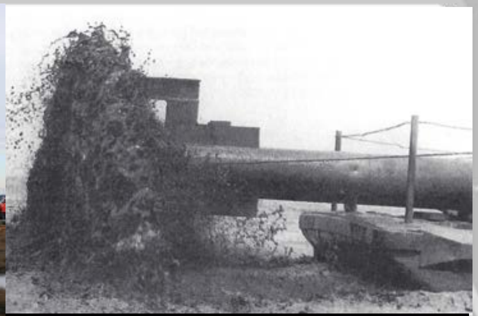

SUSTAINABLE SEDIMENT MANAGEMENT AND DREDGING SEMINAR

6-8 MARCH 2019

SAUSALITO, CA

Thin Layer Placement (TLP) Guidance

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ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

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What is “Thin Layer Placement?”

Table 1. Terms associated with TLP within available literature	
Term	Source
Thin layer placement	USACE, others
Artificial sediment enhancement	La Peyre et al., 2009
Thin layer deposition	Ford et al., 1999
Sediment subsidy	Mendelssohn and Kuhn, 2003
Sediment slurry application/addition/amendment	Schrift et al., 2008
Sediment enrichment	Slocum et al., 2005
Thin layer sediment renourishment	Croft et al., 2008
Thin layer disposal	USACE, others

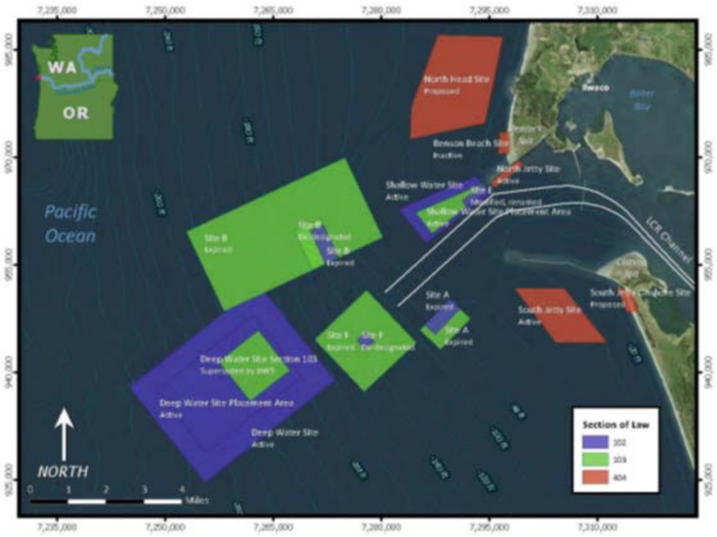
(Berkowitz et. al., 2019)

What is “Thin Layer Placement?”

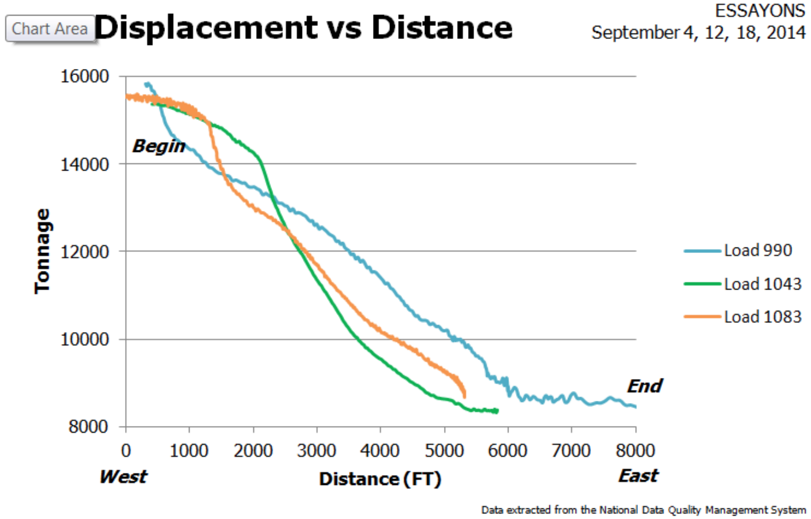
TLP means different things to different people: *Wetlands*

- Ray (2007; others) Placement of dredged material or other sediment to a thickness as little as a few centimeters up to 0.5 m.
- Wilber (1992) 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
- Marsh Nourishment (CPRA 2018): Marsh nourishment is typically accomplished by the placement of hydraulically dredged material into unconfined or confined vegetated marsh area(s), to the elevation (typically lower than marsh creation) required to achieve the project intertidal marsh objectives for the project design life.

TLP means different things to different people: *Open Water*

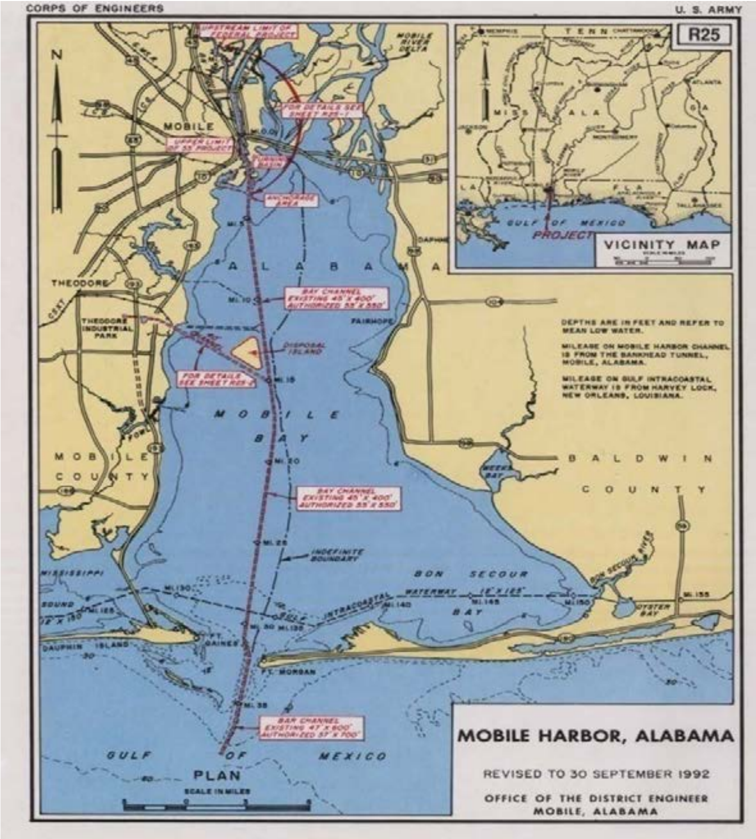


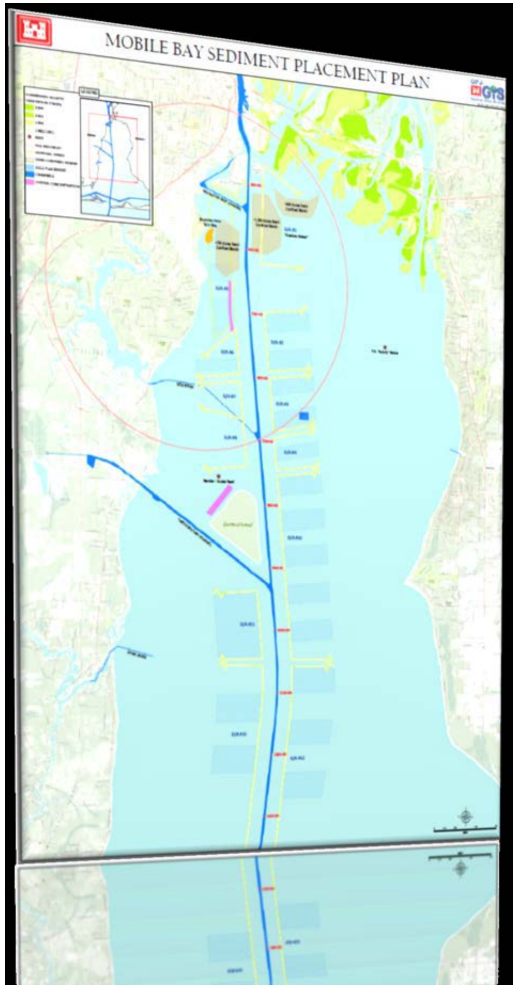
TLP Portland District Style



TLP means different things to different people: *Open Water*

TLP Mobile District Style





What is “Thin Layer Placement?”

Results from RSM Thin Layer Placement (TLP) Permitting and Regulation Meeting

Workshop TLP Definition:

Following list highlights important components of a revised TLP definition.

- **TLP sediment applications should be purposeful**
- **TLP sediments should not be limited to just dredged materials**
- **TLP projects can support infrastructure objectives**
- **TLP activities should be environmentally acceptable**
- **TLP projects provide opportunities to create, maintain, enhance, and/or restore ecological function**
- **The term “disposal” should not be incorporated into the TLP definition**
- **The TLP definition should not specify particular depths or application techniques**

http://rsm.usace.army.mil/techtransfer/FY17/TLP-Meeting-2017-11-APR/index.php

What is "Thin Layer Placement?"

Technical Definition for USACE:

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.

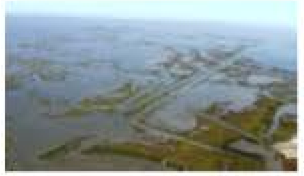
ERDC TN-19-1, February 2019: Thin Layer Placement: Technical Definition for U.S. Army Corps of Engineers Applications
DOER, RSM, DOTS, and EMRRP programs

https://erdc-library.erdc.dren.mil/xmlui/bitstream/handle/11681/32283/ERDC%20TN-19-1.pdf?sequence=1&isAllowed=y

THE CHRONOLOGY OF TLP

1926

Petroleum canals in Louisiana dredged by mechanical dredges that formed "spoil banks"



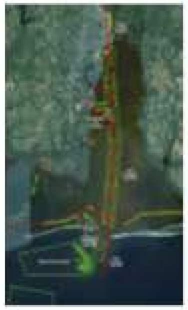
Late 1960s early 1970s "spoil banks" determined enviro-bad

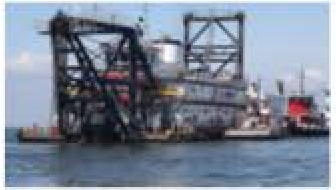
1979

High pressure spray TLP first applied southern LA wetland

1986

Open water TLP project at Fowl River in Mobile Bay AL





2012

Open water TLP in Upper Mobile Bay AL

2014

Open water TLP Project in Mouth of Columbia River OR

2015

Open water/wetlands TLP at Prime Hook DE

2016

Wetlands Avalon NJ TLP

2017

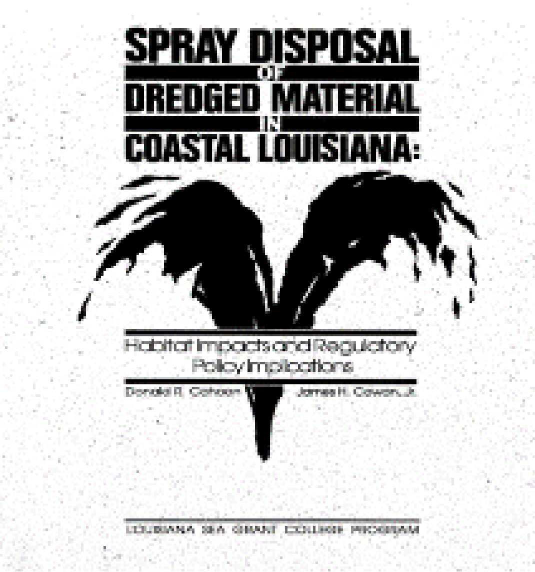
Wetlands John H. Chaffee Refuge RI TLP

History of TLP: *Wetlands*

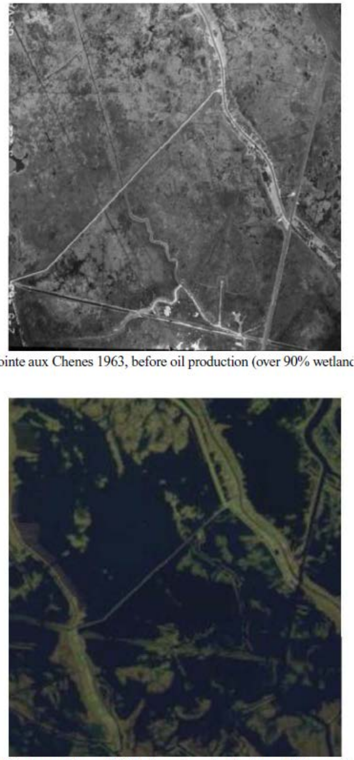
Cahoon and Cowan 1988

- Oil and gas exploration in Louisiana wetlands soils usually unstable (high water and organic content) used board roads
- Submersible drilling barge built in 1934
- 1938 dredging of access canals
- Mechanical (dragline bucket) dredging vs. hydraulic dredging (low pressure spray) 1930s-1940s both used

History of TLP: *Wetlands*



Impact

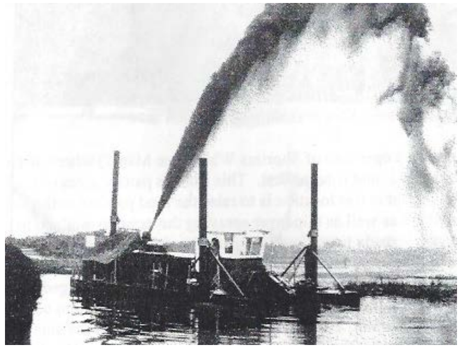


Pointe aux Chenes 1963, before oil production (over 90% wetland

Pointe aux Chenes 2014, after oil production (over 90% water)

