volunteer/homeowner project.

These steps will allow the City to respond effectively in an informed and timely way as climate events unfold, human activity in the watershed intensifies, and community concern grows.

Attached are letters of support from stakeholders who join us in asking the City of Larkspur to take steps to prevent further deterioration of Piper Park Marsh and to ensure its resiliency for the benefit of the entire community and generations to come. (See Appendix D).

Owned by the City of Larkspur, Piper Park Marsh is currently zoned R-1 (area in blue). Marsh habitat fringing Piper Park continues onto privately owned properties of Boardwalk One Community, 35 homes, zoned TR, Tidelands Residential, on the southeast edge of Corte Madera Creek.

Primary Stakeholders Include: City of Larkspur and Larkspur residents, Boardwalk One residents, Friends of Corte Madera Creek Watershed, Larkspur/Corte Madera School District. A more complete list of stakeholders is provided in endnotes. [iii]

Important Benefits of Piper Park Marsh:

A. Environmental

1. **Carbon sequestration and storage:** In one year this marsh sequesters about as much CO_2 as 97 acres of U.S. Forest land, the equivalent of not driving an average passenger car about 250,000 miles. It sequesters approximately 28 metric tons of carbon per year, equivalent to about 103 metric tons of CO_2. http://www.southbayrestoration.org/pdf_files/Carbon%20Sequestration%20Dec%2020%2007.pdf [iv] [v]
2. **Protection of unique tidal marsh habitat:** Provides habitat for the special status Ridgway's Rail and many other watershed-adapted salt marsh aquatic and terrestrial species as listed on Friends of Corte Madera Creek Watershed's website: http://friendsofcortemaderacreek.org/ws/FishWildlife.pdf. Upland habitat at marsh periphery protects marsh inhabitants during highest floods. [vi]
3. **Water and air quality improvement:** Salt marshes work as natural water filters for pollutants, toxins, and sediment, and remove greenhouse gases from the air.
4. **Functions as a floodplain:** Temporarily stores and slows down storm water which helps prevent flooding of adjacent and downstream areas.

B. Economic

1. **Naturally reduces carbon emissions:** A healthy marsh effectively sequesters CO_2 and stores carbon with little cost to the community.
2. **Provides low cost bank protection:** The marsh offers protection for the park, homeowners and public buildings from storm surges and wave erosion. Acting now to prevent additional marsh deterioration will preclude the need for "hard" barriers, which are more expensive and less effective. [vii]
3. **Maintain property values:** A healthy marsh will help maintain the safety and value of nearby properties.

Special status Ridgway's Rail in Piper Park Marsh

C. Social & Equity

1. **Helps protect Boardwalk One community:** This historically significant community is one of the most affordable housing options in Larkspur. It has successfully coexisted with a healthy marsh for decades. Protecting the marsh and creek shoreline from erosion will help foster this lifestyle and can provide an example of successful sea level rise adaptation for other communities.
2. **Educational opportunities:** Proximity to schools makes it an excellent opportunity for study by both students and the community.
3. **Community and stakeholder cohesion:** Promotes connections between Boardwalk One Community, Larkspur Public Works Department, Friends of Corte Madera Creek Watershed, San Francisco Regional Water Quality Control Board (RWQCB), California Department of Fish and Wildlife (CDFW), County of Marin and others.
4. **Enjoyment of public open spaces and views:** Visitors to Piper Park and all adjacent properties benefit from open marsh and wildlife views across the marsh.

D. Governmental

1. **Re-zoning will protect the marsh:** Marsh will be preserved and protected from any further dumping, development, or inappropriate infrastructure.
2. **Compliance with SB32:** A healthy Piper Park marsh would help the City of Larkspur comply with the ambitious greenhouse gas reduction requirements of SB32, signed into law in 2016, which requires the state to slash greenhouse gas emissions to 40% below 1990 levels by 2030.
3. **Climate Action Plan update:** Include the marsh as an asset that will contribute to greenhouse gas reduction, as called for in the Climate Action Plan. The required periodic review of the climate action plan will help assure a process for reviewing the strategic significance of the marsh as we come to better understand climate change.
4. **Marsh Resiliency Plan:** To assure long term resiliency, develop a marsh management plan to become part of the ongoing City maintenance and operational budget. The maintenance budget should be minimal; requiring only a day or two of staff time annually to record data and coordinate with other agencies.
5. **Formation of an assessment district:** If agreed to by adjacent homeowners, the possible formation of some kind of assessment district can allow homeowners to act in concert to protect the marsh on their properties at less cost per owner, and can facilitate coordination with the City's marsh stewardship plans.
6. **Facilitate future adaptation:** Consider possible future revisions to TR zoning which would allow existing homes to be supported by driven piles, (rather than resting on mud sills vulnerable to surface erosion), and/or floating homes, in order to allow homeowners to adapt to rising sea levels.

Marsh Vulnerability

Understanding Marsh Vulnerability will help focus resources and slow continued deterioration.

- **Lack of marsh stewardship and coordination with public/private stakeholders.** The marsh is adjacent to privately owned marsh areas with residences on them. How each property owner addresses his/her vulnerabilities will affect the marsh as well. Currently there is no system for sharing data or coordinating marsh stewardship among homeowners, the LCM School District, or the City.
- **Impacts of Watershed Flood Control Planning & Increased Runoff.** The marsh is a floodplain on Corte Madera Creek, which is vulnerable to increasing upstream run off, water velocity, and other watershed events including development and drainage changes. Flood management decisions, such as installing detention basins, can reduce vulnerability. By tracking changes in the marsh and correlating information with other activity in the watershed, the City can proactively seek to protect the marsh from adverse effects of upstream activity.
- **Lack of baseline data.** Currently there are limited data on the marsh, making it difficult to correlate marsh changes with other changes going on in the watershed. In order to respond effectively to changing conditions the City needs marsh-specific data collected over time. These data, combined with the BayWAVE Study, Marin County's shoreline vulnerability assessment (https://www.marincounty.org/main/baywave/vulnerability-assessment), will allow the City to understand watershed and climate impacts on the marsh and respond appropriately.
- **Accelerating erosion.** Marsh erosion appears to be accelerating, and possibly losing sediment.
- **Shoreline will not accommodate marsh migration.** Adjacent development limits upland migration of the marsh, making the prevention of subsidence essential.
- **Invasive plants.** Non-native marsh and upland plants are spreading, displacing habitat.
- **Increasing local runoff.** The east side of the marsh is directly impacted by storm flow from Larkspur Creek. The west side is likely impacted by local runoff which deserves further study.

