Water Injection Dredging (WID) in the US, Challenges & Solutions

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Outline

• Traditional Dredging Methods

• Hydrodynamic Dredging
  o Agitation & Plow
    ▪ Tiamat Harwich Haven Authority (HHA)
  o Water Injection Dredge (WID)
    ▪ Environmental Considerations
    ▪ Economic Benefits

• Case Study
  o North Carolina State Ports Authority (NCSPA)

• The Future
  o NCSPA Federal Turning Basin
  o USACE-NAO (Norfolk District & Virginia Port Authority (VPA)
  o Kansas Water Office (KWO)
Hydraulic Cutter Suction Dredge

Courtesy Damen
Mechanical Backhoe Dredge

Courtesy Boskalis
Comparison of Dredging Techniques

**Hydraulic & Mechanical Dredging**

are *traditional dredging* techniques that hydraulically or mechanically remove sediments from a waterbody.

All **Hydraulic & Mechanical Dredged** sediments are *transported* using buckets, pipeline, hoppers, barges, etc.

**In comparison, all Hydrodynamic Dredging** techniques horizontally transport the dredged material, *entirely within the water column*.

All **Hydrodynamic Dredging** sediments *flow through the water* from the dredge area to the final disposal area.
Water Injection Dredge, Damen, Netherlands

Dredging Methods - Hydrodynamic Dredges
Types of Hydrodynamic Dredges

**Agitation & Plow Dredging** disperses the sediments from the bottom into the *whole water column*.

**Water Injection Dredging** fluidizes the sediments, creating a near-bottom *density current* with higher density than the surrounding water.
Boskalis Terra Plana Plough Dredge

Hydrodynamic Dredges – Agitation & Plow Dredging
Hydrodynamic Dredging - Agitation & Plow

**Agitation & Plow Dredging** require:
1. Equipment that suspends sediments into the water column
2. Water flow that transports the sediment away from the site

Various means can be used for this process, including:
- Prop-Wash
- Hopper Dredge overflow
- Vertical mixers or Air Bubbles
- Drag beams or Rakes (Plow Dredging)

**Agitation & Plow Dredging** produce a turbid water column & thus, at least temporarily, higher water quality impacts.

*Arulaq Agitation Dredge, Brice Civil Constructors, Morgan City LA*
Hydrodynamic Dredges – Water Injection Dredges
Water Injection Dredging

**WID** pumps water into channel bottom sediments at relatively high-volume & low pressure.

The objective is to remove the material from a selected area by taking advantage of the near-bottom density current:
- Tides
- Currents
- Gravity
- Other Hydrodynamic Forces

**WID** allows sediments to flow horizontally out of a waterbody, while the fluidized sediment layer remains close to the bottom.
Water Injection Dredging (WID)

Courtesy Van Oord
Environmental Considerations

**WID** cannot be used where **unacceptable environmental impacts** may occur
- Contaminated resuspension
- Suspended solids effects
- Site specific impacts

Sediment transport modelling is required to determine the destination of **dredged sediments**

**WID** has the **ecological advantage** as it does not disturb the sediment distribution & waterbody balance

All **WID** sediments **must be analyzed** & most sediments will be appropriate for the dredging technique

**Parameters** that influence **WID** production include:
- Soil characteristics
- Site bathymetry & geometry
- Hydrodynamic conditions
- Geographic location
- Type & level of contamination
- Regulatory agency acceptance
Economic Benefits

Traditionally dredged sediments require more costly transportation, using pipelines, buckets, hoppers, barges, etc.

Traditional dredged sediments require acquiring placement or disposal areas for the storage.

Traditional dredging costs:
- Mobilization/Demobilization
- Transportation & Storage
- Complex dredge plant O & M
- Lower production rates

In comparison, for all hydrodynamic dredging (including WID) the dredged material is transported entirely within the water column.