- 1950s mechanical dredges ruled
- Late 1960s early 1970s “spoil banks” determined enviro-bad
- High pressure spray placement first applied southern Louisiana 1979*

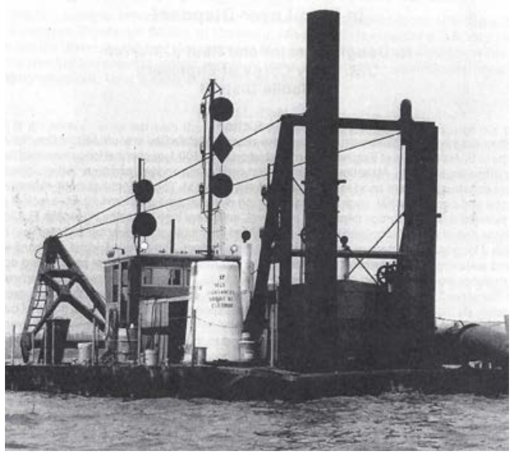
*Cahoon and Cowan 1988



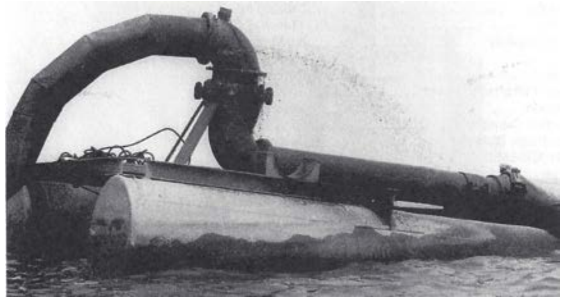
History of TLP: *Open Water*

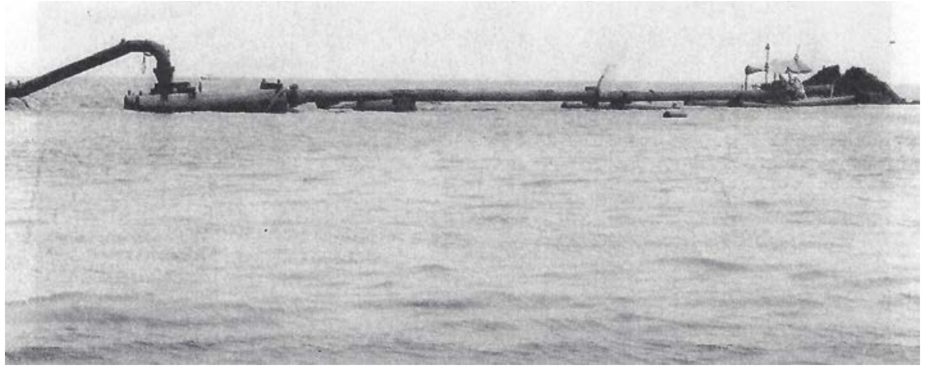
The Effectiveness of a Twenty-Inch Dredge in Thin Layer Disposal

Nester and Warren, 1987



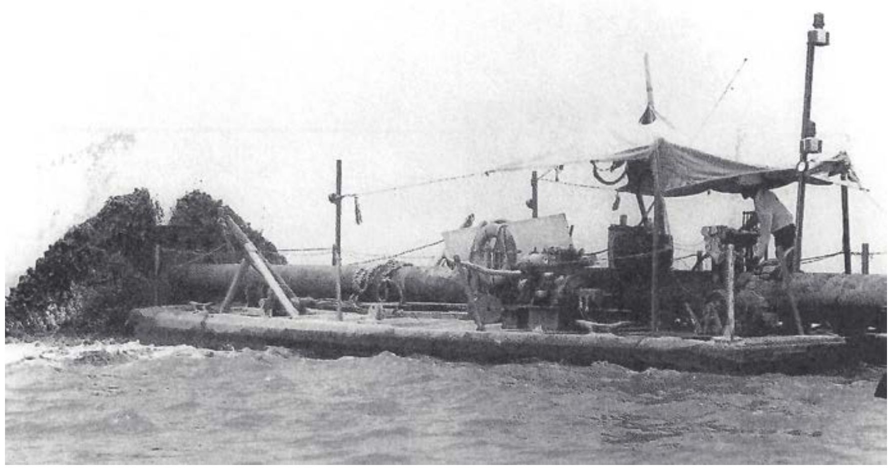
20” Cutterhead Georgia





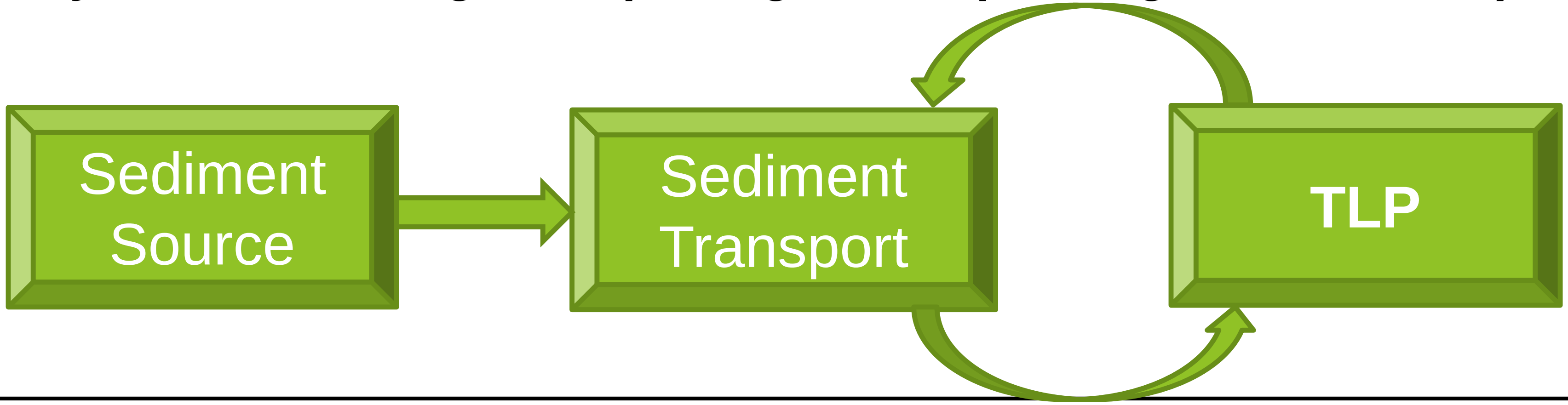
Bell and ball vertical swivels

- 1986 Pipeline Placement at Fowl River, AL
- Lack of adequate dredged material disposal capacity
- 190,000 yd^3 placed in ~ 10 ft deep water not to exceed 6 inches thick
- “,,,it is evident from the preliminary surveys that a twenty-inch dredge can economically achieve a thin layer disposal with dredged material.”

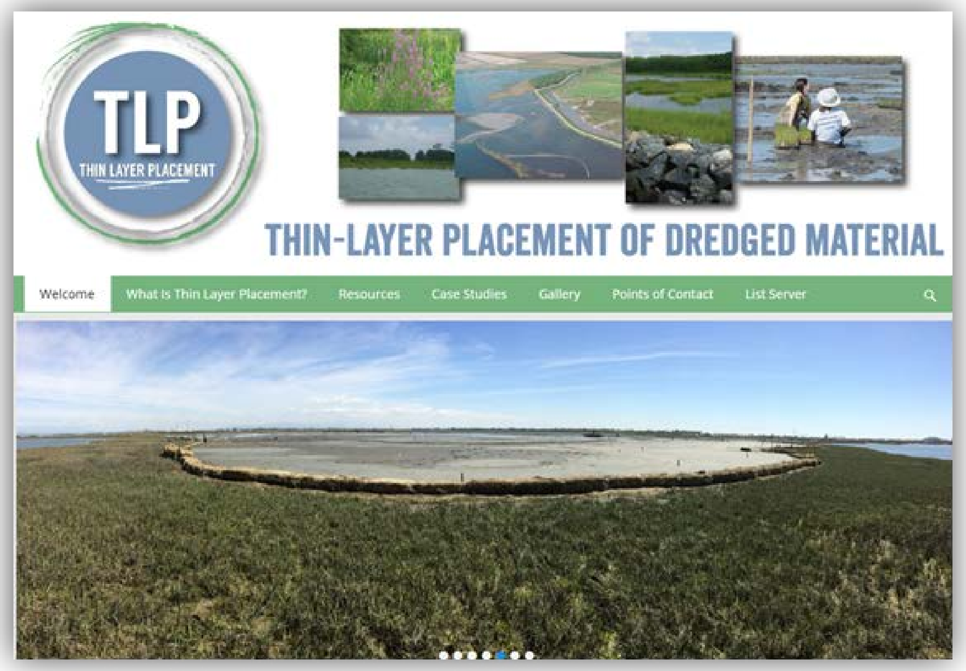


General TLP Project Process Flow

- ✓ Nexus – sea level rise/degrading wetlands&beaches&etc./limited dredged material placement areas that is an evolving methodology relatively early in development spiral
- ✓ Must have a degraded wetlands or open water site that needs sediment added to be sustainable
- ✓ Must have a sediment source (navigation and/or dedicated dredging)
- ✓ Planning, engineering (including environmental), permitting and construction aspects required to attain that sustainability
- ✓ Where getting sediment from, what kind of sediment is it, and how is it being placed (specifically how excavating, transporting, and depositing this sediment)?



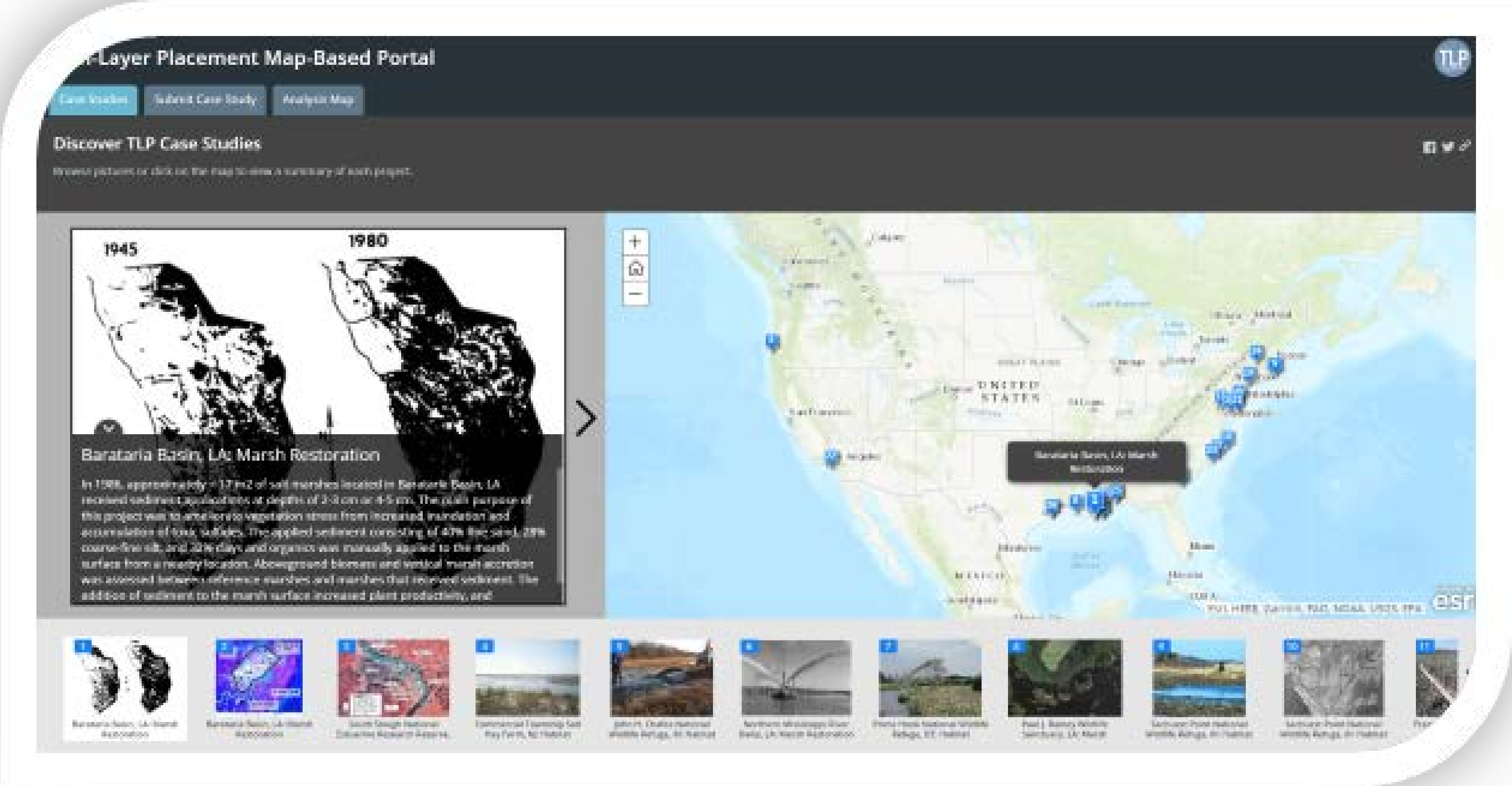
USACE TLP Website and Database



https://tlp.el.erdc.dren.mil/

- **Aggregate the current state of knowledge regarding thin layer placement of DM**
- **Consolidate literature/references pertaining to all project phases – from design to post-construction monitoring**

USACE TLP Website and Database



- **Provide centralized, accessible, and consolidated resource for case studies**

DOER TR – "Thin Layer Placement Guidance"

The purpose of this document is to provide a history of the evolution of TLP and present guidance on the design and construction of dredged sediment TLP projects based on the current state-of-the-practice with application to both wetland and open water environments.