- **Climate change and sedimentation rates.** Because of the long list of benefits derived from preserving the integrity of this marsh, and because adequate sediment seems to be the key to marsh resiliency, we believe it is not really essential to quantify a series of climate change scenarios, as is typical in many wetland preservation projects. [viii] Using the online Point Blue [ix] modeling tool, it is quite apparent that with either a high or low sea level rise assumption, adequate sedimentation is the key to keeping the marsh resilient, slowing inundation and upland migration, protecting the adjacent homes, park, school and public buildings. The only way to validate or adjust this model is to collect the data over time.

  We have provided the Point Blue Conservation Science San Francisco Bay Future Marshes Report and maps in Appendix A. This model suggests that with adequate sediment the marsh can remain at mid-level for about 50 years. Without adequate sediment, it drops to low marsh and in an additional 20 years will revert to mudflat, leaving very little upland in Piper Park and vicinity.

Suggested issues for further study, based on current marsh observations and research, and as funding becomes available, are listed in endnotes. [x]

Taking Stewardship of the Marsh

Our expert consultants agree that the City of Larkspur can undertake stewardship of Piper Park Marsh with little funding and minimal ongoing maintenance by taking the following steps:

1. **Rezone Piper Park Marsh:** From R-1 ("Residential First") to OS (Open Space), per the City's General Plan, Chapter 6, "Open Space Goals, Policies, Programs," *Shoreline & Marsh Conservation.*

2. **Elements of an Assessment and Monitoring Plan**: To optimize the City's ability to understand and respond to changes in the marsh, it has been suggested that at minimum the following elements be included in an assessment/monitoring program. These methods are relatively inexpensive, track longer term and more subtle changes, and will likely have a very high rate of return as the City continues to draft its response to climate change and other factors affecting this valuable community asset. See "Why Monitor?" in endnotes [xi] for additional benefits of monitoring.

   Monitoring the following parameters will form a strong basis for understanding how to preserve, protect and manage the marsh in a cost-efficient manner:

   A. **Monitor marsh elevations for changes:** Marsh plain elevation changes are indicators of the effects of sea level rise on wetland systems. "Understanding…vulnerabilities to sea level rise is important for both biodiversity conservation and for management of public infrastructure." [xii]
      i. Install sedimentation plates (about 5) along an elevation transect.
      ii. Monitor annually to assess rates of change in sedimentation. See endnote [xiii] for more details.
      iii. This will allow the City to respond to changes in sedimentation inventory in the creek and seek mitigation and help in managing negative impacts.

   B. **Track channel expansion to observe potential subsidence:** Experts suggest focusing on the slough channel that flows from the City-owned marsh under the boardwalk bridge between #28 & 29 Boardwalk One homes, then parallels Corte Madera Creek.
      i. Install survey post at each side of the channel.
      ii. Annually monitor the cross-section for changes in the tidal prism. [xiv]
      iii. This will provide evidence of regional activities affecting the volume of water in the marsh, which suggest impending changes in habitat that might call for mitigation efforts.

C. **Coordinate with other agencies to monitor creek flow and dredging:**
   i. Corte Madera Creek is in Flood Zone 9, a designated flood control unit of Marin County. US Army Corps of Engineers and the Flood Control District jointly monitor the Corte Madera Creek Flood Control Project. Larkspur should be in regular contact with the District and the Corps to assess impacts on the marsh.
   ii. Obtain environmental assessments (EIR, EIS) for dredging permits along Corte Madera Creek to understand current shoreline erosion issues and how it might affect the marsh and property owners.
   iii. Through the Army Corps and BCDC, be aware of the sedimentation inventory, how it affects the marsh, and how agencies can cooperate to mitigate any negative impact. Piper Park Marsh may be an ideal pilot project for understanding sedimentation issues which may lead to funding opportunities for the City from agencies such as the Army Corps, BCDC or the County.
   iv. Be aware of opportunities to coordinate with dredging in the vicinity, and work to make use of clean, suitable dredge materials to enhance sedimentation rate over time – a key to keeping the marsh resilient. Using dredge material may be combined with other strategies, such as sediment trapping with soft structures made of natural local materials.

D. **Monitor Vegetation changes:**
   i. Establish a vegetation transect [xv] along the same line as the elevation transect (or some other simple vegetation inventory system).
   ii. Annually monitor vegetation along transect at peak growing season.
   iii. Commit to early removal of invasive species to preserve marsh habitat integrity.
   iv. Monitor the interface between the marsh and the park for invasive species and any unintended negative impacts resulting from routine park maintenance.

3. **Larkspur Climate Action Plan**: Because marsh resiliency will lead to continued reduction of GHG emissions and allow for adaptation to sea level rise and shoreline protection, Piper Park Marsh should be included in the updated Larkspur Climate Action Plan as an important environmental asset.

4. **Invasive Species**: Remove current invasive plant species through volunteer/homeowner project. In addition to preserving this wetland habitat, this activity can encourage homeowners and volunteers to join the City in increased awareness of the valuable role the marsh plays in the greater community.

Conclusion

Implementation of the steps outlined above would serve to align the City's current policy with its General Plan and Climate Action Plan. Ongoing assessment and monitoring will further serve to create a resource of data which will give clear guidance in dealing with future challenges to the health and resiliency of this valuable resource for which we share custody.

Appendix A – San Francisco Bay Future Marshes Report

http://data.prbo.org/maps/sfbmap_html.php

Point Blue Conservation Science

San Francisco Bay Future Marshes Report

About This Report

This report summarizes several effects of sea-level rise on San Francisco Bay tidal marshes (marsh vegetation composition, bird abundance, and conservation value). Analyses were based upon maps of projected future shoreline elevation available at the Future San Francisco Bay Tidal Marshes Web Tool (http://data.prbo.org/apps/sfbslr). Future analyses were done for the years 2030, 2070, 2090, and 2110; baseline (current) analyses assume conditions from 2010. Four scenarios were considered for each year: low and high sedimentation rates (specific to watershed; see below) combined with low (0.5 m/century) or high (1.65 m/century) rates of sea-level rise.