Optimized hydrodynamic dredging:
- Rapidly moved on short notice
- Don’t require disposal facilities
- Reduced dredge plant O & M
- Higher production rates
USACE NDC Dredging Costs (1963-2020)

- Overall US dredging volumes decreased:
  - USACE CY has decreased by ~277%
  - Industry CY has decreased by ~25%
  - Overall, CY has decreased by ~70%

- Overall US dredging costs (adjusted for inflation) increased:
  - USACE $/CY has increased by ~78%
  - Industry $/CY has increased by ~150%
  - Overall $/CY has increased by ~155%

- Overall US dredging volumes by type have decreased:
  - New Work CY has decreased by ~673%
  - Maintenance CY has decreased by ~21%

- Overall US maintenance dredging responsibility has shifted to Industry:
  - USACE portion has decreased by ~17%
  - Industry portion has increased by ~43%
Water Injection Dredge (WID)

North Carolina State Ports Authority (NCSPA)
Dredging Template

Limits of Dredging by Maintenance Dredging (PipeLine Cutter Head Dredge).

Underwater King Pile Toe Wall

Accumulated Sediment to be Removed by Scour Jet or Water Injection.

EL -30.4 (NGVD)

EL -42.0 MLLW (Dredge Line)

TIP EL -66.40 (NGVD)
Request for Proposals (RFP), Selection, & Delivery

• **Design-Build RFP**
  - Issue RFP to all Potential Teams
  - Technical Proposals & Sealed Price Proposals Due
  - Technical Presentation by Teams

• **Selection & Delivery**
  - NCSPA Board of Directors Meeting
    - Recommend Selection
    - Final Selection
  - Contract Execution
USACE-ERDC Monitoring Event

• Since June 2021
  • Dredged ~270,000 cubic yards (CY)
  • Approximately 90 hours
  • Production rate of around 3,000 CY/hr.

• NCSPA costs include:
  • Annual depreciation of the vessel
  • Annual insurance costs
  • Dredging operations costs
  • Fuel
  • Other O&M costs (repairs, parts, contract services, expendables, training not related to a dredging event, etc.)
  • Pre- & post-dredging surveying

• Estimated $1M/YR in cost savings
Pre-Dredging & Post-Dredging Survey Results
WID Channel
Dredging above the Chesapeake Bay Bridge-Tunnel

Virginia Port Authority (VPA)
Chesapeake Bay’s Federal Waterways

USACE District:
Norfolk - NAO

USACE Channel:
All

Channel ID:
All

Survey Date Range:
Predefined
Custom Date Range:

- All Surveys

USACE Hydrographic Surveys – eHydro
www.navigation.usace.army.mil/Survey/Hydro
Chesapeake Bay Bridge-Tunnel

USACE District:
Norfolk - NAO

USACE Channel:
All

Channel ID:
All

Survey Date Range:
Predefined  Custom Date Range

From

5/8/2022  h:mm A

Until

5/9/2022  h:mm A

Use the dropdown menus or simply pan and zoom on the map to filter the Hydrographic Survey data.

Use any combination to drill down to the desired map scale.
VPA FINAL SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT (SEA)

• Norfolk Harbor Navigation Improvements Project, Chesapeake Bay Bridge-Tunnel (CBBT)

• Preconstruction engineering & design efforts raised concerns about risks to the tunnel structure

• WID ↔ chosen alternative dredging method

• US Army Corps of Engineers Norfolk District (USACE-NOA) was responsible for preparing the SEA

• Non-federal sponsor (VPA) providing input on the technical aspects of the proposed project
Water Injection Dredge (WID) in Reservoirs

Kansas Water Office (KWO)

Tuttle Creek Lake
WID Kansas Water Office (KWO) Tuttle Creek Lake
Tuttle Creek Lake: 1957-2010
WID KWO – Tuttle Creek Lake (Cont.)

Tuttle Creek Lake: 1957-2010

Southern end of Tuttle Creek Lake

Tuttle Creek Dam

Spillway gates

Stilling basin aka “the tubes”

Tuttle Creek Lake: 1962

Tuttle Creek Lake: 2010
Annual Storage Volume Lost

- Sedimentation Rate in the Reservoir’s Multi-Purpose Pool (1957 – 2010)
  - 3,600 acre-feet/year
  - 5.8 million cubic yards per year

Open the sluice gates & release the sediment through the existing low elevation discharge conduit under the forces of:
- Gravity due to elevation changes
- Current (suction) from the low elevation discharge conduit