EMRRP TR – "Framework for understanding ecological considerations associated with restoration techniques and intervention measures to sustain existing marshes in the face of relative sea level rise"

Report contributes to the understanding of how and when thin layer placement and other management activities may benefit degrading marshes.

DOER TR – "Thin Layer Placement Guidance"

This guidance is organized into 10 sections:

- **Presents the history of TLP**
- **How to conceptualize the project area**
- **Setting goals and objectives**
- **Project design steps**
- **Construction considerations**
- **Monitoring and adaptive management aspects**
- **Discussion of knowledge gaps and future R&D needs**

Wetland TLP
Seal Beach CA

- **Salt marsh habitat has been adversely affected by subsidence and sea level rise.**
- **Main objective was to improve habitat quality and facilitate sea level rise (SLR) adaptation.**

Wetland TLP
Seal Beach CA

- Main Stakeholders: USFWS, OC Parks, CA Dept. of Fish and Wildlife, California Coastal Conservancy, USACE, Naval Weapons Station Seal Beach, CA State Lands Commission, UCLA, USGS, CSULB, Chapman University
- ~13,500 yd^3 sand placed high (barge mounted) and low pressure discharge
- Used an 8 inch cutterhead then switched to 12 inch
- A 10 inch (plus/minus and average of 2 inches) thin layer of dredged material was placed over 8 acres of low elevation salt marsh from Dec 2015 to Mar 2016

Wetland TLP
Seal Beach CA

- **Hay bales, straw waddles, sand bags and geotextile fabric and 6-acre vegetated buffer**
- **The cost of project construction and long term biological and physical monitoring is $3,305,554**

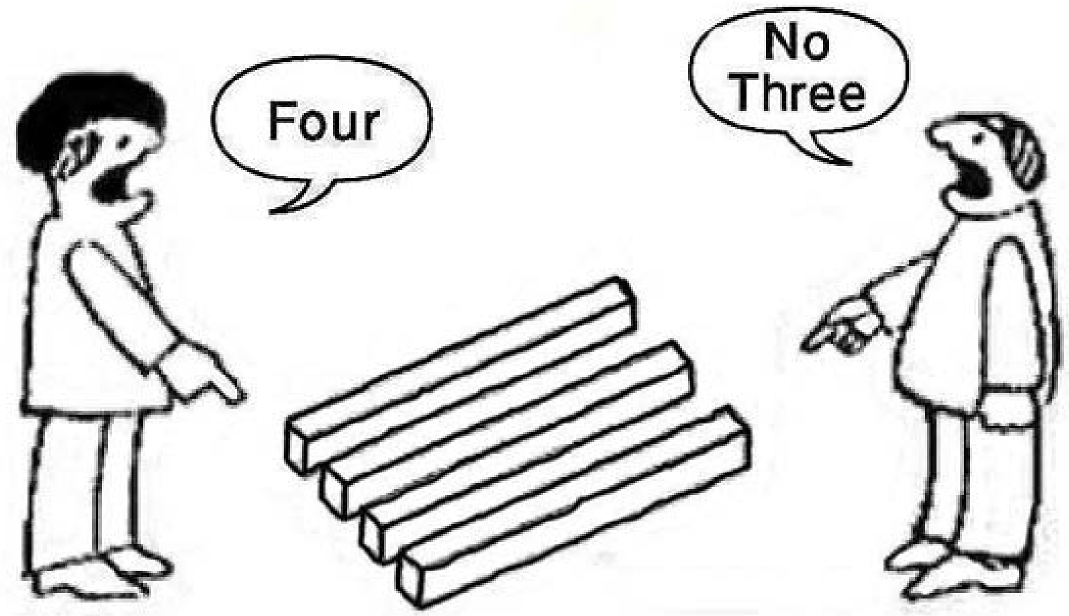
Wetland TLP
Seal Beach CA

- Monitoring an essential component since TLP has not been used in this area.
- Pre- and post-construction monitoring on the project site and control site includes:
  - Assessing the plant and benthic invertebrate communities
  - Associated abiotic parameters (e.g., temperature, porewater salinity, redox)
  - Monthly bird surveys
  - Measuring the thickness and bulk density of added sediment
  - Assessing the morphology of tidal creeks
  - Measuring net sediment accretion rates and the carbon accumulation rate
  - Evaluating sediment flux; and measuring seasonal emissions of CO_2, CH_4 and N_2O
- Post-construction monitoring started immediately following dredged material placement and will continue over a time period of 5 years.

Wetland TLP

What Is This?

Dredging a channel vs. restoring/maintaining a wetland USACE, dredging contractor and wetland stakeholders Different Perspectives!



https://qph.ec.quoracdn.net/main-qimg-b2f3c1af916f729567f8a57456b7b0c7-c?convert_to_webp=true bryanRidgley.com

Wetland TLP

Stumbling Blocks to TLP Adoption Include:

- Differing perspectives on what it is
- Differing perspectives on what it does including:
  - Vegetative recovery time
  - Biogeochemistry
  - Better to have a modified wetland or no wetland?
- Small volumes of sediment at relatively large costs

General Planning and Permitting Considerations

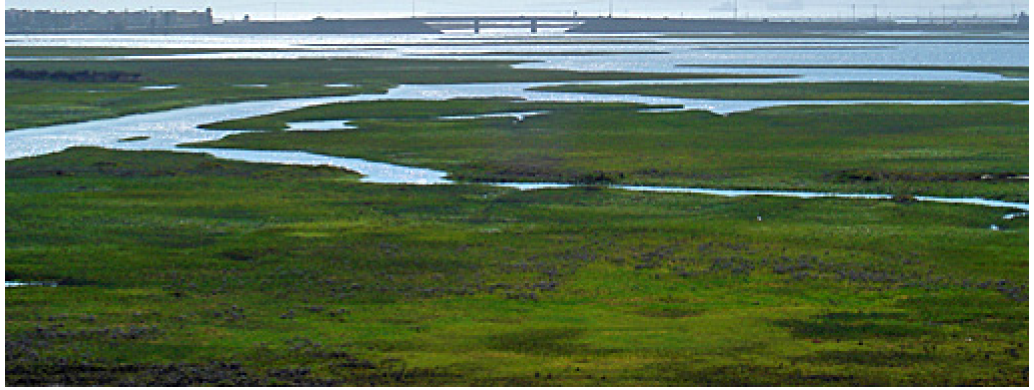
- Setting goals and objectives
- Establishing baseline conditions
  - Vegetation, soils, hydrology, elevation, wave/velocity information, accretion rates, sampling of in-situ sediment for geotechnical and chemical properties, marsh bearing capacity and other analyses of marsh surface, etc..
- Additional considerations for permitting
  - EFH assessment, T&E surveys, cultural resources, and other State and NEPA specific items (as needed)
- Developing a conceptual design
  - Staging areas, pipeline corridor, nearby infrastructure assessment, site access, safety
  - General Project goals – habitat, resiliency, both
  - Planning for sea level rise
- Plan to monitoring throughout design and implementation phase?

Onsite Hydrologic Conditions

What is needed when considering assessment of hydrologic conditions?

- Hydrologic Cycle
  - Sources, sinks, storage, and exchange of water in the environment
- Tide cycle and wave energy/velocity
- Inundation duration and time
- Rainfall
- Water table
- Numerical models
- Others?

Seal Beach National Wildlife Refuge, California

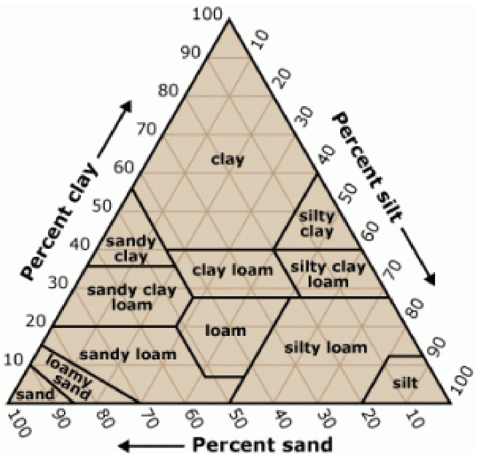


Pepper Creek, Delaware
Source: Zillow

Wetland Sediment Characteristics Evaluation

- What needs to be considered when evaluating wetland soils/sediments?
- Chemical and physical characteristics required to evaluate existing wetland sediments
  - Surface and near-surface soils
    - Permeability, fertility, organic content, salinity, pH, texture, and organic content
  - Wetland substrate soils
    - Texture, consistency limits, permeability, and in situ strength
- Soil Classification Systems
- Soil Sampling Methods
- Numerical Models
- Chemical analysis for
- permitting (like on like placement)

Source: Basic Civil Engineering



Source: University of California, Agriculture and Natural Resources

Sediment Source Characterization

- During planning phase – what needs to be considered when evaluating the sediment source?
- Chemical and physical characteristics
  - Analytical properties for permitting requirements
  - Geotechnical properties to determine fate of material after placement
  - Characterization different than typical DM disposal requirements
- Number and location of samples

Existing Infrastructure and Permitting Considerations

- **What needs to be considered when planning for issues related to infrastructure and permitting needs?**
- **Identify existing infrastructure and cultural resources for wetlands, pipeline corridor, and equipment access corridors/staging:**
  - **Review infrastructure databases where available**
  - **Conduct magnetometer surveys**
- **Permitting needs**
  - **Essential Fish Habitat concerns,**
  - **T&E surveys,**
  - **Cultural/tribal resources**
  - **Other State and NEPA specific items**

Topography and Bathymetry Surveys

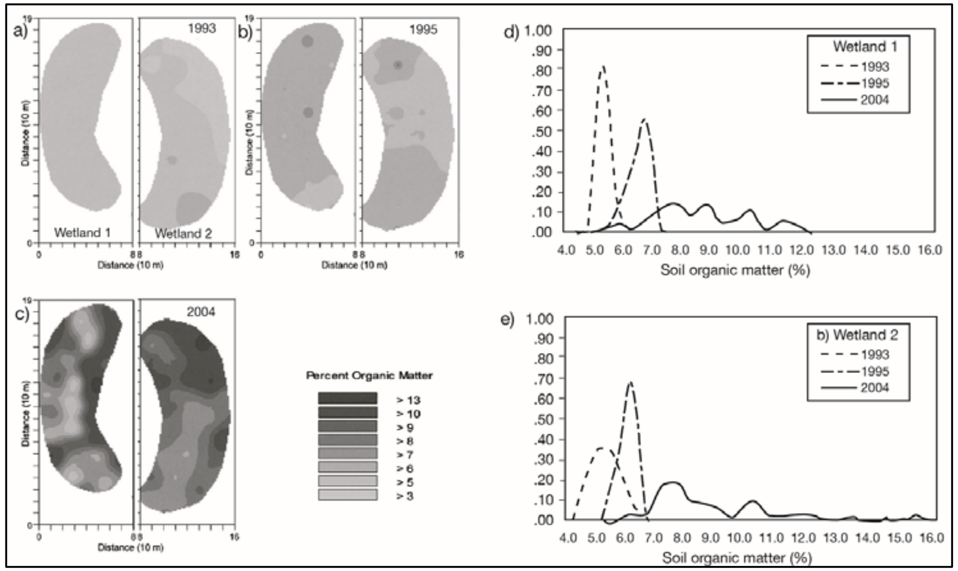
- Pre- and post-sediment placement topography and bathymetry survey requirements
  - Accuracy requirements in micro- and macro-tidal regimes
  - Meeting required accuracy
    - Aerial LIDAR, Terrestrial LiDAR, UAS LiDAR, RTK, combination
  - Recommended RTK transect spacing distances and sampling density
  - Surveying in pans/pools
  - Bathymetry for project area and access points
- What has worked in the past, what hasn't?
- Biggest obstacles?
- Costs implications vs benefit?

