Thin Layer Placement: State of the Science

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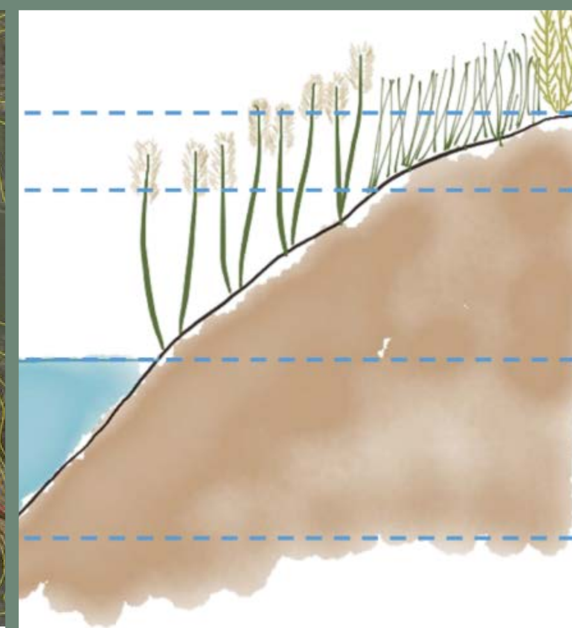
Jacob F. Berkowitz[1]
Candice D. Piercy[1]
Tim L. Welp[1]

Collaborators:

Susan Bailey[1], Monica A. Chasten[2], Dave Golden[3], Jackie Jahn[4], Paul Schroeder[1], Zachary Tyler[1], Christine VanZomeren[1], Elizabeth Murray[1], Damarys Acadevo-Mackey[1], John White[5], and Metthea Yepsen[6]
[1]USACE Engineer Research and Development Center
[2]USACE Philadelphia District
[3]New Jersey Department of Environmental Protection
[4]Greenvest LLC
[5]Louisiana State University
[6]The Nature Conservancy



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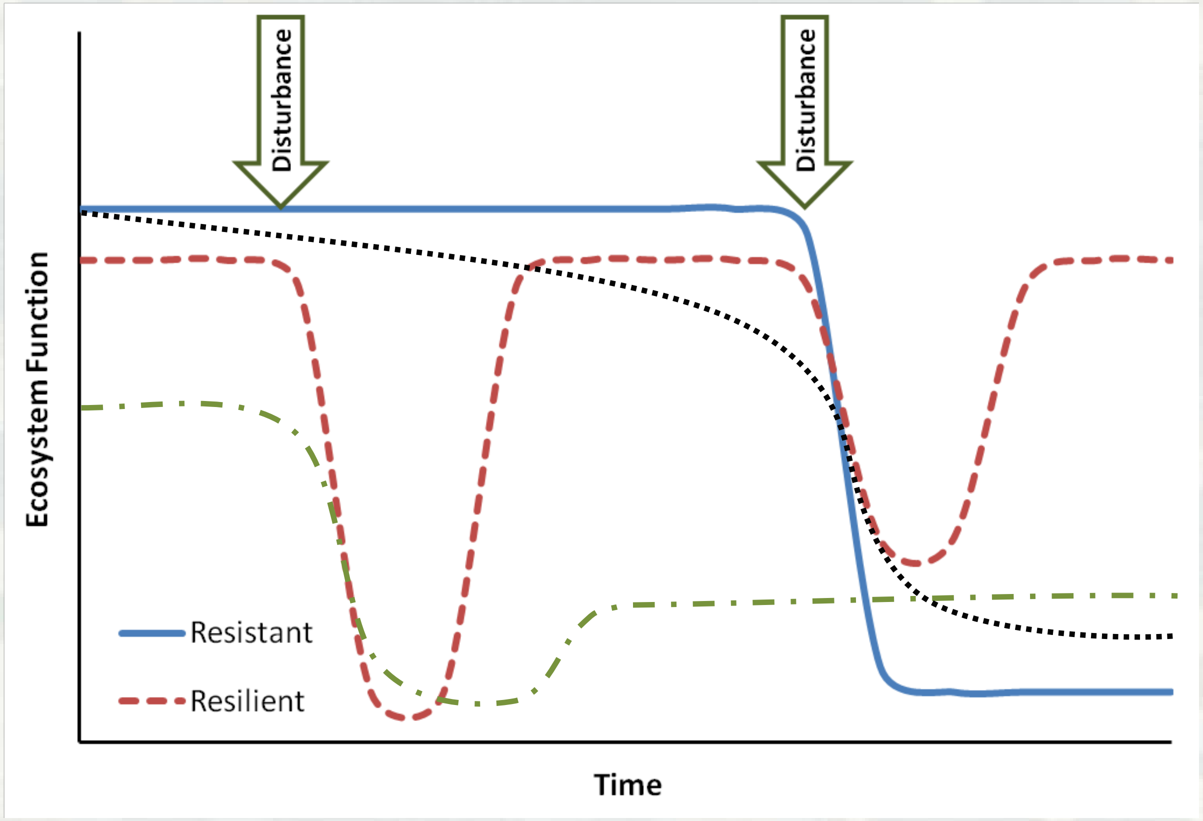
Presentation objective: highlight current state of the science, identify knowledge gaps, and introduce ongoing ERDC research to inform TLP practitioners.