In addition to the site summary below, there are two graphs on the following page. The plots show the projected elevation-derived composition of future marshes (percent subtidal, mudflat, low marsh, etc.) and the projected abundances of five marsh-dwelling bird species. Note that all scenarios assume that full tidal action occurs across the entire site: the following summary ignores the effects of levees even if a levee currently exists at a site. The conservation valuation is based on the abundance and diversity of these five bird species across all scenarios and years. All results, including conservation prioritization ranks, are based on elevations circa 2010. Management actions, such as sediment delivery, that result or have resulted in bed elevations higher than those shown in the current elevation map will increase a site's conservation prioritization ranking.

For more information, click on section titles (which are hyperlinks, denoted by light blue boxes): you will be directed to a help file where you can learn how to interpret these results, view an example report, examine the methodology, and see citations.

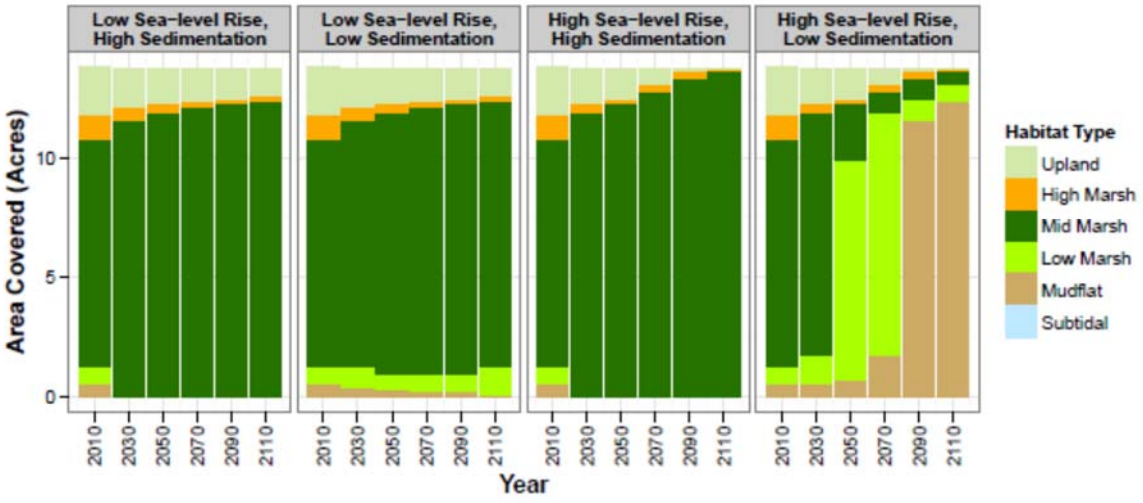
Site Summary: Piper Park West

Site Area: 13.79 acres (5.58 hectares)
Tidal Marsh Conservation Value: 19.44 (30th percentile)
Tidal Marsh Conservation Value Per Acre: 0.88 (88th percentile)
Suspended Sediment Concentration Assumptions: Low = 100 mg/L, High = 300 mg/L
Organic Deposition Assumption: Low = 1 mm/Year, High = 3 mg/L

Report produced by Point Blue for the Future Marshes Project (http://data.prbo.org/apps/sfbslr).

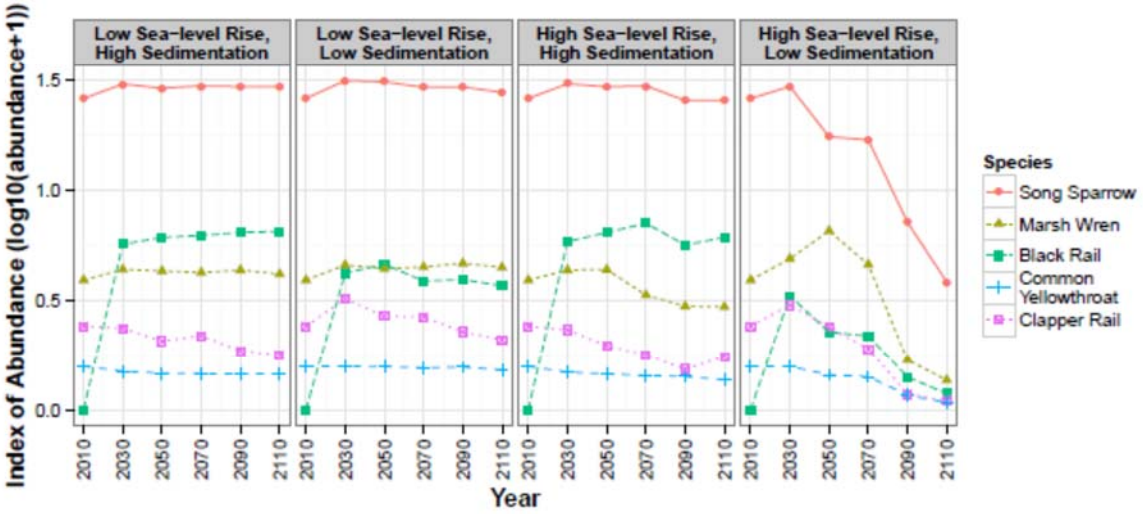
Tidal Marsh Sensitivity: Sea-level Rise Effects on Marsh Habitat Composition

Compare the results for each scenario to assess how habitat availability will change with high or low sea level rise and high or low sedimentation levels. Questions to consider: Is the site more sensitive to the sediment assumptions than the two rates of sea-level rise? Is the timing of changes in the habitat composition consistent across scenarios?