Source: BirdsEyeView Aerobotics

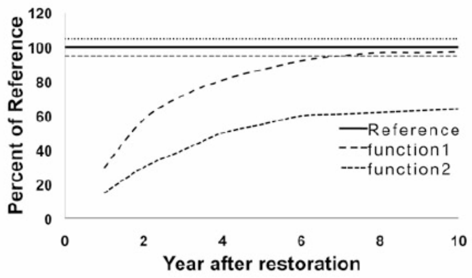
Aerial LIDAR
Source: geodatapoint

Possible Success Criteria

- **Physical criteria**
  - **Elevation**
  - **Inundation durations**
  - **Creek network form**
- **Biogeochemical criteria**
  - **Microbial biomass**
  - **Redox conditions**
  - **Carbon storage**
- **Ecological criteria**
  - **Vegetation (cover/biomass/species diversity)**
  - **Food web dynamics**
  - **Bird use**
  - **Benthic invertebrates**
- **Ecosystem goods and services**
  - **Water filtration**
  - **Carbon sequestration**
  - **Storm damage reduction**



Mitsch and Gosselink 2015



Buchsbaum and Wigand, 2012

Possible constraints

- **Cost (obviously)**
- **Biological requirements**
- **Equipment availability**
- **Proximity to roads**

Lessons Learned - Ideal Application

- TLP is best for projects where:
  - Elevation has been lost considerably (from subsidence or sea level rise)
  - Natural sediment inputs alone are insufficient to nourish the marsh over time
- TLP is not well suited for degraded marshes affected by invasive species or sediment overloads
- TLP should be a “restoration” project, and not designed as a “dredged material placement” (or “disposal”) project

Photo Credit: Dredge America - Blackwater Restoration Project

General Lessons Learned

- Strong partnership between stakeholders
  - Early engagement and “buy in” is critical
- Project objectives should consider sediment dynamics at a “system” level
- Include habitat diversity as part of restoration concept
- Evaluate circulation pre- and post- project
- Protect marsh edge erosion
  - Living shorelines versus other systems
- Approach permitting agencies early on
  - Build a true partnership for success
- Incorporate adaptive management, as part of long term monitoring
- Allow for natural processes to facilitate long term recovery

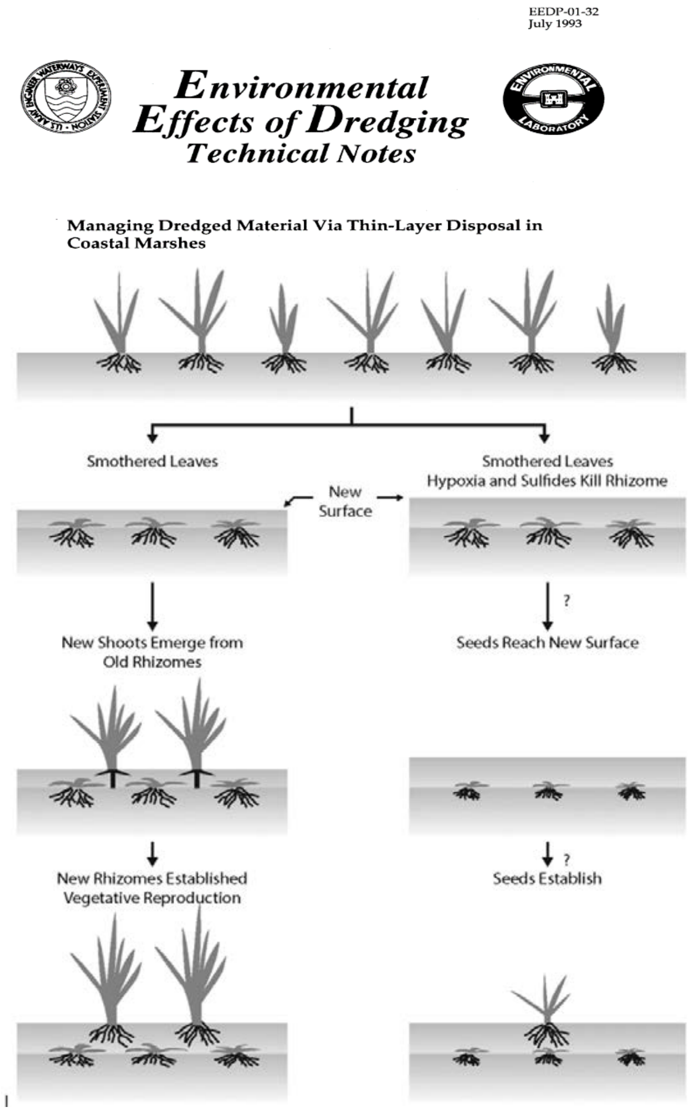
Source: MES – Poplar Island Restoration Project

Lessons Learned - Ideal Application

- TLP in the upper tidal range generally provides the best marsh resilience
  - Should incorporate SLR and consolidation/subsidence
- Adequate characterization of the dredged material and placement site are vital to project success
  - Bathymetry, topography, water levels, tides
  - Atterberg properties, moisture/solids content, grain size, texture, contamination, etc.
  - Use numerical models, verified by real-world data
  - Do not be afraid to revise assumptions
- Direct placement still has some challenges, particularly with respect to marsh access for placement
  - Pipeline routing, material supply, access roads and restoration, etc.
  - Material containment

Lessons Learned - Design

- Protect key features (edges, channels/creeks)
- Material/Elevation Balance:
  - Bulking noted: two to four times in situ
  - Shrinkage: 10% to 40% in first 10-15 days
- Vegetation responds well to TLP generally in the range of 6-12 in.
- Recovery times vary, but is generally on the order of 2-5 years
- Natural recovery is possible, particularly for thin (less than 12 in.) placement
  - Natural recolonization is preferred
  - Planting should therefore be a secondary (contingency) criterion



Lessons Learned - Construction

- Well engineered design is key to success
  - Use experienced engineering and construction teams to avoid costly field changes and/or delays
  - Avoid redundancies
- Do not overengineer or over-prescribe
- Prequalify contractors
  - Evaluate for demonstrated experience on similar projects
  - Weed out ones with violations
  - Provide the contractor with the ability to innovate in the field
- Adaptive management can be key to success

Source: Bob Blama – Blackwater Restoration

Construction Considerations

- TLP project construction requires coordination and cooperation between Owner, Contractor, and stakeholders
- Construction work plan
- Project execution (safety first)
- Adaptive Management should be incorporated into construction phase as well

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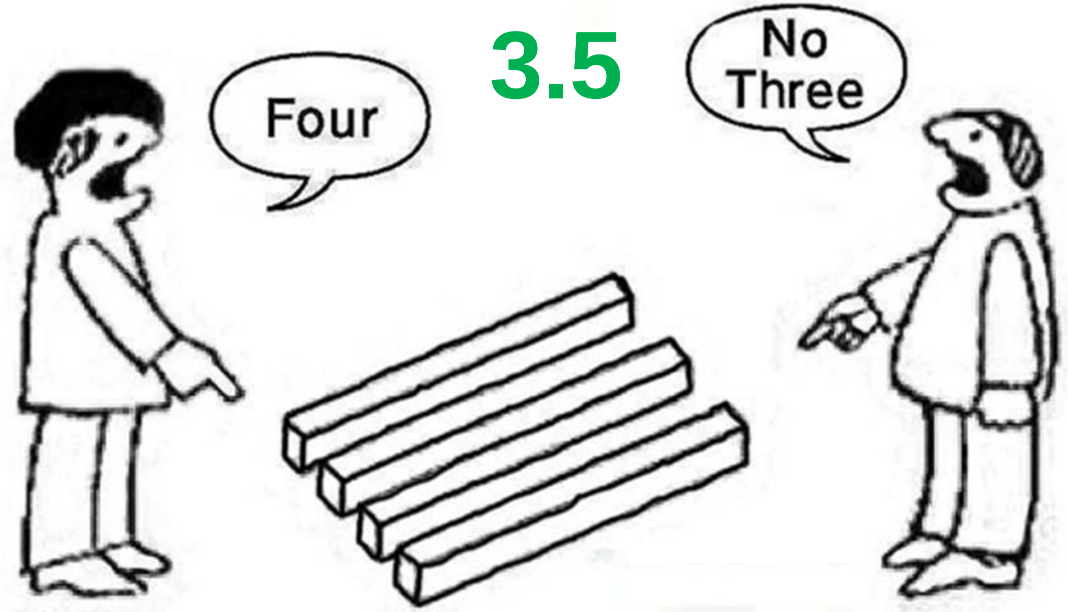

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What should be required in a contractor’s Construction Work Plan?

- Equipment access route layout(s)?
- Equipment staging area layout(s)?
- Construction equipment (land and water-based) data sheets to be used?
- Access channel dredging?
- Dredge pipeline corridor?
- Dredge pipe type, diameter, thickness, and length, schedule for layout (booster?), installation, maintenance, and removal?
- TLP site construction: containment features and schedule?
- Channel or borrow area dredging plan and schedule?
- TLP placement layout, grade stake placement, and fill schedule?
- Dredge production rates slurry heights to be monitored during placement?
- Construction survey methodology and software used to process data?
- Restoration plan?

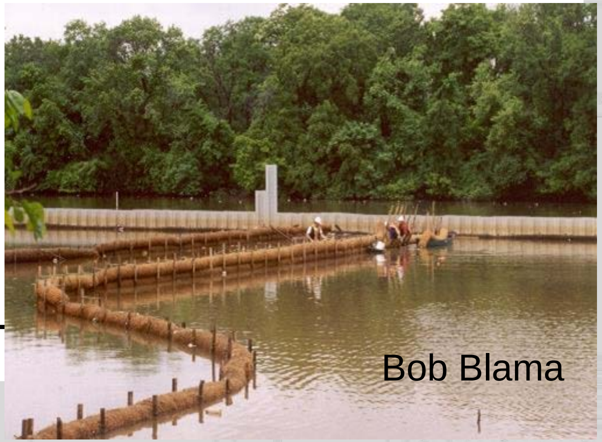
What are TLP Project Related Safety Aspects?

- How to enhance safety of personnel on working on wetlands.
- How to safely and efficiently survey placement elevation in a panne/pool?
- How to avoid stepping into pannes after slurry placement.
- Work at night? What requirements are needed?
- Any particular safety issues related to jet spraying?

Sediment Control Structure Considerations

- **Intended application: lateral sediment containment, maintain/promote creeks, drainage, etc.**
- **Design configuration, installation, and maintenance requirements**
- **Removal/Revise/Remain requirements**

Nate Lovelace



Types of Sediment Containment Structures and How Do They Perform?

- Straw bales (no hay?) vs. coir logs vs biodegradable soxxs vs. ??
- Natural channels plugged with haybales, coir logs, or other materials to protect them from being infilled during placement (generally required to withstand greater horizontal loads)?
- Remove, revise, or remain out on wetland to decompose?
- Use of earthen dikes like used in Louisiana too radical?
- What kind and how much lateral containment should be used - always necessary, or can we minimize its use by using existing topography, vegetation buffer, burlap silt curtain (mud flat nourishment)?

Wetland Construction Equipment Considerations

- Use should be evaluated for operational performance in site-specific conditions yet minimize impacts to wetlands
- Operating areas designed and best management practices employed to further reduce impacts

Avalon NJ, Jackie Jahn

WILCO

New Jersey DOT

What Construction Equipment is Best for Wetlands and How Should it be Operated to Minimize Ecological Damage?

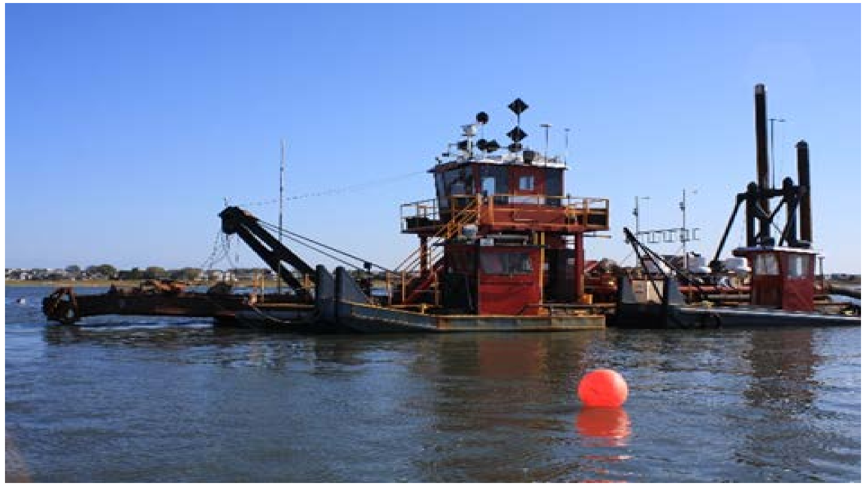
- Do wetlands need to be characterized for assessing use of low ground pressure vehicles?
- Require minimum level of experience for operators?
- Equipment will damage the marsh - need to use mats?
- Need operational guidelines - equipment operating considerations (Best Management Practices) to minimize environmental impacts on wetlands

Dredging Equipment Considerations

- Physical characteristics of sediments
- Quantities to be dredged
- Dredging depth
- Distance to dredged material placement area
- Physical environment of and between areas
- Contamination level of sediments
- Method of placement
- Production required
- Types of dredges available
- Environmental considerations

http://www.dredge.com

10 inch diameter discharge Ellicott 470 SL



14 inch diameter discharge “Fullerton”

Sediment Deposition Equipment Considerations

- **Equipment requires capability to efficiently achieve design target elevation(s) while minimizing impacts on wetlands and dredge production**
- **Project-specific conditions that can influence equipment selection include:**
  - **Dimensions and layout of placement area(s)**
  - **Equipment access**
  - **Dredge production**
  - **Lift thickness to meet design target elevation**
  - **Where you want sediment and where you don't**
  - **Type of sediment**