- Planning and design
- Physical and ecological response
- Monitoring
- Ongoing research

TLP planning and design

TLP planning and design:
key questions???



- How do we identify degraded systems?
- How to determine drivers of the degradation?
- What actions do we take to improve outcomes?
- How do we increase function in severely degraded systems?

TLP planning and design: How can we restore degraded ecosystems?

- Remove barriers (culverts, levees, tide gates)
  - Restore hydrologic connectivity
  - Facilitate sediment transport
- Remove ditches/depressions
  - Restore natural hydrograph (overdrained or oversaturated)
  - Remove local sediment sinks, maintain sediment is system
- Raise elevation
  - Decrease inundation, alleviates flooding and sulfide stress (marshes)
  - Increase littoral exposure (SAV)
- Mitigate vegetation stress
  - Herbivory, drought, waterlogging, nutrient/contaminants
  - Invasive species

TLP planning and design: When do we use thin layer?

- Thin layer is applicable in areas where
  - Sediment inputs are lacking (e.g. upstream dams)
  - Elevation has been lost (e.g. die off caused collapse of marsh platform)
  - Sea level rise is too great to allow for natural sediment accumulation and biological accretion
- Not applicable where
  - Main cause of degradation not caused by sediment supply or elevation deficiencies (e.g. invasive species)

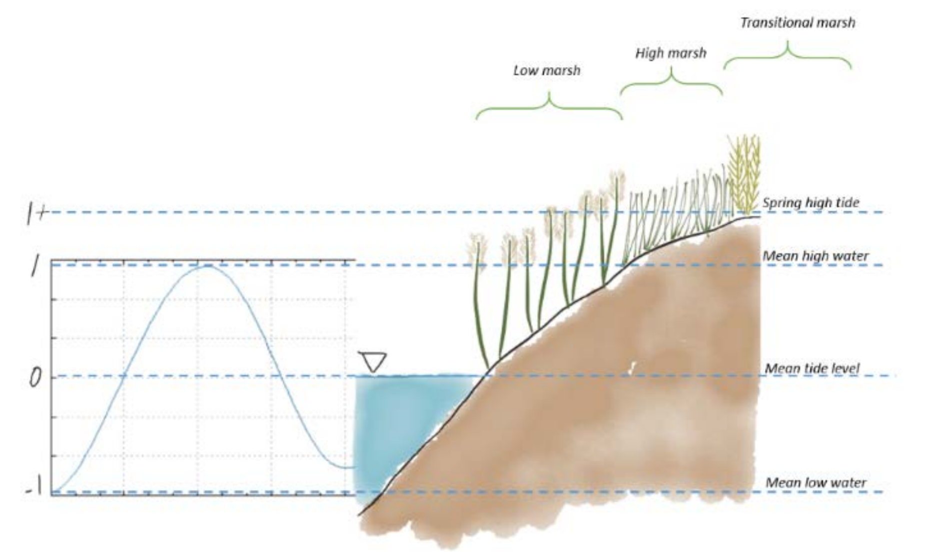
TLP planning and design: Where do we place dredged sediments?