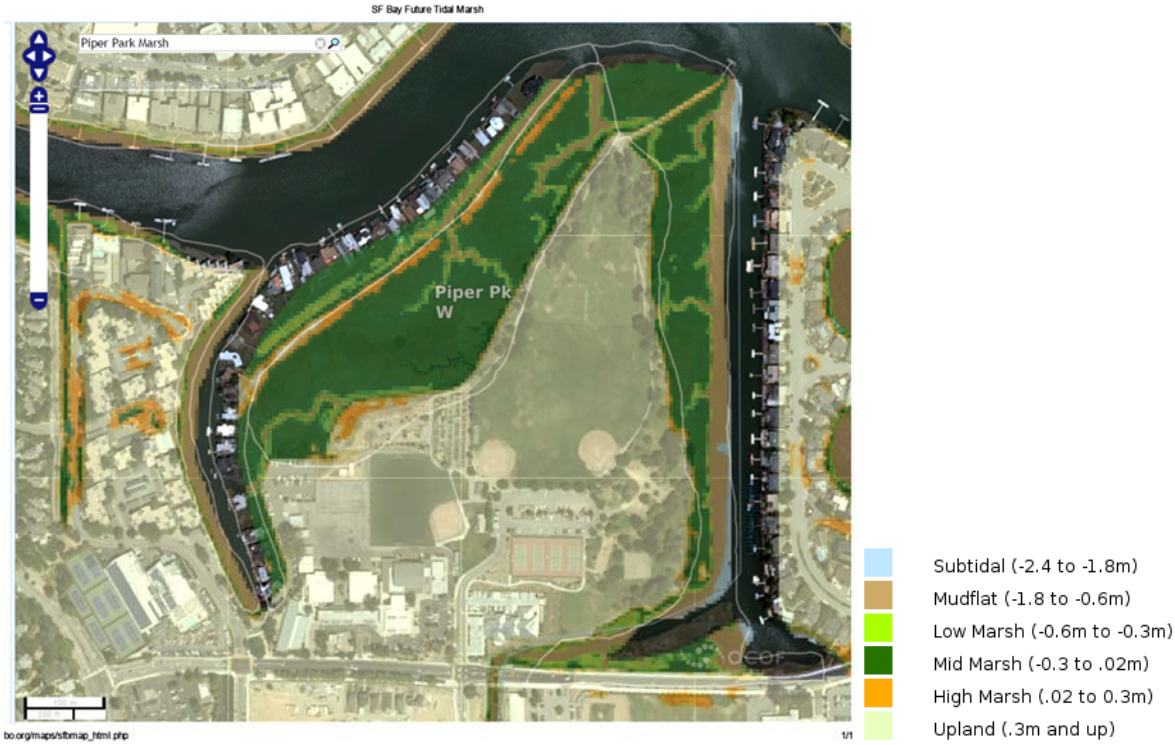
Projected Effects of Sea-level Rise and Salinity Change on Bird Populations

Use each of the panels to evaluate how differing magnitudes of sea-level rise in each scenario will effect tidal marsh bird populations. Questions to consider: Under how many scenarios will the site provide habitat for birds at each time period? Will the species composition of the site change through time and is the projected composition the same in each scenario?



Report produced by Point Blue for the Future Marshes Project (http://data.prbo.org/apps/sfbslr).

2010 Piper Park Marsh Level – mostly mid marsh elevation and surrounding Piper Park uplands.



2070 Projection – 162cm/century sea level rise (high SLR); high organic, <u>high sedimentation rate</u>.

Even in the high SLR scenario, adequate sediment should allow the marsh to keep up for about 50 years, restoring some existing mudflat to mid marsh elevation.

But without adequate sediment the marsh will subside to mid marsh level and mudflats will increase.

2070 Projection – 162cm/century sea level rise (high SLR); low organic, <u>low sedimentation rate</u>.

Add another 20 years to the same low sediment scenario and the entire marsh will be mudflat with little upland left in Piper Park and surrounding areas.

2090 Projection – 162cm/century sea level rise (high SLR); low organic, <u>low sedimentation rate.</u>

Appendix B – Funding Sources

1. **Marin Community Foundation/Buck Family Fund & State Coastal Conservancy Grants -** https://www.marincf.org/buck-family-fund-grants/environment/nature-based-climate-adaptation
2. **BayWAVE (Marin Bay Waterfront Adaptation Vulnerability Evaluation) Pilot Sedimentation Project - NOAA's Office of Habitat Conservation** - http://www.habitat.noaa.gov/funding/index.html
3. **San Francisco Bay Restoration Authority** (Measure AA funds) - http://sfbayrestore.org
4. **San Francisco Estuary Partnership (SFEP)** - The *Innovative Wetland Adaptation Techniques in Lower Corte Madera Creek Watershed* project is a pioneering effort led by BCDC that examines the resilience of San Francisco Bay tidal marshes and intertidal mudflats to accelerating sea level rise, and considers how the wave attenuation and other ecosystem benefits they provide can be preserved. This collaborative project was conceived in recognition of the significant gap in understanding of the role bay lands play as the first line of defense against coastal flooding, and how that role may change in the future. The project was supported with funding from the San Francisco Estuary Partnership (SFEP) through a **Resilient Watersheds for a Changing Climate** grant of the **San Francisco Bay Water Quality Improvement Fund** from the **U.S. Environmental Protection Agency**, and by the generous contributions of research partners including the **U.S. Geological Survey, UNESCO-IHE, University of San Francisco,** and **Marin County.**
5. Corte Madera Creek Unit 4 Project 2006-ish - funding from the **Marin County Flood Control District** and the **National Fish and Wildlife Foundation.** Fluvial Geomorphology Consulting and Friends of Corte Madera Creek Watershed provided in-kind support. See Friends of Corte Madera website: http://friendsofcortemaderacreek.org/new_site/reports Report: http://friendsofcortemaderacreek.org/rep/Unit4DesignSummary.pdf
6. **Bay Area Resilient By Design Competition -** http://www.resilientbayarea.org A design competition in which interdisciplinary design teams work in collaboration with communities to identify solutions to vulnerable locations on the Bay waterfront. Teams will develop creative, exciting, & effective solutions to protect communities and preserve the Bay for generations to come.
7. **San Francisco Bay Joint Venture -** http://www.sfbayjv.org/funding.php
8. **San Francisco Bay Water Quality Improvement Fund (SFBWQIF), EPA Region IX -** https://www.epa.gov/sfbay-delta/sf-bay-water-quality-improvement-fund
9. **North Bay Watershed Association –** http://nbwatershed.org/projects/project-grants
10. **California Coastal Conservancy -** http://scc.ca.gov/grants The Conservancy may awards grants to public agencies and 501(c)(3) nonprofit organizations whose purposes are consistent with the Conservancy's enabling legislation – **Division 21 of the California Public Resources Code**. Projects must also be consistent with the Conservancy's **Project Selection Criteria**.
11. **Bay Conservation and Development Commission (BCDC) –** provides support, guidance, tools, and information to help agencies and organizations understand, communicate, and begin to address complex climate change issues. The ART project helps to identify and assess the community assets and natural resources that are most at risk to climate impacts, in particular, sea level rise (SLR) and storm surge.
12. **Marin Watersheds** http://www.marinwatersheds.org/funding.html
13. **Marin Fish & Wildlife –** grants for up to $5,000 for equipment.