Pepper Creek DNREC

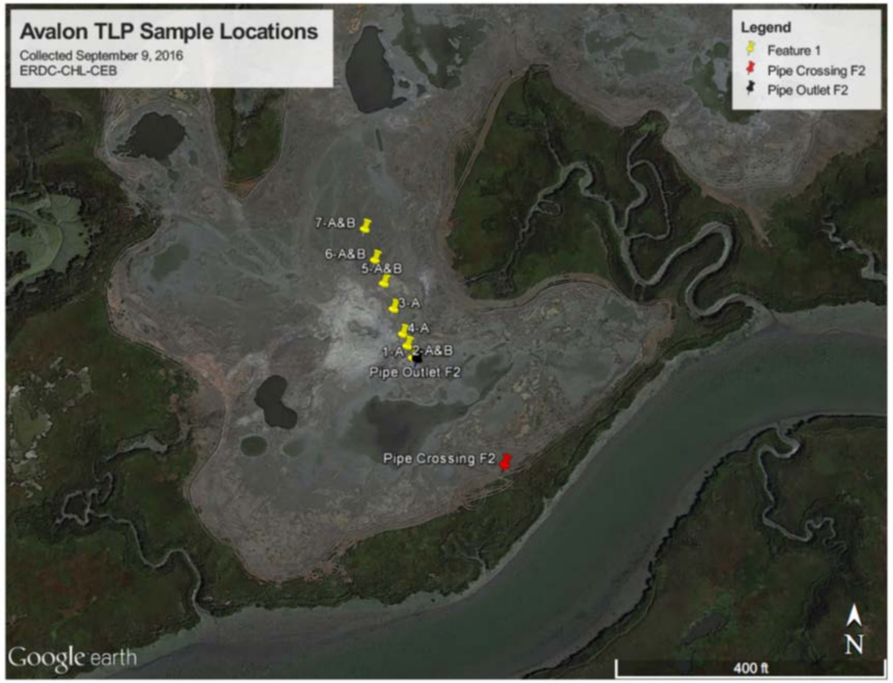
Avalon, NJ

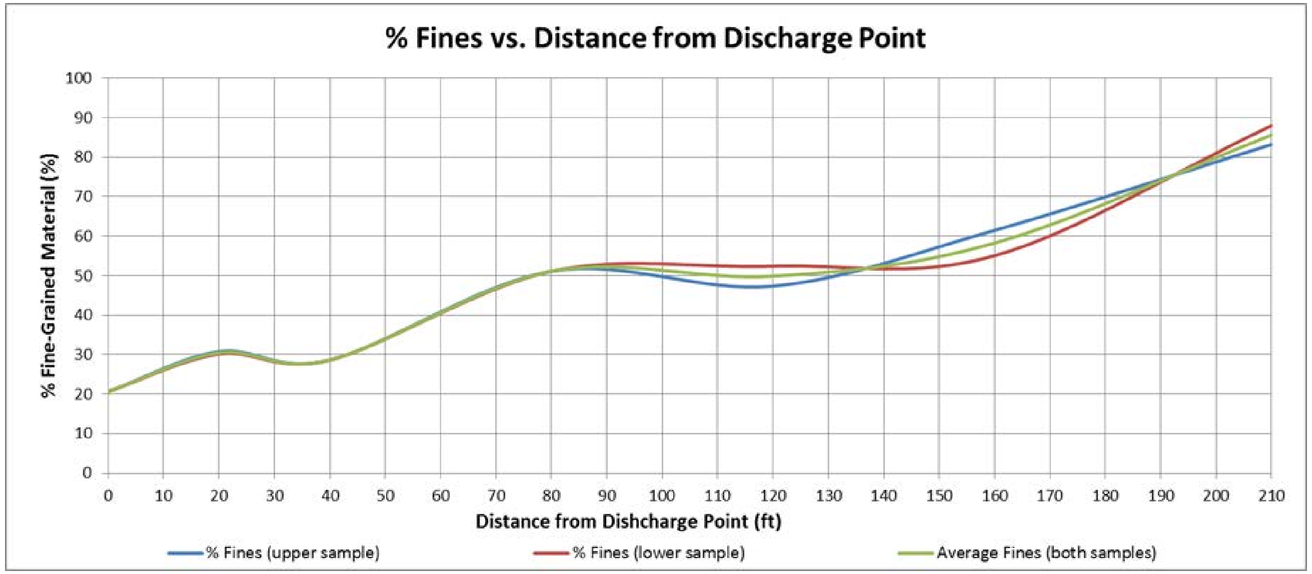
Fortescue, NJDOT

Prime Hook, USFWS

Sediment Deposition Equipment Considerations

Hydraulic settling characteristics of fine and coarse-grained sediments have to be considered in equipment design and operation





Avalon, NJ

Sediment Deposition Equipment Advantages and Disadvantages, and How Could it be Optimized?

- What do we know about spreader and spray configurations?
- What different mounting systems have been used in past (dredge-mounted, static cribbing, barge-mounted, marsh buggy-mounted, etc.)?
- Advantages and disadvantages of one method over other (e.g., placement accuracy when placing sand)?
- What are the different ways to adjust nozzle spray direction azimuth and altitude (more sandy material requires more timely adjustment)?
- Rock box to clean out so nozzle doesn’t clog?
- Pump water to knock down high spots?
- R&D needed to optimize performance?

Discharge Pipe Dia (in)	Velocity (ft/sec)	Flow (ft^3/sec)	Flow (GPM)	Slurry (yd^3/hr)	Sediment (yd^3/hr)	Sediment (yd^3/sec)
8	10	3.5	1566	465.2	35	0.6
8	15	5.2	2349	697.8	52	0.9
8	20	7.0	3132	930.4	70	1.2
8	25	8.7	3915	1163.0	87	1.5
10	10	5.5	2447	726.8	55	0.9
10	15	8.2	3670	1090.3	82	1.4
10	20	10.9	4894	1453.7	109	1.8
10	25	13.6	6117	1817.1	136	2.3
12	10	7.9	3523	1046.7	78	1.3
12	15	11.8	5285	1570.0	118	2.0
12	20	15.7	7047	2093.3	157	2.6
12	25	19.6	8808	2616.7	196	3.3
14	10	10.7	4796	1424.6	284.9	4.7
14	15	16.0	7193	2136.9	427.4	7.1
14	20	21.4	9591	2849.2	569.8	9.5
14	25	26.7	11989	3561.6	712.3	11.9

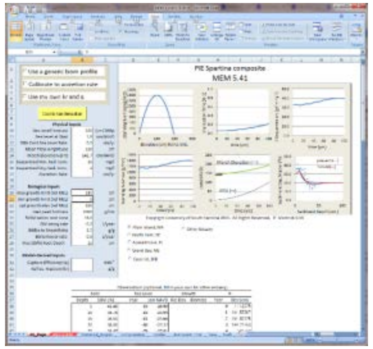
Examples of Wetland TLP R&D

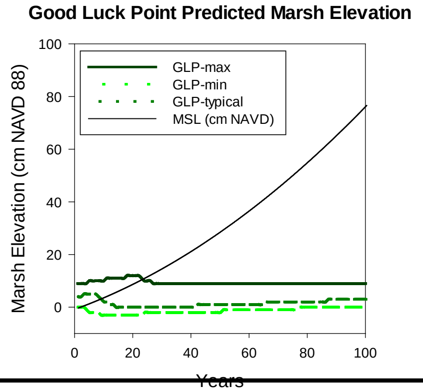
Bulking and consolidation of DM in marsh environments

- If material is hydraulically placed, elevation changes over time.
- Elevation change can be modeled.
  - Maximum volume: at end of placement
  - Elevation subsides during primary settling and drainage of ponded water **(SETTLE)**
  - Long term: consolidation of dredged material and underlying foundation **(PSDDF).**

Long-term marsh elevation response to DM placement & SLR

- Marsh Equilibrium Model projects future conditions based on known interactions between biomass and accretion
- Developed at University of South Carolina by Dr. James Morris
- Goal: use MEM to predict the response of marshes to thin-layer and other episodic sediment deposition events





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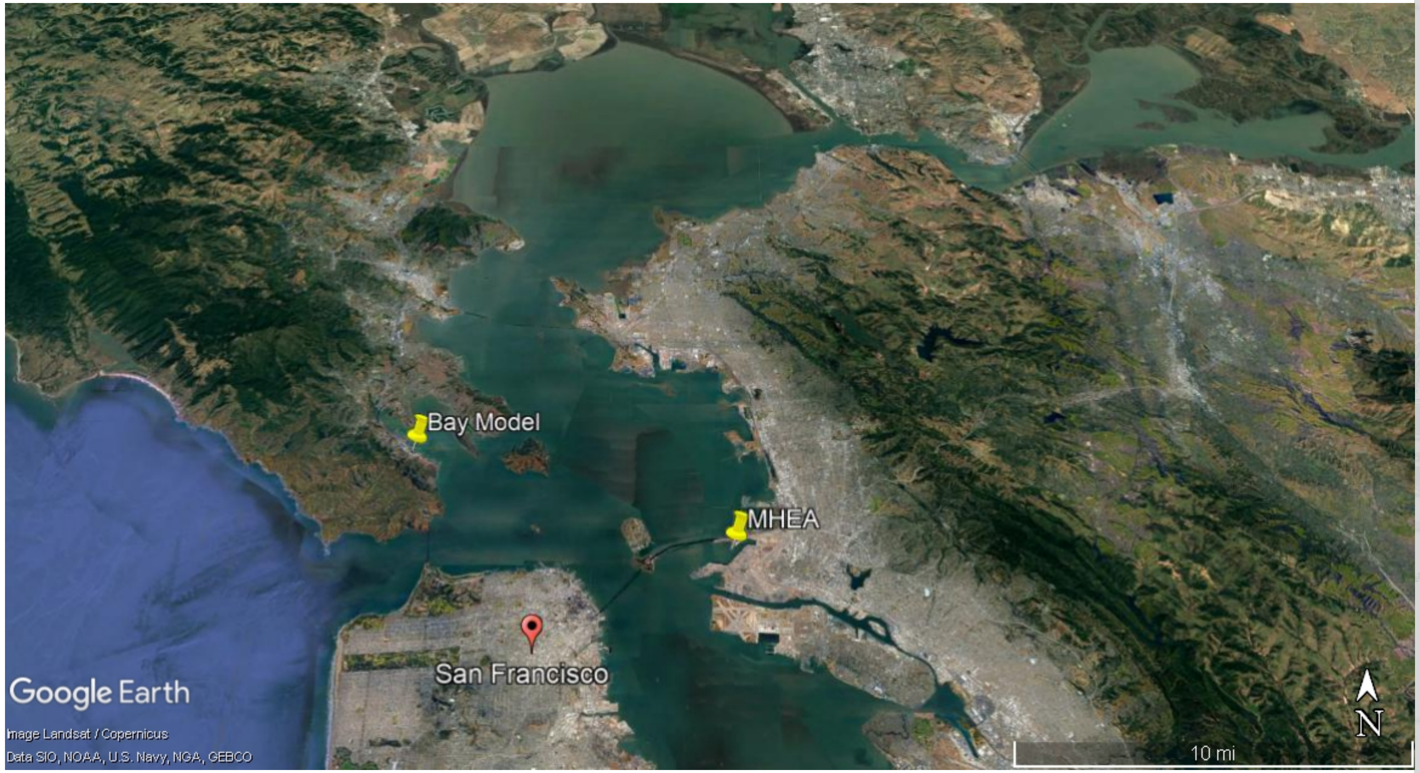
San Francisco District

Open Water TLP
SPN Middle Harbor Enhancement Area

- **Oakland Inner and Outer Harbor deepening - 12.8 million yd^3**
- **Feasibility phase - project stakeholders negotiated an agreement ~½ that in-bay**
- **~180-acre in-bay site known as Middle Harbor (former U.S. Navy Fleet Industrial Supply Center)**
- **1st permitted action in decades to allow large volume filling of the Bay**
- **Permitting stipulated 2 additional wetland projects be developed during the deepening project**
- **Cost effective placement of dredged material enabled Hamilton & Montezuma restoration sites (not going to fill up bay for free)**



Structure and Stakeholders

- **San Francisco Bay Long Term Management Strategy (LTMS)**
- **Goal: establish new environmental dredging plan for Bay & improve/coordinate permit process**
- **Conducted comprehensive studies of navigation/biological/physical environment**
  - **- sediment transport**
  - **- hydrographic/biological surveys**
  - **- etc.**
- **LTMS principle DM is a resource, not a waste**
- **BU to restore tidal marshes, wetlands, levees, and other infrastructure features)**
- **Used LTMS & resulting LTMS Management Plan as environmental framework for design & construction of MHEA and Middle Harbor Shoreline Park (MHSP)**
- **Created a Habitat Technical Advisory Committee (TAC)**
  - **- State and federal wildlife biologists (eelgrass specialists)**
  - **- Members of the local community.**
- **LTMS planning process and the TAC adaptive management were *instrumental* in achieving:**
  - **- public support and the issuance of federal and state permit**
  - **- the construction of the MHSP and the MHEA projects**

US Army Corps of Engineers
San Francisco District

SPN Middle Harbor Enhancement Area

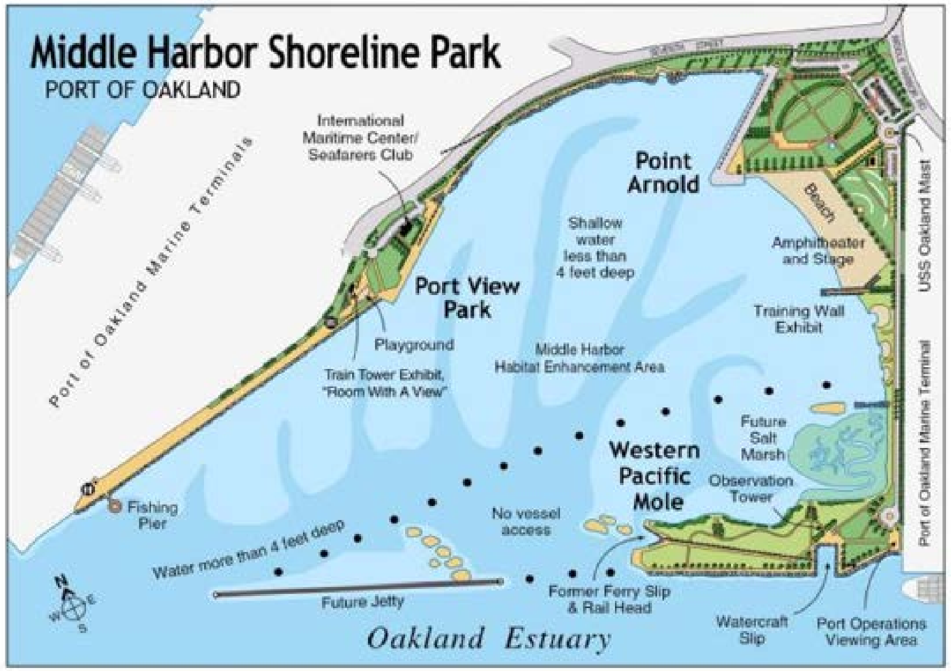
- Unlike other upland Bay BU MHEA was unique - not fully isolated from tidal fluctuations.
- Perimeter containment of two stone-armored jetties totaling 1,900 ft and 1,800 ft steel sheet pile wall.
- Final configuration almost entirely sub-tidal designed for supporting propagation of eel grass.
- Salt marsh, bird roosts, fish habitat coves & human use