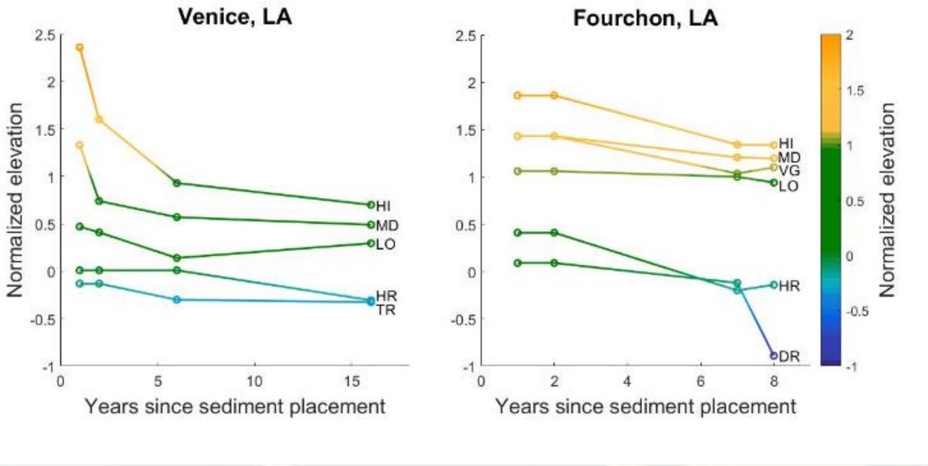
- Marshes aren’t flat and sediment slurry flows
- Large scale field data collection efforts are time consuming and difficult
- On-site work can be tricky
  - Gradients hard to determine
  - Soft substrate
  - Ditches/tidal creeks
  - Hidden drainages

TLP physical and ecological response

Physical response to TLP: How much sediment do we add to reach our goal?

- Biological vs. construction target elevations
  - TLP within upper intertidal range results in greatest marsh resilience (VanZomeren and Piercy, *in review*)
  - Must consider elevation relative to the tide changes over time (SLR, subsidence)
- Determining goal elevation
  - Goals for restoration (low versus high marsh)
  - Relative sea level rise rate
  - Settling, consolidation, and compression (see Welp et al.)