Appendix C – Piper Park Marsh Resiliency Proposal Background

Environmental Forum of Marin Master Class

Kathi deFremery, Elizabeth Clark and Alan Jones, authors of this report, are participants in the 43rd Environmental Forum of Marin's (EFM) Master Class. EFM educates environmental advocates who address issues of climate, habitat and natural ecosystems to help preserve a healthy environment for future generations. http://www.marinefm.org/Master-Class

Elizabeth and Kathi are Larkspur residents; Alan lives near Bothin Marsh in Mill Valley, which has challenges similar to Piper Park Marsh. Bothin Marsh is the site of a Marin County demonstration project, "Coyote Creek to Bothin Marsh Dredge Sediment Beneficial Reuse Project" which plans to use Coyote Creek dredge material to augment the natural sediment accretion process in the marsh. http://www.onetam.org/programs-and-projects/bothin-marsh.

We chose to focus on Piper Park Marsh after learning that in spite of its many valuable attributes and its contribution to reducing greenhouse gases, no one was taking responsibility to assure its continued resiliency.

Kathi deFremery - defremfm@pacbell.net
Elizabeth Clark – bclark@bclark-la.com
Alan Jones - ajarchitect@comcast.net

Our Process

1. We consulted with a number of well-known, qualified wetland professionals in search of feasible and effective methods for establishing baseline data and an easy-to-maintain ongoing monitoring routine. Each wetlands expert visited the marsh to make first hand observations.
2. We were advised to focus on broad metrics that would provide a background for understanding the direction and magnitude of long term changes in the marsh.
3. We explored a considerable amount of data and information about marsh habitat, benefits, vulnerabilities, likely effects of sea level rise, funding sources, public meetings and workshops, and community groups – especially those focused on Corte Madera Creek and its watershed.
4. In an effort to make stewardship sustainable over time we call for periodic review of the Resiliency Plan and inclusion of the marsh as an asset for meeting climate change goals. Additionally we encourage the City to rezone to OS to make the value of this community asset more apparent and worthy of public preservation and support.

Acknowledgements:

Our sincere thanks to the following community members, wetlands experts and Larkspur staff who gave generously of their time, expertise and enthusiasm in helping us draft this proposal!

Julian Skinner, Director of Public Works, City of Larkspur
Phil Williams, hydrologist (retired) Philip Williams and Associates, Ltd.
Phyllis Faber, wetlands biologist and author (retired)
Roger Leventhal, Marin County Department of Public Works Director & BayWAVE Study author
Sandy Guldman, Gerhard Epke, Friends of Corte Madera Creek
Rachael Kamman, PE – Kamman Hydrology & Engineering, Inc.
Sarah Phillips, Marin Resource Conservation District, Program Manager
Boardwalk One Residents in support of marsh preservation

Appendix D – Letters of Support

Wetlands Experts

To Whom It May Concern:
I join members of the Environmental Forum of Marin, Master Class 43, in calling on the City of Larkspur to undertake active stewardship of Piper Park Marsh and adopt a resiliency plan for the marsh as detailed in the attached "Piper Park Marsh Resiliency Proposal".

(s) Phil Williams, hydrologist (retired)
(s) Phyllis Faber, wetlands biologist (retired)
(s) Sandy Guldman, Friends of Corte Madera Creek Watershed
(s) Rachel Kamman, PE, hydrologist
(s) Sarah Phillips, Marin Resource Conservation District, Program Manager

Concerned Citizens

To Whom It May Concern:

I join members of the Environmental Forum of Marin, Master Class 43, in calling on the City of Larkspur to undertake active stewardship of Piper Park Marsh and adopt a resiliency plan for the marsh as detailed in the attached "Piper Park Marsh Resiliency Proposal".

PRINT NAME:	SIGNATURE:
p Linda Rikli	s
p Kathleen Raleigh	s
p Hull	s Herbert B Lanner
p Claudia Wilson	s
p Joan Wilson	s
p William Ryde	s
p Sandy + Gerrit Blauvelt	s
p Bill McMillan	s
p	s Kim Sheeran
p Chris Albinson	s
p Pascale Soumoy	s Pascale Soumoy

Endnotes

[i] Natural Shorelines

http://www.adaptingtorisingtides.org/howto/art-approach
http://www.adaptingtorisingtides.org/portfolio/natural-areas
The natural shorelines in the ART Subregional Project area range from fully tidal marshes that are either exposed to the open Bay or are protected from wave and tidal energy by offshore mudflats, to muted tidal marshes and ponds that are protected from the Bay by berms and levees and have water levels controlled by tide gates and other structures.

These natural shoreline systems provide ecosystem service benefits such as flood risk reduction, water quality improvement, habitat for threatened and endangered species, carbon sequestration, and opportunities for education and interpretation.

ART evaluated the vulnerability and risk of twelve tidal and five managed marshes in collaboration with PRBO, Point Blue Conservation Science. The assessment used an online decision support tool developed by Point Blue (http://data.prbo.org/apps/sfbslr/). This tool allowed for analysis of several critical factors, including the rate of sea level rise, the current elevation of the natural shoreline area relative to the tidal frame (the elevation range between the lowest and highest tides), mineral sediment availability either from the Bay or nearby tributaries, and the rate of organic matter accumulation.