SPN Middle Harbor Enhancement Area

- 2004 and 2005 used big cutterhead to pump 3M yd^3 into Harbor
- 2008 & 2010 used a clamshell dredge and scows to place 2.8 M yd^3

SPN Middle Harbor Enhancement Area

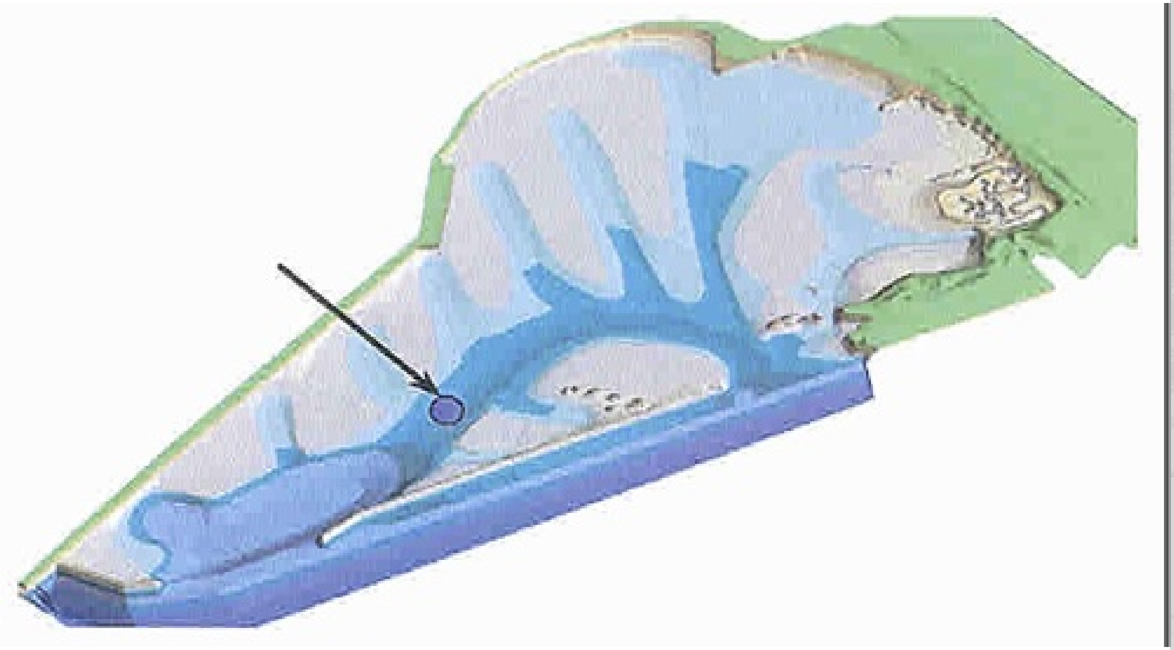
- MHEA construction occurred in two construction contracts
- First contract completed October 2012 (major redistribution
- Second contract complete 2015 (final sculpting)
- Construction schedule varied significantly due to number of factors including intermittent federal funding, material classification, and other technical constraints
- Fills were intended to be sand w/ minimal amounts of silts/clays to avoid wait periods for consolidation settlement.
- Filling intended to occur in two stages; bulk filling & final filling.
- However, rate of federal funding necessitated dredging changes
- Modification compelled bulk fill to occur in two events (initial and final) with non-homogenous material with the final filling to occur as planned.
- ~65 percent final bulk filling - decision made to stack remaining sandy materials on eastern half for subsequent sculpting



SPN Middle Harbor Enhancement Area

US Army Corps of Engineers®
San Francisco District

- Completion of bulk filling ~ 6 million yd^3 to achieve design grades.
- Clean sand sufficient to supply final grading of the peninsulas.
- But locations of different materials required combination of excavating and filling to redistribute sands at the surface to design elevations/grades.
- Initial concepts for completing final sculpting included modifications to containment structure to isolate site from tide.
- Wanted to either dewater site or maintain static water levels to achieve grading/elevation tolerances
- Both concepts abandoned due to preliminary cost estimates and multiple environmental risks (e.g. water quality, fish trapping, etc.)



SPN Middle Harbor Enhancement Area

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- First contract for final sculpting assumed marine based dredging/filling operation.
- Decision made to reduce final construction costs, but raised risk of failing to meet grades/ elevations.
- Key construction constraints:
  - Fill in lifts no >2 ft to prevent mud waves foundation failures
  - Vertical elevation tolerance of +/- 1.0 ft.
- Target elevations ranged from -6 to +2-feet, fill heights from 2 to 8 feet.
- Assumed a 200 yd^3/hr production rate.
- Key goals of contract were to dredge and fill to design grades and prove constructability
- Success, or failure, could then be extended evaluating the feasibility for similar future Bay projects

SPN Middle Harbor Enhancement Area

US Army Corps of Engineers
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- Assumed contractor would redistribute sands with hydraulic dredge and rainbow to prevent filling too fast and/or too high.
- And that grades would be evaluated/confirmed with hydrographic surveys after filling moved
- With this "guess-and-check" was likely to experience negative overfilling impacts
- Also anticipated to incur costs associated with down time caused by tides
- Contractor used a different approach:
  - used one-of-kind fill placement dredge capable of working in 2 ft depths
  - measured fill placement in real-time.

SPN Middle Harbor Enhancement Area

- 12 inch cutterhead dredge "Pecos" used a discharge pipe with a 90^{o} elbow directed upwards to rainbow fill
- Used a 3 ft-wide grade roller linked to RTK to measure fill depths in real time (the Fred)
- Fill depths and production rates captured with DredgePak
- Operator would modify swing speed and/or direction based on these realtime inputs
- Contractor was able to achieve:
- - average production rate of ~ 500 yd^3/hr
- - specified grade tolerance +/- 1 ft ~85% time.
- Areas not meeting the vertical tolerance were generally higher but typically > 1 ft out
- Contractor's strategy to aim for +1 ft of finish grade and avoid the need to return
- Contract structured with periodic payment surveys that lagged fill ops by a few weeks.
- Considering contractor strategy was able to achieve target grade >95% time on the first try.

SPN Middle Harbor Enhancement Area

- Overall, the performance of the contract was a huge success.
- Proved ability to achieve tolerance on grades - ingenuity of a skilled contractor/ flexible contractor-client team.
- Production rates showed that operations of similar scope can be executed in a relatively cost effective manner.
  - Navigation dredging $40,600,000
  - 2 grading contracts $8,000,000
  - Containment $7,500,000
- Eel grass planting (50 acre) maybe later this summer (estimated ~$2,000,000) and possibly replace roosting islands (least terns).

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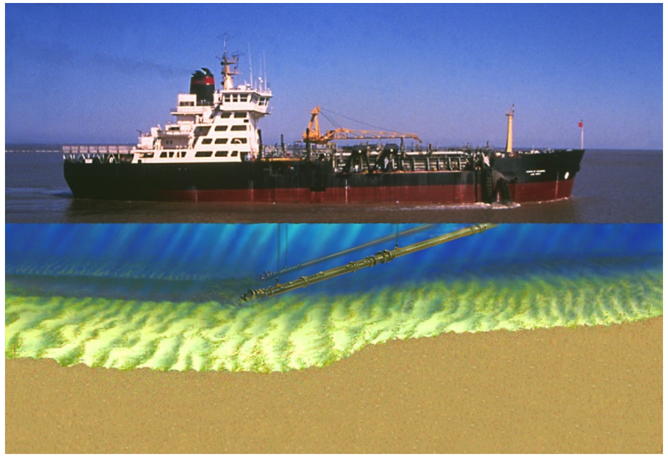
SPN Middle Harbor Shoreline Park (MHSP)

US Army Corps of Engineers
San Francisco District

Completed in 2006-07

Dredges Used for Nearshore Placement

Mechanical



Hopper

Cutterhead

Transport Methods

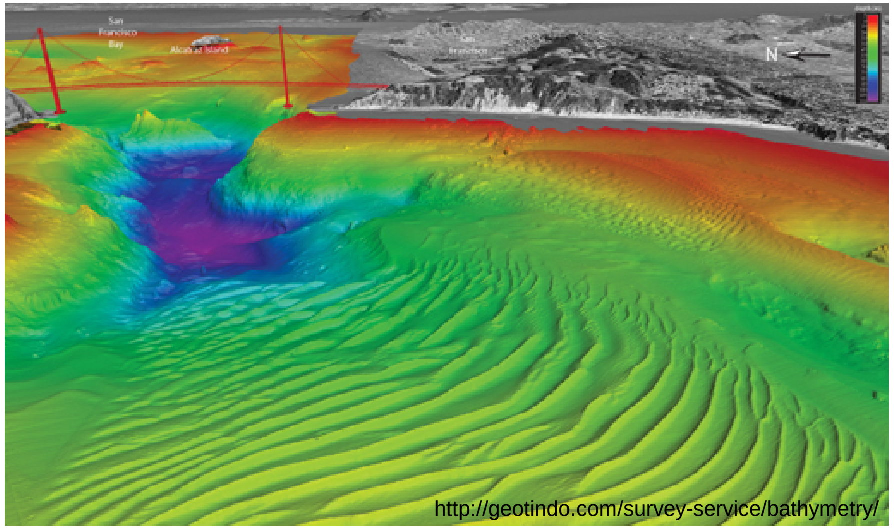
Spider Barge

Hydraulic Unloader

Nearshore Placement Equipment

Site Conditions

Priestas, McFall, and Brutsché, 2018



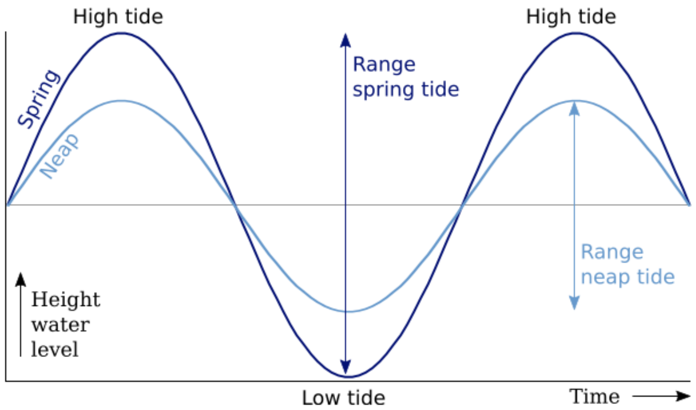
http://geotindo.com/survey-service/bathymetry/

Bathymetry

https://www.snubakeywest.com/the-best-coral-reef-cruise-in-key-west-florida/

Environmental Considerations

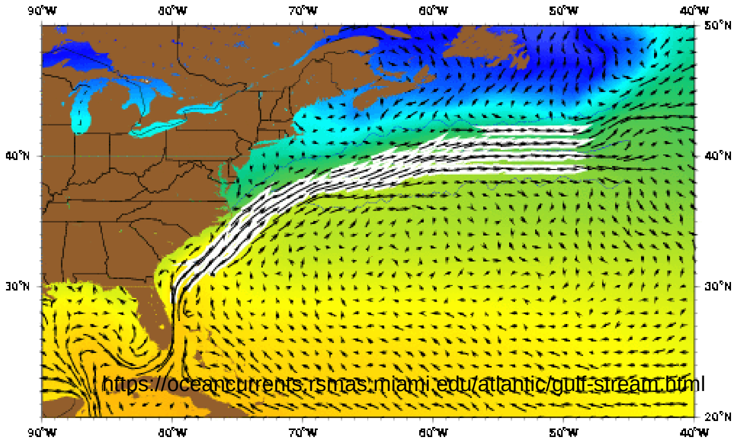
Site Conditions



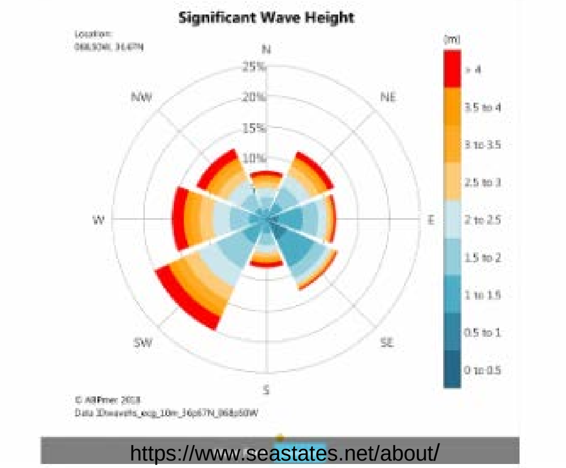
https://www.sailingissues.com/navcourse6.html

Tides

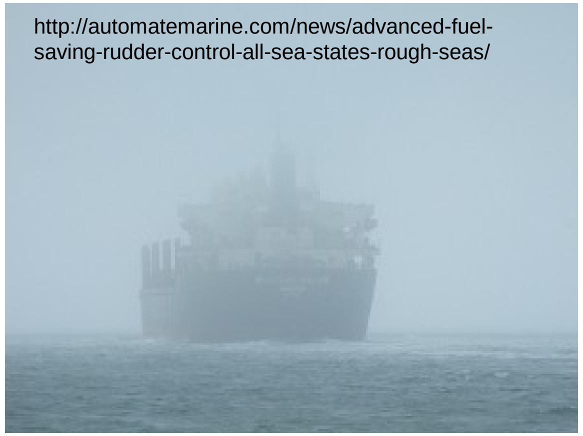
Wind



Currents



Waves



Fog

Sediment & Mechanical Dredges

Soil type	Bulking factor, B
Hard rock (blasted)	1.50–2.00
Medium rock (blasted)	1.40–1.80
Soft rock (blasted)	1.25–1.40
Gravel, hardpacked	1.35
Gravel, loose	1.10
Sand, hardpacked	1.25–1.35
Sand, medium soft to hard	1.15–1.25
Sand, soft	1.05–1.15
Silts, freshly deposited	1.00–1.10
Silts, consolidated	1.10–1.40
Clay, very hard	1.15–1.25
Clay, medium soft to hard	1.10–1.15
Clay, soft	1.00–1.10
Sand/gravel/clay mixtures	1.15–1.35

(NB B = dredged volume/*in situ* volume)

(Bray, Bates, & Land, 1997)

Mechanical dredges dig with buckets.