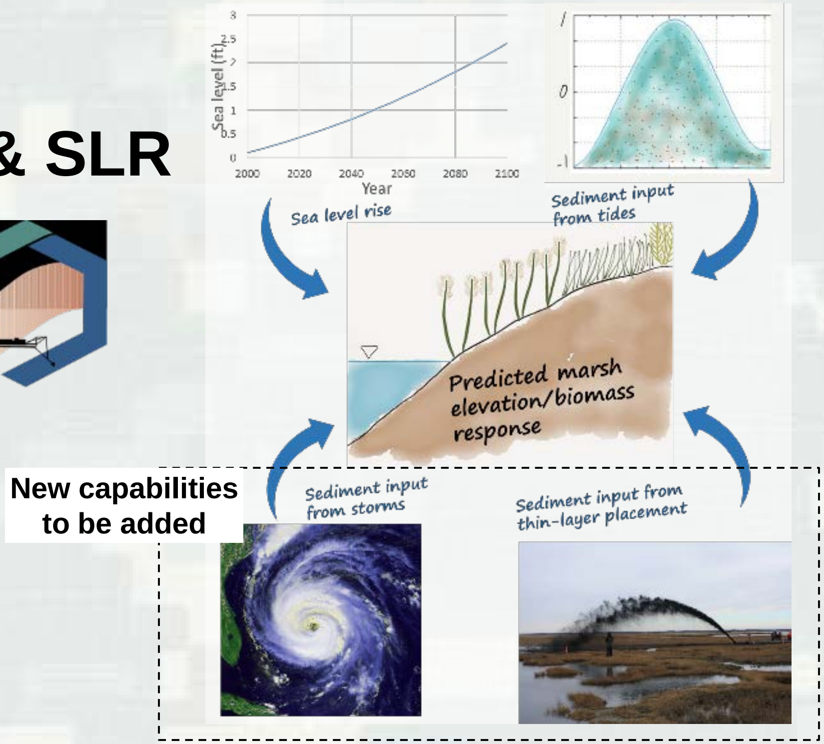


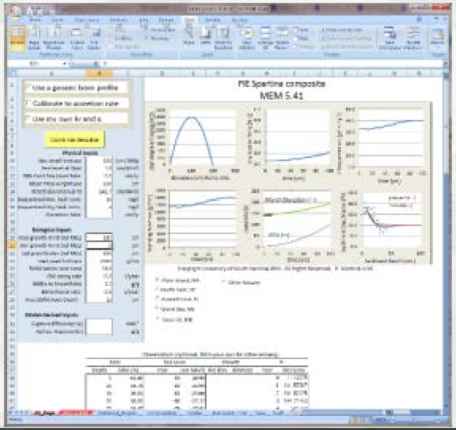


Coupled physical and biological responses to TLP: improving predictions

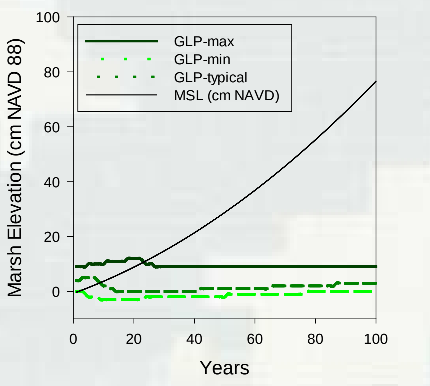
Long-term marsh elevation response to DM placement & SLR

- PDT Lead: Candice Piercy
- Team: University of South Carolina - Dr. James Morris, Christine VanZomeren
- Marsh Equilibrium Model (MEM) projects future conditions based on biomass and accretion rates
- Goal: Update MEM to predict the response to sediment inputs from storms and TLP





Good Luck Point Predicted Marsh Elevation



TLP ecological Response: what do we know?

Ray (2007) provides a review of thin layer placement case studies in marshes

Sediment applications helps achieve restoration goals by maintaining elevation despite ongoing subsidence or sea level rise (Broome et al., 1988)

Direct placement remains challenging; need to achieve target elevations while maintaining or establishing plant communities that stabilize marsh platform (DeLaune et al., 1994)

Most studies focus on vegetation (Pezeshki et al., 1992; others)

Reimold et al. (1978) - *Spartina alterniflora* recovered following the placement of 23 cm of dredged materials on the marsh surface

Cahoon and Cowan (1987, 1988) - up to 38 cm; plants smothered after 14 months; recovered within 48 months (LaSalle 1992)

DeLaune (1990) - 10 cm placement; increased biomass and shoot density

Thick layers reduced or prevented plant recovery (Schrift et al., 2008)

Mendelssohn and Kuhn (2003) - *rapidly subsiding marsh*; positive response

up to 60 cm; recovery a function of thickness; better aeration, more nutrients

TLP ecological Response: what do we know?

Wilbur (1992) - 10 years after placement → 5 to 10 cm layer increased elevation by 3 to 10 cm; decreased aboveground biomass, bulk density, organic matter

Ford et al., (1999) - placement of 2.3 cm → 10X sedimentation increase; 1 year recovery of soil bulk density, organic matter, vegetation

Croft et al. (2006) - 10 cm layers increased plant density in deteriorated areas; increased redox potentials, texture and composition returned to pre-placement conditions; potential decrease in infaunal abundance

Application thickness function of the habitat type (Jurik et al. 1994):

→ freshwater wetlands tolerate a few cm

→ coastal marshes tolerate 10s of cm

Monitoring and ongoing research

Restoring and Sustaining Ecological Function in Coastal Marshes Affected by Sea Level Rise

- **PDT Lead:** Elizabeth Murray, Damarys Acevedo-Mackey
- **Product Development Team:** Jacob Berkowitz, Candice Piercy, Christine VanZomeren, Todd Swannack, Tommy Berry,
- **Purpose:** Develop an empirically supported framework delineating the ecological and environmental considerations relevant to restoration/maintenance of salt marshes for the purpose of offsetting effects of sea level rise.
- To do that we must address efficacy of coastal salt marsh restoration methods, including Thin Layer Placement.