Water Injection Dredging

Inject water into the sediment deposits to induce a density current
WID KWO – Tuttle Creek Lake (Cont.)
Summary – Case Studies, Scopes, & Conversations

- North Carolina State Ports Authority
- Port Tampa Bay
- Kansas Water Office
- New York City DEP
- Virginial Port Authority
- Port of Morgan City
- Georgia Ports Authority
- Kinder Morgan LNG, Savannah
- South Carolina Ports Authority
- Maryland Port Administration
- Alabama State Port Authority
- USACE Mobile & Wilmington Districts
Summary - Takeaways

The key benefit of WID is that horizontal **transport** of the dredged material takes place **entirely within the water column**.

Worldwide WID is a **rapidly evolving field** & will require educating regulatory agencies & the public.

**Traditional dredging** is often as much about transporting & handling water as it is about the removed sediment.

**Four-part formula** for WID success:
- Site conditions (sediment & hydrodynamic forces)
- Technical feasibility
- Legal & regulatory concerns
- Economics (benefits/costs ratio vs cost only)

The **WID technique** dilutes & fluidizes the sediments, creating a **near-bottom density current** with higher density than the surrounding water.
Water Injection Dredge (WID)

Alabama State Port Authority (ASPA)
Mobile Bay Regional Sediment Management (RSM) Strategy

• Mobile Bay Ship Channel was primarily the 45-feet-deep & 400-feet-wide extending northward from the mouth of Mobile Bay for 29 miles to the mouth of the Mobile River.

• About 4 MCY per year annual maintenance dredged material is removed by hopper dredges from Mobile Bay Ship Channel & placed in the ODMDS.

• ODMDS is roughly 4 miles from the inlet & over 4.75 square miles, but ~40 miles from the north end of Mobile Bay.

• Requirement to use hopper dredges for Mobile Bay dredging limited by USACE-SAM access to a smaller percentage of the available hopper dredging fleet.
Mobile Harbor Construction, Engineering & Design Agreement

• Six-phase project – anticipated completion by late 2024 or early 2025. Total estimated cost for the project is $365.7 M

• Project will deepen the bar, bay & river channels in Mobile Harbor to 50 feet
  o Bend easing at the double bends of the bar channel
  o Widening of the bay channel from 400 feet to 500 feet from the mouth of Mobile Bay northward for three miles
  o Expanding the Choctaw Pass Turning Basin by 250 feet to the south at a 50-foot depth.

• In April 2021, Great Lakes Dredge & Dock (GLDD) awarded a ~$54 M contract to deepen & widen portions of the Mobile Harbor with an estimated completion date of October 18, 2022
Mobile Harbor Deepening Project

MOBILE HARBOR
APPROVED PLAN

- Channel Deepening: 50 feet Bay/52 feet Bar
- Channel Widening: 3 mi. long, 100 ft wide
- Turning Basin Modification
- Bar Channel Bend Easing

CONSTRUCTION PHASING

Phase 1 | Bar Channel Deepening
Phase 2 | Bar Channel & Bend Easings to 52' plus Widener
Phase 3 | Deepening Lower Bay Channel
Phase 4 | Deepening remainder of Lower Bay Channel and portion of Upper Bay Channel
Phase 5 | Deepen Upper Bay Channel (Relic Shell)
Phase 6 | Turning Basin

FULLY FUNDED COSTS: $365.7M
*Federal Share: $274.3M
*Non-Federal Share: $91.4M
Mobile Harbor Deepening Project

MOBILE HARBOR CONSTRUCTION SCHEDULE

PHASE

DURATION


Hopper/Pipeline
Phase 1

Phase 2
Hopper

Phase 3

Phase 4
Pipeline Dredge
Hopper

Phase 5
Bucket and Scow
Float

Phase 6
Float
Dredging Efficiencies Investigation

Port Tampa Bay (PTB)
Tampa Bay’s Federal Waterways

USACE District:
- All

USACE Channel:
- All

Channel ID:
- All

Survey Date Range:
- All Surveys
- Last 60 days
- 2019
- 2018
- Custom Date Range

USACE Hydrographic Surveys – eHydro
www.navigation.usace.army.mil/Survey/Hydro
Dredged Material Management Plan (DMMP)