- **Dredge sediment (particularly fine-grained) at bulk densities at or near those of in situ conditions – tends toward a more cohesive mound or feature on bottom.**
- **Coarse-grained material maintains high bulk densities, but more likely to lose coherence during descent through the water column.**
- **Generally, however, mechanically dredged material, whether fine- or coarse-grained, is more conducive to forming a lasting berm.**

Williams & Prickett, 1998

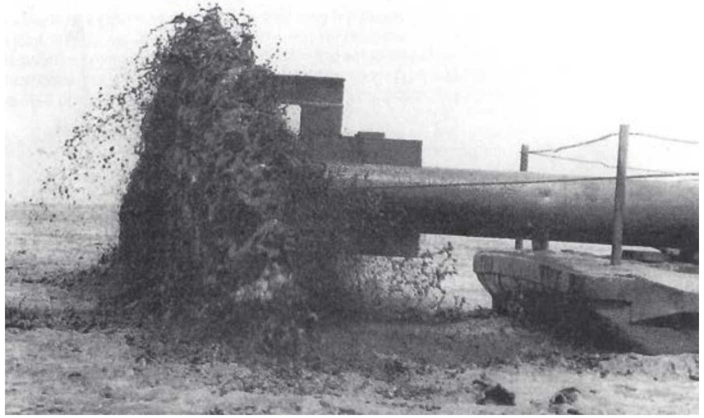
Sediment & Hopper Dredges

Hydraulic hopper dredges fluidize sediments for pumping.

- Hopper dredges fluidize sediments to pump into hoppers (significantly reducing bulk density from in situ), but once in hopper bulk density increases, though usually not to the pre-dredging levels.
- Then discharge material through doors or a split hull (sometimes using hopper water jets)
- Once load contents hit ocean - susceptible to dispersion during descent through the water column.

Williams & Prickett, 1998

Sediment & Pipeline Dredges



Nester and Warren, 1987

Grain size [mm]	Indicative range of slopes: Above water	Below water Calm seas	Below water Rough seas
0.060–0.200	1:50–1:100	1:6–1:8	1:15–1:30
0.200–0.600	1:25–1:50	1:5–1:8	1:10–1:15
0.600–2.000	1:10–1:25	1:3–1:4	1:4–1:10
> 2.000	1:5–1:10	1:2	1:3–1:6

Athmer & Pycroft 1986

Hydraulic pipeline dredges fluidize sediments for pumping.

- Hydraulic pipeline dredges fluidize material throughout the dredging and transport phases.
- Discharge directly into the water column (open pipe, spreader, diffuser).

Williams & Prickett, 1998

Special Purpose, and Shallow Draft Dredges

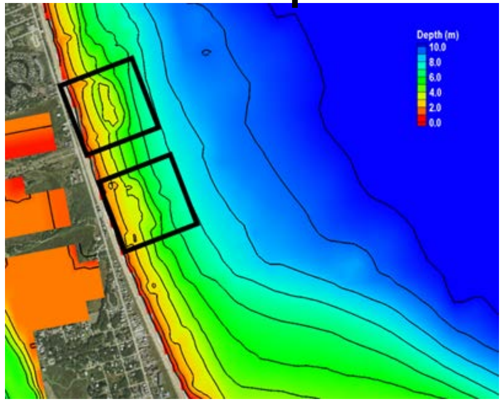
Special Purpose
Dredge Currituck

Shallow Draft Dredge
Murden

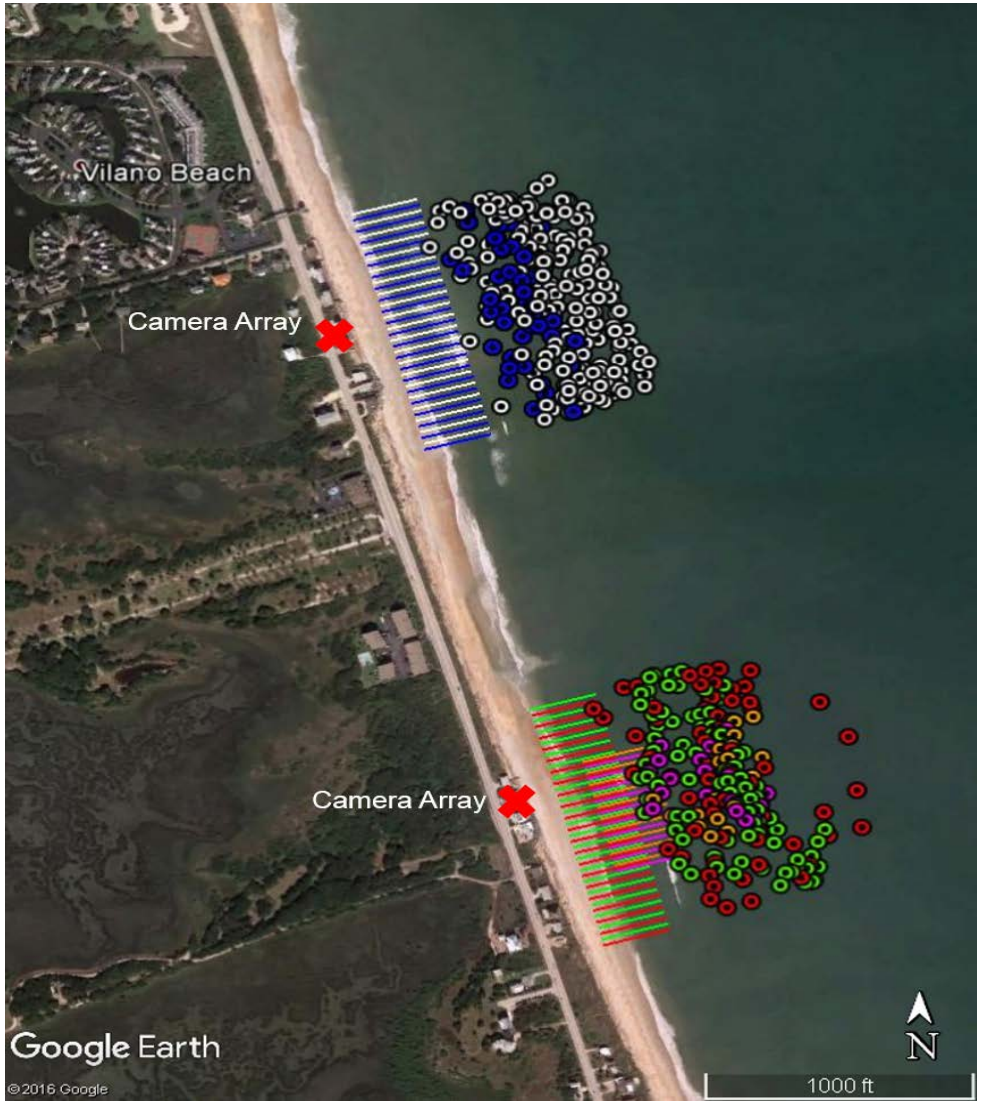
Shallow Water Dredge Placement Vilano Beach, FL

- **150,000 yd^3 placed in ~10 ft deep water**
- **Light-loaded dredge Murden**
- **Played tides to optimize operations**