Field Case Studies for TLP as Restoration Technique

Case Studies fill data gaps with new information and identify implementation complexities.

Complex restoration:

- TLP in back marsh areas
- Runnel excavation
- Marsh scarp erosion protections

Narrow River RI

Avalon, NJ

- ~35 acre marsh placement with Federal navigational dredged material
- Targeted thinner lifts in vegetated areas (~10-15 cm) and thicker lifts in expanded pannes and pools
- Multi-organizational monitoring effort

Seal Beach CA

10-acre low salt marsh TLP project supporting endangered species habitat

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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US Dept of State Geographer
Image Landsat / Copernicus
Google earth

Vegetation at Avalon

6 months

9 months

18 months

TLP at Narrow River, RI

TLP material

Original marsh surface

Monitoring: Identifying degradation

Table 2. Indicators of salt marsh distress at each case study location.

Observation	**Narrow River**	**Avalon**	**Seal Beach**
Bank Erosion	X	X	
Impounded Water	X	X	
Pool/Panne Expansion	X	X	
Ratio of Water/Mudflat to Vegetation		X	
Low Faunal Use		X	X
Loss of High Marsh Species	X	X	
Unhealthy Vegetation	X	X	X
Presences of Invasive Species	X		

VanZomeren and Murray (In Review)

Monitoring: Degradation metrics

Table 3. Metrics and measurements used to assess salt marsh health at each case study location.

Metric or Measurement	Narrow River	Avalon	Seal Beach
Aerial Imagery	X	X	X
Elevation Survey		X	X
Accretion Rate	X		X
Subsidence			X
Hydrology[ǂ]	X	X	X
Sediment Budget			X
Land Use	X		X
Avifauna Species	X	X	X
Infauna Species		X	
Epifaunal Macroinvertebrates		X	
Nekton Species		X	
Vegetation Survey*	X	X	X
Soil Salinity	X		
Soil Bearing Capacity	X		

VanZomeren and Murray (In Review)

Case studies: Design criteria

Table 4. Criteria utilized in designing thin layer application of dredged sediment to distresses marshes at each case study location.

Design Criteria	**Narrow River**	**Avalon**	**Seal Beach**
Site Access	X	X	X
Feasibility	X	X	X
Target High Marsh Elevation	X	X	
Thickness of Sediment			X
Target Slope	X		
Contour and Drainage	X	X	
Avoidance Creeks/Channels	X	X	
Sediment Properties	X	X	X
Sediment Containment		X	X

VanZomeren and Murray (In Review)

Monitoring metrics

Table 5. Metrics utilized to monitoring the effectiveness of thin layer application of dredged sediment to distressed marshes at each case study location.

Monitoring Metrics	Narrow River	Avalon	Seal Beach
Elevation/Compaction	X	X	X
Depth & Duration Flooding		X	
Tidal Creek Reformation			X
Vegetation Community	X	X	X
Avifauna Species	X	X	X
Nekton Species	X	X	
Invertebrate Species		X	X
Benthic Infauna Species		X	
Soil Salinity	X	X	
Carbon Sequestration			X

In addition, our group is examining soil physical, nutrient, and biogeochemical responses; including microbial activities as early indicators of marsh recovery

A technical note has been drafted outlined to identify monitoring approaches for future efforts

(Murray, Berkowitz, Piercy, In Review)

Relevant publications

-Berkowitz et al. 2017. Marsh restoration using thin layer sediment addition: Initial soil evaluation. Wetland Science and Practice.