Key Findings
Historically, marshes have kept pace with sea level rise by accumulating mineral sediment and by moving upward and landward in the tidal frame, but current projections suggest that the rate of sea level rise is accelerating and the concentration of Bay suspended sediment is declining. Furthermore, much of the Bay shoreline, including the project area shoreline, is fairly well developed and there are few opportunities for inland migration.

The PRBO online decision support tool findings are consistent with these regional projections: tidal marshes in the project area will "downshift" from higher to lower elevation marsh habitat (e.g., from high to mid-marsh or mid- to low-marsh), and eventually to mudflat. Under the more pessimistic sediment supply scenario (low availability), all marshes in the project area will transition to mudflat by 2050. Under the high sediment scenario only one marsh will be lost by 2050 and only one additional marsh will be lost by 2090.

[ii] City of Larkspur's Land Use Designation, Shoreline & Marsh Conservation as described in Chapter 6 of the Larkspur General Plan:

"Open Space Goals, Policies, and Programs

Goal 1: Preserve and enhance a variety of open space features including ridgelines, the wetlands along the Bay and the creeks, wildlife habitats, view corridors, and other amenities which contribute to a sense of openness in Larkspur.

Goal 2: Maintain Corte Madera and Southern Heights Ridges as community separators.

Policy a: Work with local and regional open space agencies and interest groups to develop an open space preservation strategy.

Action Program [1]: Map and rank open space features as to their value to the community.
Action Program [2]: Support the efforts of the Marin County Open Space District to acquire more open space in the Larkspur Sphere of Influence. Action Program [3] Identify financing mechanisms to acquire privately held lands designated for future open space. Action Program [4]: Educate school children and the general public about Larkspur's open space resources.

Policy b: Designate and preserve in open space the areas so shown on the General Plan Land Use map. They include Those portions of the Northridge that are above the 350-foot elevation, Baltimore canyon, the Piedmont and Redwood Avenue areas, Big and Little King Mountains and their saddle area, the Tubb Lake watershed, and the ridge above the old quarries on the San Quentin Peninsula.

Policy c: Designate and preserve in Shoreline/Marsh Conservation area the wetlands along Corte Madera Creek and at Piper Park, Redwood High School, and the Larkspur Ferry Terminal, and the shoreline between East Sir Francis Drake Boulevard and the Bay waters.

Action Program [5]: Rezone publicly-owned or dedicated open space areas to appropriate zone districts that indicate that their potential for development has been eliminated. The Land Use and Circulation Plan designates the areas listed in Policies "b" and "c" as Open Space, Shoreline/Marsh Conservation, or Parkland. Most of these areas are in public ownership or are required to remain in open space as conditions of development approval. However, except for the parkland, the underlying zoning suggests there is potential for development (e.g., the Northridge Preserve is zoned RMP, Residential Master Plan). In areas where the potential for development has been eliminated, the zoning should reflect a commitment to keeping the land open."

[iii] **Agencies/Organizations**

with Interest and/or Jurisdiction	**Contact**
Larkspur Public Works Department	Julian Skinner, Director
Larkspur-Corte Madera School District	LCMSD Board of Trustees
Larkspur City Council	Mayor Kevin Haroff & Council Member Way
US Army Corps of Engineers	Arijs A. Rakstins, Deputy Project Manager, Zone 9
Marin County Flood Control and Water Conservation District	Felix Meneau, Zone 9 Engineer
Bay Conservation & Development Commission (BCDC)	Brenda Goeden, Jim McGrath
Marin County BayWAVE Study	Chris Choo, Roger Leventhal
Friends of Corte Madera Creek*	Sandra Guldman, Gerhard Epke
Hydrologists	Philip Williams, Rachael Kamman
Wetlands Biologist	Phyllis Faber

** Also see Friends of Corte Madera Creek Watershed's "Resources" list of agencies with jurisdiction on Corte Madera Creek* http://friendsofcortemaderacreek.org/new_site/resources

[iv] **"White Paper on Carbon Sequestration and Tidal Salt Marsh Restoration",** Lynne Trulio, Ph.D., Professor, Department of Environmental Studies, San Jose State University, San Jose, CA 95192-0115 John Callaway, Ph.D., Professor, Department of Environmental Science, University of San Francisco, San Francisco, CA 94117-1080 Steve Crooks, Ph.D., Geomorphologist, Philip Williams and Associates, San Francisco, CA 94108-2404, December 20, 2007 ; pg 2, ¶3 *"… Recent data from deeper cores at Greco Island, an ancient marsh in the South Bay, representing a 100-year time span showed organic accumulation averaging 180 to 200 g C/m2 /yr range (Callaway and Drexler, unpublished data). These are currently the best estimates of longer-term carbon sequestration in South Bay marshes."*

[v] **Frontiers in Ecology and the Environment article re: carbon sequestration.**
http://www.readcube.com/articles/10.1890/110004?r3_referer=wol&tracking_action=preview_click&show_checkout=1&purchase_referrer=www.habitat.noaa.gov&purchase_site_license=LICENSE_DENIED_NO_CUSTOMER

THE ECOLOGICAL SOCIETY OF AMERICA
Frontiers in Ecology and the Environment

Review: A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2

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[vi] **Management of Marsh-Upland Transitional Habitats** http://baylandsgoals.org/wp-content/uploads/2015/10/2015_Marsh-Upland-Transition_Management.pdf

[vii] **Disadvantages of Armoring Shorelines**
http://www.oyster-restoration.org/wp-content/uploads/2012/06/Pace-FSU.pdf

- Increased erosion to adjacent properties
- Reflect wave energy
- Loss of inter-tidal habitat
- Loss of sandy beach
- Decrease amount of organic matter needed for maintenance of wetlands
- Vertical erosion in front of seawall

Dr. Chris Boyd, MASGC

Managing Coastal Armoring and Climate Change Adaptation in the 21st Century, Stanford Law School http://www.oyster-restoration.org/wp-content/uploads/2012/06/CalCoastArmor-FULL-REPORT-6.17.15.pdf

"…increased armoring will cause faster and more widespread loss of the beaches and ecosystems that make the coast so valuable to many Californians," p.3.