Illustrates importance of positioning



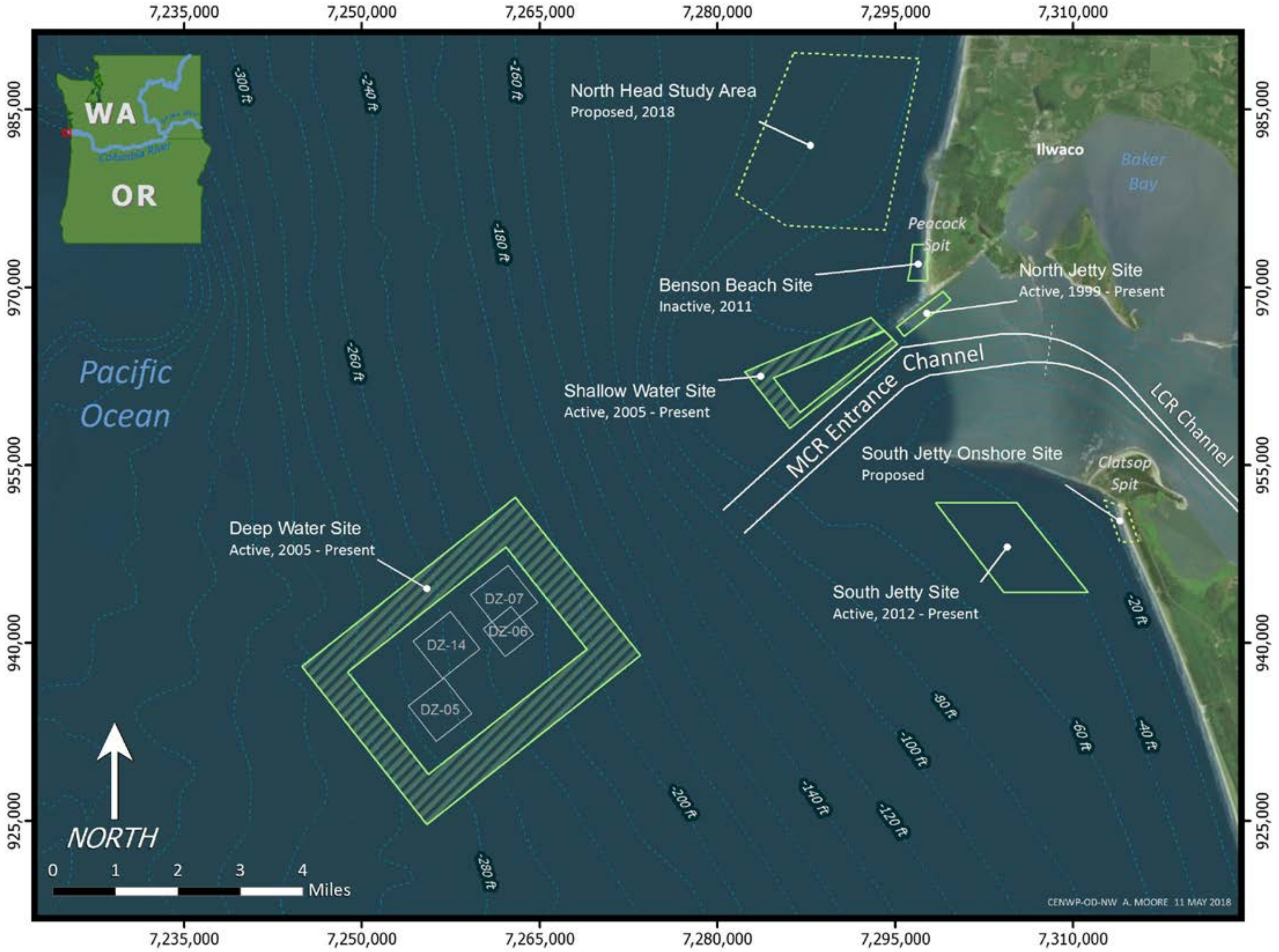
McFall et al. 2019



New Smyrna Nearshore Placement

https://www.news-journalonline.com/news/20180813/dredging-begins-in-ponce-inlet

ESSAYONS TLP

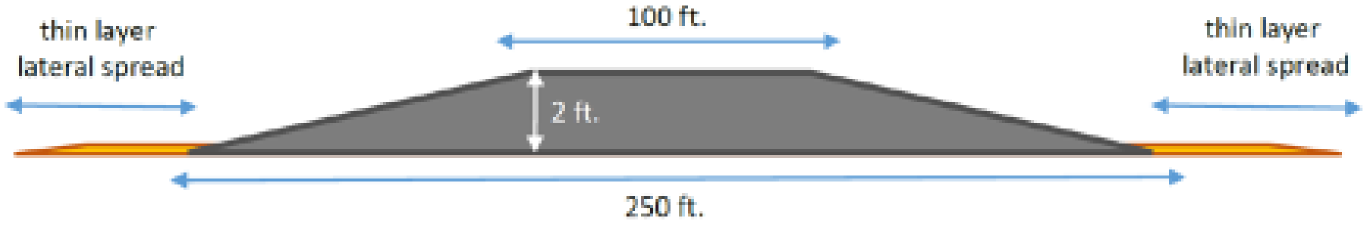


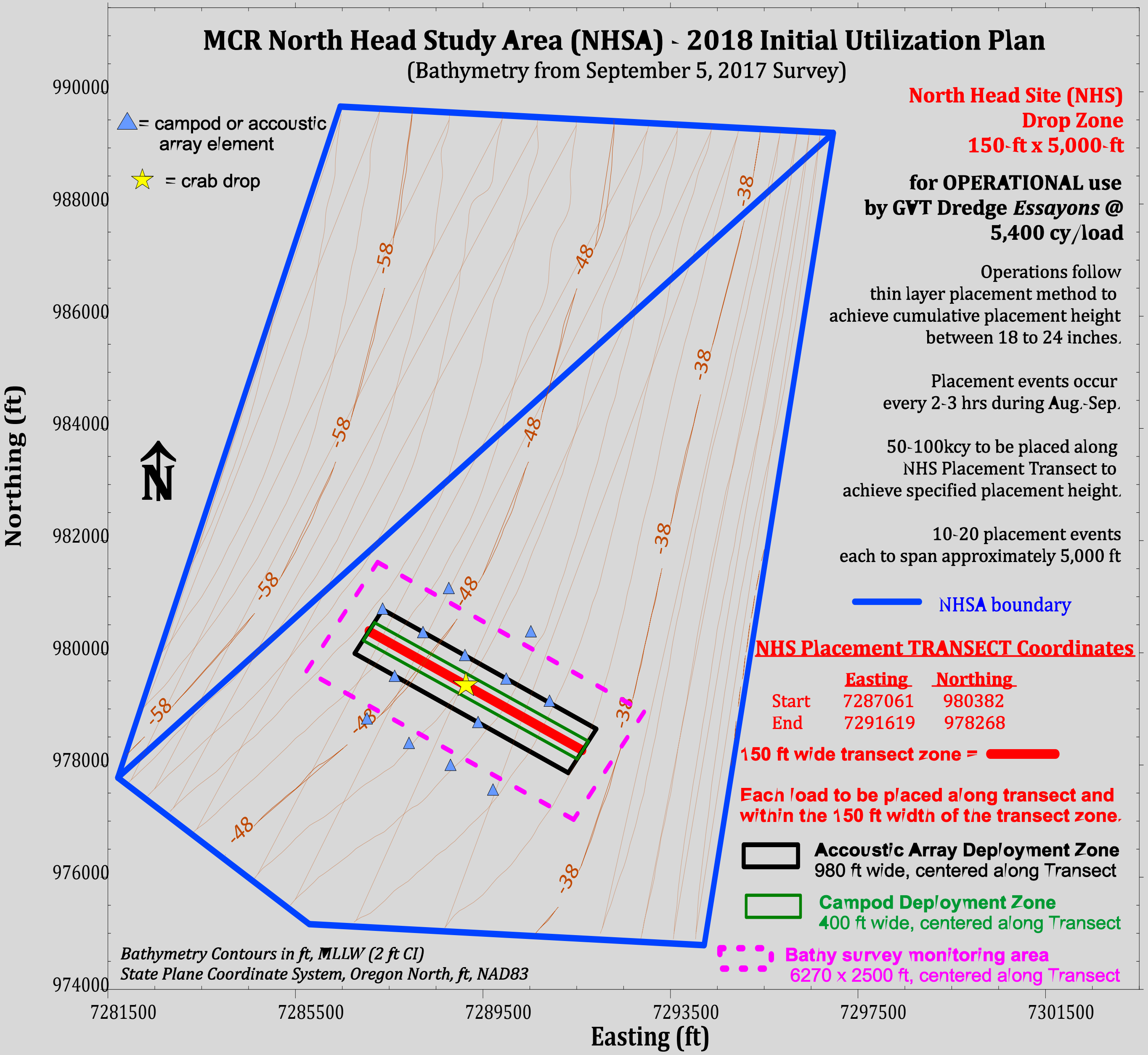
ESSAYONS TLP

Review of Intended Concept: Presented in MAY 2018

Proposal: Build a detectable feature on the North Head Site seafloor in about 35-50 ft. water depth to observe sediment dispersion. A feature of 2-ft. high in about 35-40 ft. water depth.

CROSS SECTION

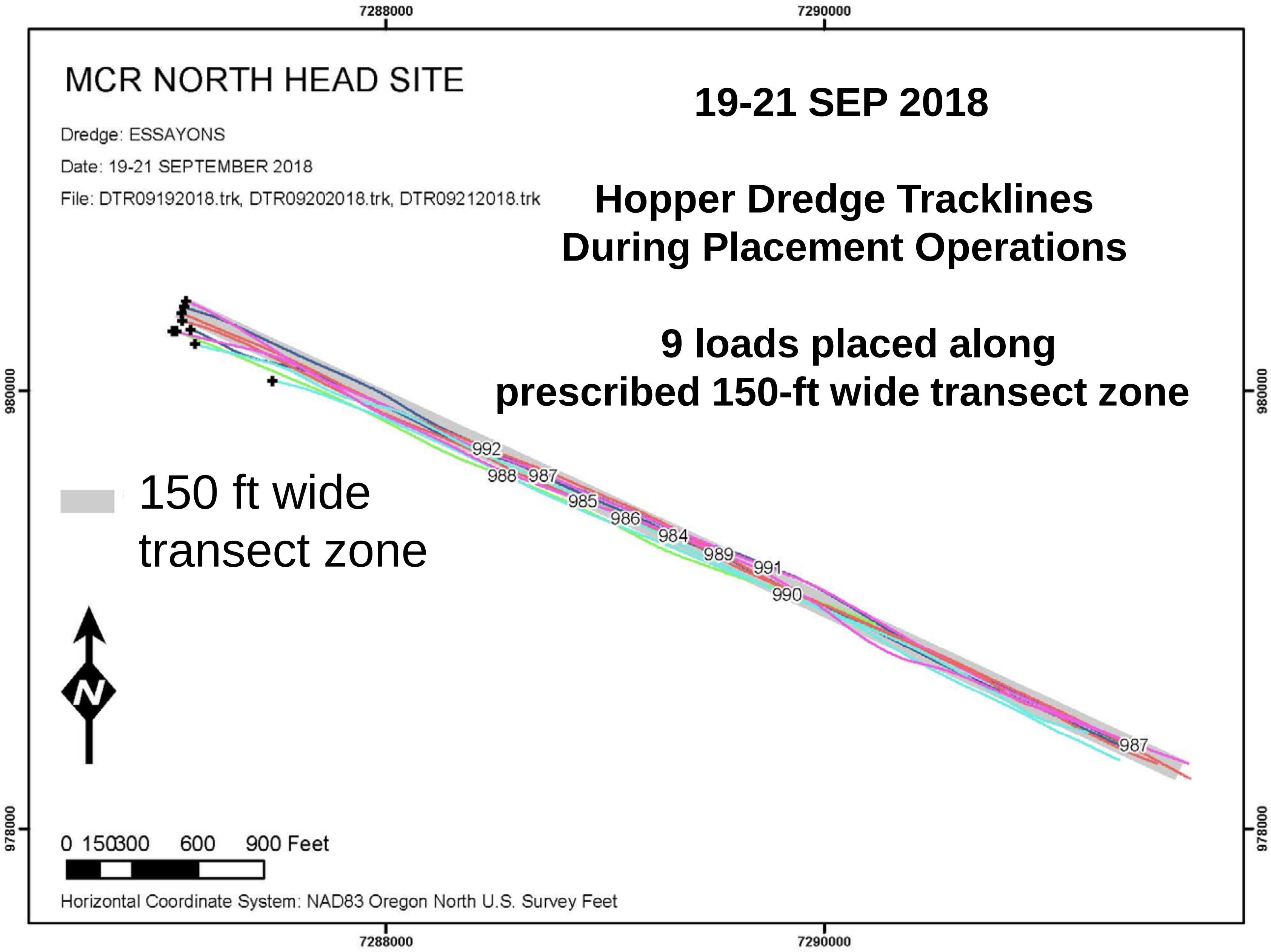



MCR North Head Study Area (NHSA) - 2018 Initial Utilization Plan
(Bathymetry from September 5, 2017 Survey)
= campod or accoustic array element
= crab drop
North Head Site (NHS) Drop Zone 150-ft x 5,000-ft
for OPERATIONAL use by GVT Dredge *Essayons* @ 5,400 cy/load
Operations follow thin layer placement method to achieve cumulative placement height between 18 to 24 inches.
Placement events occur every 2-3 hrs during Aug.-Sep.
50-100kcy to be placed along NHS Placement Transect to achieve specified placement height.
10-20 placement events each to span approximately 5,000 ft
NHSA boundary
NHS Placement TRANSECT Coordinates
Easting Northing
Start 7287061 980382
End 7291619 978268
150 ft wide transect zone =
Each load to be placed along transect and within the 150 ft width of the transect zone.
Accoustic Array Deployment Zone
980 ft wide, centered along Transect
Campod Deployment Zone
400 ft wide, centered along Transect
Bathy survey monitoring area
6270 x 2500 ft, centered along Transect
Bathymetry Contours in ft, MLLW (2 ft CI)
State Plane Coordinate System, Oregon North, ft, NAD83
N
-58
-48
-38
Northing (ft)
990000
988000
986000
984000
982000
980000
978000
976000
974000
Easting (ft)
7281500
7285500
7289500
7293500
7297500
7301500

19-21 SEP 2018

Hopper Dredge Tracklines During Placement Operations

9 loads placed along prescribed 150-ft wide transect zone

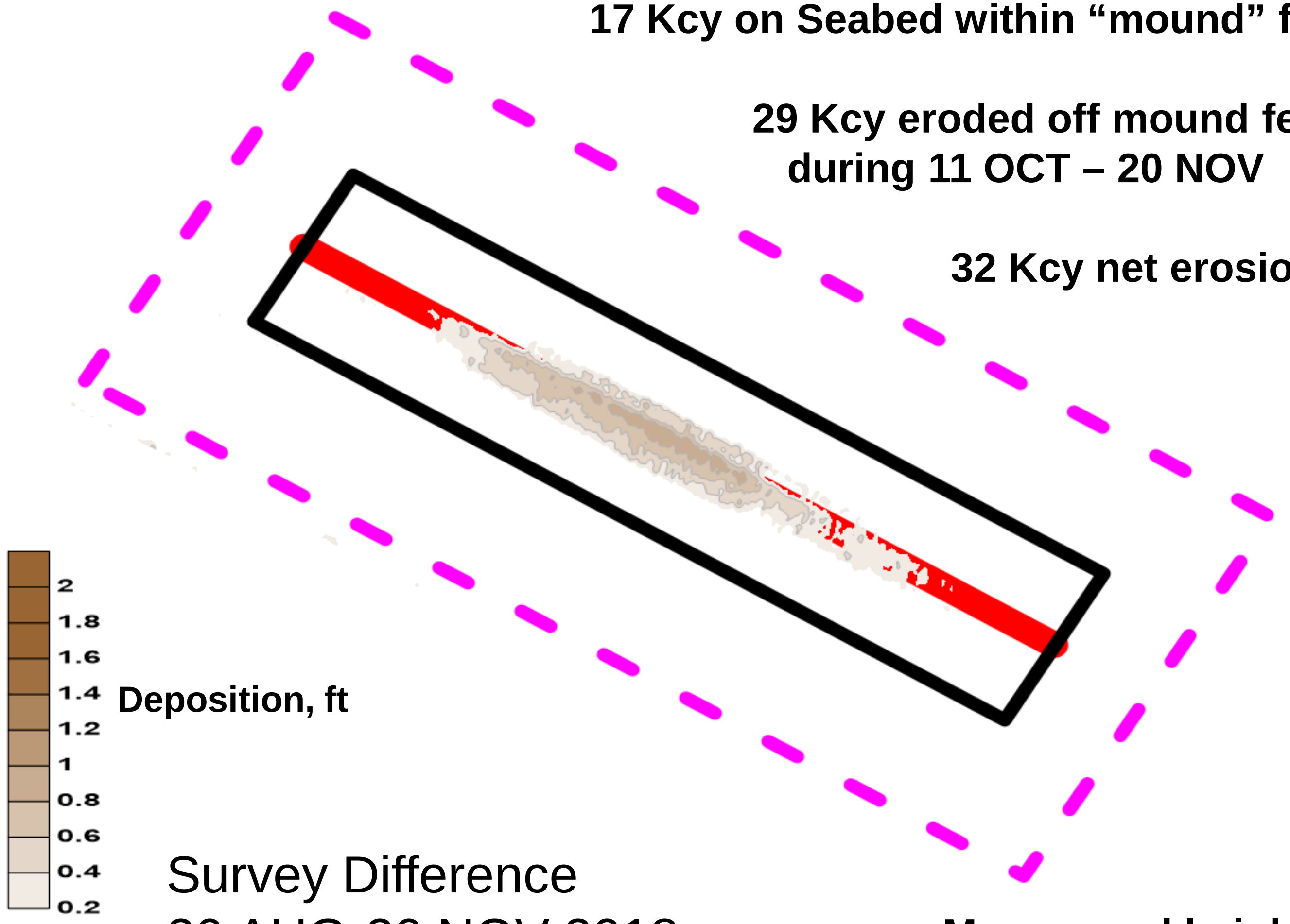


61 days AFTER placement - 51,000 CY initially placed

17 Kcy on Seabed within "mound" feature

29 Kcy eroded off mound feature during 11 OCT – 20 NOV

32 Kcy net erosion from 21 SEP



Survey Difference
20 AUG-20 NOV 2018

Max mound height = 1.0 ft with respect to 20 AUG seabed

Discussion Questions:

"Bleeder" Pipe for Levee Construction?

Source: Naylor Pipe Company
Huston 1986

Water Irrigation Systems?

Deltafarmpress.com

ebirdseed.com

Discussion Questions:

West coast MURDEN?
Use navigation DM to cap contaminated sediment in Bay?
Reverse rainbow?

What is "Thin Layer Placement?"

Technical Definition for USACE:

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.

ERDC TN-19-1, February 2019: Thin Layer Placement: Technical Definition for U.S. Army Corps of Engineers Applications
DOER, RSM, DOTS, and EMRRP programs

https://erdc-library.erdc.dren.mil/xmlui/bitstream/handle/11681/32283/ERDC%20TN-19-1.pdf?sequence=1&isAllowed=y