- More than 67 miles of channels with various depths & widths & six turning basins
- Roughly 1 MCY of maintenance dredging per year
- Approximately 7.5 MCY of capacity is available
- The USACE DMMP calls for:
  - Continual raising of existing Dredged Material Containment Facility Dikes
  - More disposal in Ocean Dredged Material Disposal Site (ODMDS)
  - Beneficial Reuse of dredge material
  - Reducing dredging needs
Discussion Summary & Feasibility Study Outline

• $3 M maintenance dredging annual budget
  • Includes PTB’s federal responsibilities
  • Does not include any new infrastructure

• Feasibility study outline evaluation:
  • Current dredging methods efficiency
  • Review & summarize existing studies documenting the dominant circulation features
  • Potential effectiveness of WID
  • Possibility of using in-channel sumps & wideners to “collect” material re-fluidized by the WID
Water Injection Dredge (WID)

Georgia Ports Authority (GPA)
Savannah Harbor Expansion Project (SHEP)
GPA Waterways – Savannah Harbor

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<th>Savannah - SAS</th>
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Savannah Harbor (West)
Savannah Harbor (East)
Savannah Harbor Expansion Project (SHEP) General Re-evaluation Report (GRR)

- Savannah Harbor Bar Channel is 11.5 miles long, 44 feet deep & 600 feet wide, & an Inner Harbor Channel 21 miles long, 42 feet deep & 500 feet wide

- Ongoing deepening will result in 47 feet depths

- Up to 7 MCY of sediments (sand, silt & clay) removed each year from the Inner Harbor into ~8 DMCA

- Up to 800 KCY of sediment from the Entrance Channel from December through March
GPA Waterways – Brunswick Harbor
Brunswick Harbor

USACE District:
Savannah - SAB

USACE Channel:
All

Channel ID:
All

Survey Date Range:
Predefined    Custom Date Range

- All Surveys:
  Last 60 days:
    2019
    2018

USACE Hydrographic Surveys – eHydro
www.navigation.usace.army.mil/Survey/Hydro
Brunswick Harbor

USACE Hydrographic Surveys - eHydro
Brunswick Harbor Modification Study Draft FONSI

- Brunswick Harbor Bar Channel is 38 feet deep, 500 feet wide, & 10.7 miles long & an Inner Harbor Channel 36 feet deep, 400 feet wide, & 15.3 miles long through St. Simon's Sound, Brunswick River & East River

- Inner Harbor has two turning basins – East River & Turtle River

- Inner Harbor dredged material placed in Andrews Island, the sole upland DMCA

- Brunswick Harbor has not been dredged to authorized project dimensions since 2010 due to funding shortfalls, a limited number of hopper dredges, & environmental hopper dredging windows
Water Injection Dredge (WID)

South Carolina Ports Authority (SCPA)
Cooper River & HLT
Charleston Harbor Regional Sediment Management (RSM) Update

- More than 39 miles of channels with various depths & widths & six turning basins.
- Roughly 6.9 MCY of maintenance dredging per year
- ODMDS is roughly 8 miles from the inlet & over 12 square miles, with a smaller drop zone
- USACE Charleston District is currently dredging parts of the Harbor to 52 feet & entrance channel to 54 feet
Project Focus

- Charleston Harbor is formed by the junction of the Ashley, Wando, & Cooper Rivers

- In 1942, Santee-Cooper Hydroelectric Project was completed, & was flow into the west branch of the Cooper River

- In 1959 three (3) contraction dikes were constructed in the Cooper River

- As long ago as 1992, the USACE has acknowledged the need to reconfigure the contraction dikes

- HDR’s proposed study would, among other issues like the contraction dikes, look at the potential effectiveness of WID in the Charleston Harbor
Water Injection Dredge (WID)

Maryland Port Administration (MPA)
MDOT MPA DMMP 2020

- A series of vast & complex channels with various depths & widths & multiple turning basins
- Roughly 5 MCY of maintenance dredging per year
- Mid-Bay Island Ecosystem Restoration Project’s beneficial use of dredged material is the Port’s number one federal priority
- What is the Future of Confined Aquatic Disposal?
- What are the most daunting & potentially long-lasting programmatic challenges?
- What are the crucial budget concerns?
Water Injection Dredge (WID) in Reservoirs