viii **State of California's sea level rise assumptions** – In March 2013, the State of California adopted the 2012 National Research Council Report "Sea-Level Rise for the Coasts of California, Oregon, and Washington." This report identifies projected SLR for 2030/near term as 2-12 inches (4-30 cm), 2050/medium term as 5-24 inches (12-61 cm) and 2100/long term as 17-66 inches (42-167 cm). http://www.marincounty.org/main/baywave/sea-level-rise-scenarios

ix **Future San Francisco Bay Tidal Marshes – A Climate-Smart Planning Tool**
http://data.prbo.org/apps/sfbslr/

x **Suggested Issues for Further Study**, based on current marsh observations and research:

- Infrastructure & Easements. Identify and avoid infrastructure and easements in the marsh.
- Corte Madera Creek Watershed Hydrology Changes. Watershed-wide storm water drainage projects that increase flow volumes and velocities in Corte Madera Creek should be analyzed to neutralize effects on marsh and creek edge properties vulnerable to flooding.
- Low Impact Development Policy (LID) - Adoption of Limited Impact Development (LID) policies throughout the watershed would help reduce storm water flow increases from upstream sources, thereby protecting downstream floodplains, wetlands and shorelines, and reducing marsh/ creek bank erosion and channel shape changes.
- Piper Park Marsh Hydrology. Man-made ditches were dug in the ostensibly for mosquito control in the 1940's, the purpose of which was to partially drain the marsh, effectively altering its natural hydrology. Does the ditch (which passes through the City's marsh and through Boardwalk One properties) interfere with healthy marsh hydrology, or does it exacerbate scouring and faster water movement? What current benefits does it have?
- Tide Level Changes. Monitor tide level changes as they relate to sea level rise and/vs changes in storm water volume in Corte Madera Creek.
- Piper Park Marsh Cordgrass & Erosion. Are rates of erosion within the marsh changing over time? Do changes in erosion rates scour banks such that cordgrass is uprooted? Is the cordgrass in the marsh healthy and holding the banks?
- Marsh Substrate Structure. Is marsh soil structure healthy? Are soil organisms and bivalves healthy/numerous/aiding soil stability? Does soil instability play a role in higher erosion rates & cord grass viability?
- Former Larkspur Landfill & Water Quality. Determine former landfill disturbance effects on water quality and marsh viability.
- Sediment Load. Determine whether sediment load in Corte Madera Creek marsh contributes to sustainable sediment accretion in marsh. Marsh sediment accretion/loss should be evaluated and mitigated.
- Water Quality. Elements affecting water quality in Corte Madera Creek and Piper Park marsh should be identified, such as silt, oil, sewage spills, herbicides, pesticides.
- Biological Inventory of Marsh. An inventory of current marsh and upland biota (flora & fauna) should be part of a more detailed assessment.
- Special Status Species. Marsh and adjacent upland conditions for nesting and forage of special status species should be evaluated and improved as necessary.
- Litter. Sources of litter accumulation in marsh should be identified and mitigated. Adjacent park and school properties propagate litter that blows into the marsh. Litter carried downstream in Corte Madera Creek also reaches the marsh.
- Rubber Pellets from Artificial Turf. Hall Middle School's artificial turf field currently is the source of great quantities of rubber pellets migrating into a drainage ditch that flows to the marsh. Removal and replacement of that field is slated to occur soon (in 2017?), which procedure should be closely controlled to avoid rubber pellets blowing/migrating into the marsh drainage. A permanent barrier, such as a concrete curb, should be installed along the edge of the newly replaced turf to avoid synthetic material blowing into/entering the drainage or the marsh.
- Non-Native Grasses in Marsh. Areas of non-native grasses in the marsh appear to be increasing. Determine source. If source is Piper Park turf re-seeding efforts, prevent grass seed from blowing entering marsh.
- Dredging Larkspur Creek. Riviera home owners along Larkspur Creek routinely dredge the creek to maintain navigability. Effects on the marsh should be identified and mitigated.

- Boardwalk One Homes. Long term viability of homes coexisting with the marsh should be evaluated in terms of developing sustainable ways for people to live with flooding, which events will increase with Climate Change. Effects of homes, human activities and parking lot on the marsh should be identified.
- Erosion Near Homes. Rates of marsh, channel and creek erosion on both City-owned marsh and private Boardwalk One properties may be increasing. Homes are vulnerable to erosion, as they are built on mud sills. Appropriate (soft & hard) methods of erosion control need to be coordinated with similar treatments so as to be continuous on Boardwalk properties and throughout the City-owned marsh.
- Functional Public Art. Piper Park Marsh is valuable open space, enjoyed by park users, students and residents alike. Depending on whether erosion control measures are indicated for the marsh, there are opportunities that could involve the community in constructing soft "watershed sculptures" made of natural, native materials that can effectively combine art, science and engineering to control erosion and help accrete silt.

[xi] Why Monitor?

http://www.tidalmarshmonitoring.org/why-monitor.php

Tools of Monitoring Science

The science of restoration requires two basic tools (Keddy 2000):

- The ability to manipulate ecosystems to recreate a desired community
- The ability to evaluate whether the manipulations have produced the desired change

This second tool is often referred to as restoration monitoring. Restoration monitoring begins with a strong knowledge of historical communities, the habitat and ecological processes required to support desired communities and clear goals that describe the desired change. Monitoring has been described as the financial equivalent of accounting, and is critical for project evaluation (Lee 1993). For land managers, monitoring also informs their understanding of what resources are present at a site, what conditions favor desirable habitat for trust species, and what effects management actions are having on habitat and/or fish and wildlife populations. In order to increase the likelihood of achieving restoration goals, there remains a great need for monitoring and adaptive management. However, even the most strategically planned restoration program can yield surprising and unexpected results (Zedler 2005). The cumulative effects of restorations may have synergistic, additive, unknown, or immeasurable results (Johnson 2007). Long-term science-based monitoring can be a strong tool in addressing these key uncertainties (Woo et al. 2011).

Benefits of Monitoring:

- tracks trends over time
- provides information on restoration progress
- provides baseline for changing conditions
- program effectiveness
- measure of accountability
- justifies funds spent to restore
- improves understanding of action-based results
- serves to inform adaptive management decisions in a timely manner
- allows interventions when unexpected changes occur
- improves knowledge of coastal adaptation and resilience
- documents effects of climate change
- provides additive learning
- informs the collective restoration community

References

Johnson, G.E. (editor.). 2007. Evaluating cumulative ecosystem response to restoration projects in the Columbia River estuary, Annual Report 2006. PNNL-16561. Report to the U.S. Army Corps of Engineers, Portland District, by Pacific Northwest National Laboratory, Richland, Washington.