-Vanzomeren et al. In Review. Literature review of thin layer placement studies. ERDC TR-X.

-Berkowitz et al. In Review. Thin Layer Placement: Technical definition for US Army Corps of Engineers applications. ERDC-TN-X.

-Berkowitz et al. In Review. Evaluation of coastal wetland soil properties in a degrading marsh. Estuarine Coastal & Shelf Science.

-Berkowitz, VanZomeren. In Review. Short term response to Thin Layer Placement. Ecological Indicators.

-Murray, Berkowitz, Piercy. In Review. Application of thin layer sediment placement for wetland restoration, enhancement, and stabilization – monitoring approaches and considerations. ERDC TN-X.

-Vanzomeren, Murray. In Review. Ecological Function of Coastal Salt Marshes in Response to Sea Level Rise: Webinar Series Summary. ERDC TN-X.

Take homes

1. Most research focused on marshes
   - ► Vegetation responds well to TLP <30 cm

2. Must consider project objectives in planning and design
   - ► Keep sediment in system; restore sediment dynamics

3. Additional tools under development
   - ► Marsh Equilibrium Model
   - ► Guidance for engineering, regulatory, monitoring
   - ► Case study results

Questions

Contact:
Jacob.F.Berkowitz@usace.army.mil
Candice.D.Piercy@usace.army.mil
Timothy.L.Welp@usace.army.mil

Definitions

Wilber 1992

Thin-layer Placement: has been used to describe thicknesses ranging from less than 0.5 in. to 3 ft, and in the context of both subtidal placement and marsh nourishment.

Since the ecological impact of placement thickness differs among habitats, Wilber concluded that the best definition of thin layer placement would be **placement of a thickness of dredged material that does not transform the receiving habitat's ecological functions.**

Definitions

Type of placement method is partly dependent on the goals of the project, whether creation, restoration, or enhancement of a wetland. (NRC's 1994 terminology)

- Creation is defined as "the construction or formation of a habitat of a different type than existed before the site was disturbed, or conversion of one habitat form to another."
- Restoration is the "return of a degraded or altered natural area or ecosystem to a close approximation of its condition prior to disturbance."
- Enhancement is the "improvement of one or more of the values (functions) of an existing habitat, usually one that has been degraded or disturbed."

Definitions

Louisiana Dept of Natural Resources
Coastal Wetlands Planning, Protection and Restoration Act, (CWPPRA)

- Marsh Nourishment: A relatively new restoration strategy that can refer to either the direct placement of a thin-layer of sediment through spray or hydraulic dredging or from the “spilling” of a thin-layer of sediment over marsh that is adjacent to an uncontained restoration project (LaPeyre et al. 2006).

LaPeyre, M., B. Piazza, and B. Gossman. 2006. Short and long-term effects of thin layer deposition of dredged material on marsh health (1434-05HQRU1561, RWO No. 77). NMFS – USGS Interagency Agreement No. HC-119. Year 1 Report. 32 pp. + appendices.

Definitions

DOTS Thin Layer Placement website (2015)

Thin Layer Placement broadly encompasses the purposeful placement of sediment or dredged material in a manner that produces a specific disposal layer thickness or ground surface elevation necessary to achieving the overall project objectives. In thin layer placement projects, disposal layer thickness typically ranges from a few centimeters to some fraction of a meter, depending upon the variation in ground surface or water levels at the site, and the functional objectives the placement is intended to achieve.

Ray (2007; others)

Placement of dredged material or other sediment to a thickness as little as a few centimeters up to 0.5 m

Definitions

Proposed technical definition for USACE activities:

Purposeful placement of thin layers of sediment (e.g., dredged material) in an environmentally acceptable manner to achieve a target elevation or thickness. Thin layer placement projects may include efforts to support infrastructure and/or create, maintain, enhance, or restore ecological function.


Where Do We Go From Here?
Questions?
Contact:
Jacob.F.Berkowitz@usace.army.mil
Candice.D.Piercy@usace.army.mil
Timothy.L.Welp@usace.army.mil