Kansas Water Office (KWO)

Tuttle Creek Lake
WID Kansas Water Office (KWO) Tuttle Creek Lake
WID KWO – Tuttle Creek Lake (Cont.)
WID KWO – Tuttle Creek Lake (Cont.)
Annual Storage Volume Lost

- Sedimentation Rate in the Reservoir’s Multi-Purpose Pool (1957 – 2010)
  - 3,600 acre-feet/year
  - 5.8 million cubic yards per year

Open the sluice gates & release the sediment through the existing low elevation discharge conduit under the forces of:

- Gravity due to elevation changes
- Current (suction) from the low elevation discharge conduit

Water Injection Dredging

Inject water into the sediment deposits to induce a *density current*
### USACE NDC Dredging Costs (1963-2020)

https://publibrary.planusace.us/#/series/Dredging%20Information

#### Corps of Engineers

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#### Industry

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#### USACE & Industry

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USACE NDC Dredging Costs (1963-2020)

- Overall US dredging volumes have decreased
- New work dredging volumes have dramatically decreased
- Maintenance dredging volumes have slightly decreased
- Overall US dredging costs have significantly increased
- Overall US maintenance dredging responsibility (both volume & dollars) has shifted to Industry
USACE NDC Dredging Costs (1963-2020)

• Overall US dredging volumes decreased
  o USACE CY has decreased by ~377%
  o Industry CY has decreased by ~125%
  o Overall CY has decreased by ~170%

• Overall US dredging costs increased
  o USACE $/CY has increased by ~178%
  o Industry $/CY has increased by ~250%
  o Overall $/CY has increased by ~255%

• Overall US dredging volumes by type have decreased
  o New Work CY has decreased by ~773%
  o Maintenance CY has decreased by ~121%

• Overall US maintenance dredging responsibility has shifted to Industry
  o USACE portion has decreased by ~17%
  o Industry portion has increased by ~43%
### Corps of Engineers

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140% 66.7% 125% 262% 558% 250%

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121% 77.3% 170% 256% 578% 255%
Project Approach

- NCSPA authorized research into acquiring a WID, hiring a WID contractor, or some other variant (Spring 2018)

- Contacted over 70 organizations, including dredge manufacturers & other possible sources of relevant information
  - Dredging related electronic newsletters
  - Trade publications
  - Trade show membership & attendance
  - Annual dredging related directories
  - Hydraulic agitation dredge operators

- Interview roughly 20 organizations, with 11 of them becoming promising candidates for WID design-build teams (Fall 2018)
“Section 1 of the Act of May 24, 1906 (34 Stat. 204; 46 U.S.C. App. 292), provides that, “a foreign-built dredge shall not, under penalty of forfeiture, engage in dredging in the United States unless documented as a vessel of the United States.”
Procurement Fact Sheet

• Solicited feedback from dredge manufacturers & others regarding several crucial project factors:
  • Preliminary schedule
  • Time needed to fabricate & transport the dredge to the NCSPA

• Factors similar to any NCSPA purchase of large, expensive equipment
  • Maintenance
  • Warranties
  • Operation manuals

• Unique factors included:
  • Proof of concept demonstrations
  • Training requirement
Request for Pre-Qualifications

Project sequence:

• Commissioning of a fully equipped WID

• Delivery of WID to the NCSPA Ports of Wilmington & Morehead City
  
  • Execution of a Port operator’s training program
  
  • Full week demonstration at each Port

• Report summarizing the Contractor’s executed proof of concept, including pre- & post- dredge hydrographic survey data

• Modification of the WID plant, as necessary, & handover to NCSPA
Request for Information & Geotechnical Data Collection

• Sediment characterization fieldwork at both ports
• Ponar grab & cone penetrometer test (CPT)
• Several unique sediment parameters
  • CPT Testing
    • Tip resistance
    • Sleeve resistance
    • Pore water pressure
  • Measuring ability to fluidizes
    • Post-decant solids mass loss
    • Slurry mass loss
    • Slurry volume loss