Keddy, P. A. 2000. Wetland ecology: Principles and conservation. Cambridge University Press, 614 pp.

Lee, K. 1993. Compass and Gyroscope: integrating science and politics for the environment. Washington, D.C: Island Press, 255 pp.

Woo, I., R.Fuller, M. Iglecia, K. Turner, J. Takekawa. 2011. The Nature Conservancy: Port Susan Bay Estuary Restoration Monitoring Plan. Unpublished report to The Nature Conservancy. US Geological Survey, Western Ecological Research Center, 505 Azuar Drive Vallejo CA 94592. 115 pp.

Zedler, J.B. 2005. Ecological restoration: guidance from theory. San Francisco Estuary and Watershed Science 3(2):1-31.

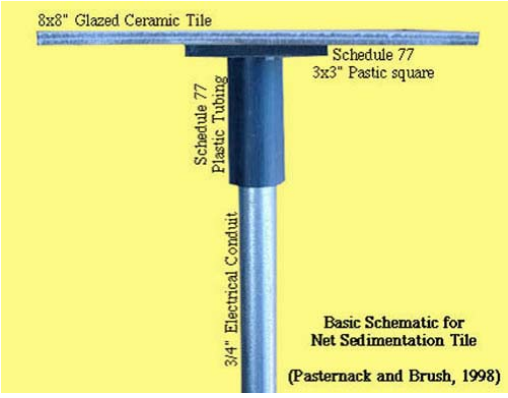
[xii] California Landscape Conservation Cooperative Tidal Marsh Elevation Models

http://climate.calcommons.org/dataset/tidal-marsh-elevation-models

[xiii] Sediment Plates

http://www.tidalmarshmonitoring.org/monitoring-methods-sediment-plates.php

Sediment plates are typically used in areas of soft sediment, where a hard plate is placed flush with the sediment surface and accumulation is measured on top of the plate. Plates can be made from a variety of materials including tiles and if the plate is anchored to a rod driven into the ground, erosion can also be measured, by measuring the distance from the sediment surface to the top of the fixed plate.



Benefits: easy, inexpensive, possible to measure accumulation and erosion, reduces error of rod penetrating into soft sediments, mm resolution, can be used to calculate sediment volume

Limitations: plates can be undercut

Installation and Measurement Methods: A comprehensive source for sediment plate installation and measurements can be found at UC Davis professor, Dr. Gregory B. Pasternack's Field and Lab Protocols website. Sediment plates can be surveyed so that sediment surface elevation changes can be tracked over time.
Other references include: Christiansen, T., P.L. Wiberg, and T.G. Milligan. 2000. Flow and Sediment Transport on a Tidal Salt Marsh Surface. Estuarine, Coastal and Shelf Science. 50: 315-331.
Neubauer, S.C., I.C. Anderson, J.A. Constantine and S.A. Kuehl. 2002. Sediment Deposition and Accretion in a Mid-Atlantic (USA) Tidal Freshwater Marsh. Estuarine, Coastal and Shelf Science. 54: 713-727.
Pasternack, G.B. and G.S. Brush. 1998. Sedimentation Cycles in a River-Mouth Tidal Freshwater Marsh. Estuaries. 21: 407-415.
Data Entry and Analysis: Data entry and analysis is similar to methods used for sediment pins, marker horizons and SETs and is typically focused on measuring change over time. The following graph gives an example of this using sediment pin data at a restoration site within San Pablo Bay, CA.

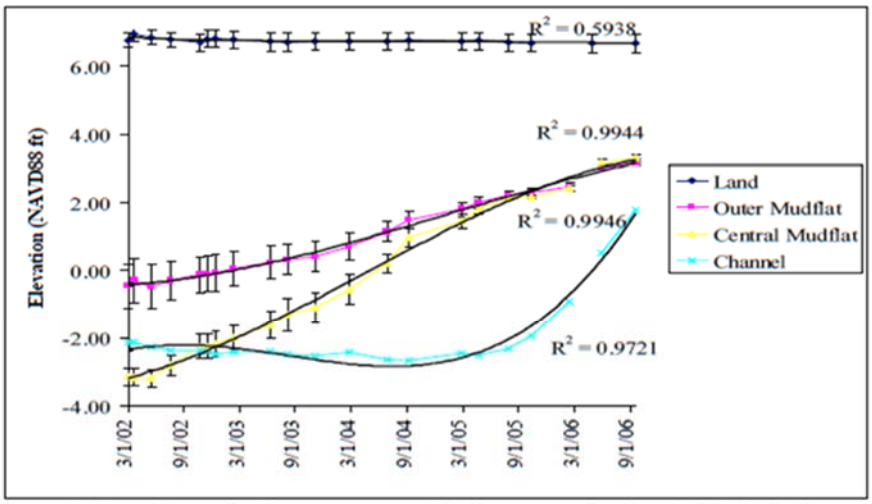


Figure 1. Example graphical representation of sediment pin data from Tubbs Setback Restoration Project, CA (Woo et al 2007). Sediment elevation (NAVD88 ft) at 24 sediment pin locations from March 2002 to September 2006. After 3.5 years, the central and outer mudflat areas reached an intersection point despite an almost 3 ft difference in average initial elevation. The channel has shown an almost 3 ft increase in elevation since 2005.

References: Woo, I., J. Y. Takekawa, A. Rowan, R. Gardiner, O. Bernstein, and G. T. Block. 2007. The Tubbs Setback Restoration Project: Final Report. U. S. Geological Survey, Unpubl. Progress Rep. Vallejo, CA. 75p.

[xiv] **Change in Tidal Prism**

http://evidence.environmentagency.gov.uk/FCERM/en/SC060065/Decisiontree/Hydromorphologicalchanges/H16.aspx

[xv] **"Vegetation Transects and Survey Plot Standard Operating Procedures"**

http://www.tidalmarshmonitoring.org/monitoring-methods-vegetation.php