



# Environmental Dredging – Equipment Capabilities and Selection Factors



(Tab G)

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4/20/2005

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# Equipment Selection – Considerations



- Selection depends on a number of factors
  - Objectives Goals and Standards
  - Inherent capabilities of equipment
  - Site and sediment conditions
- Mechanical vs. Hydraulic
- Conventional vs. Specialty
- Size/ Number - Smaller sizes used compared to navigation
- Use of multiple dredge types

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## Early Efforts/ Gaps



- Hand et al 1979; Palermo 1991; ARCS 1994; Herbich 1995; Mohan 1998;
- EPA Superfund (Draft 2002 and 2005)
- Much of the earlier info focused on navigation
- No consistent set of factors
- No consistent definition of factors and how they relate to equipment selection
- No detailed technical basis for proposed values or ratings for given dredge types

	Loss of Liquid	Percent Solids in Slurry by Weight <sup>a</sup>	Turbidity Caused
Dipper	high	in situ	high
Clamshell or Grab	high	in situ	high
Suction	low	10-15%	low
Dredger	low	10-20%	avg.
Cutterhead	low	10-20%	avg.
Hopper	low	10-20%	avg.
MUDCAT	low	10-40%	low
PHEDMA	low	up to 80% of in situ	low
Handheld Vacuum	low	3-10%	low

From Hand et al 1979

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## EPA Sediment Guidance (2005 Draft)



- Reviewed readily available literature and data
  - Past efforts at ratings
  - Books, EPA and USACE reports
  - WEDA, WODCON, ASCE, and other proceedings.
  - Readily available databases
  - WEDA/ PIANC Specialty Sessions
- Effort was time limited - we did not review everything out there.

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## Intended Use of Table 1

“This table provides general information to help project managers make an initial assessment of dredge capabilities. There are many site-specific circumstances that will dictate which equipment will work for any given situation; in addition, because new equipment is being continuously developed, project managers will need to consult with experts who are familiar with the latest technologies in order to make a final selection.”

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## Environmental Dredging Equipment Categories



**Conventional Clam**



**Enclosed Bucket**



**Articulated Fixed-Arm**



**Cutterhead**

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**Horizontal Auger**

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**Plain Suction**



**Pneumatic**



# Environmental Dredging Equipment Categories



Diver-Assisted



Dry Excavation



Specialty Dredges

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# Characteristics



- Characteristics – *quantitative* ranges for specific operational characteristics
  - First portion of TABLE 1
- Based on data in readily available literature, summarized in TABLE 2.
- Production
- Percent solids
- Vertical Accuracy
- Horizontal Accuracy
- Max Dredging Depth
- Min Dredging Depth

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# Selection Factors



- Selection Factors – *qualitative* ratings for potential performance considering site and sediment conditions – second portion of TABLE 1.
  - **High** – generally suitable or favorable
  - **Medium** – addresses the issue, may not be preferred
  - **Low** – may not be suitable
- Based on experience and best professional judgment
- **Sediment Resuspension**
- **Contaminant release control**
- **Residual/ Cleanup Level**
- **Transport by pipeline**
- **Transport by barge**
- **Positioning Control**
- **Maneuverability**
- **Portability/Access**
- **Availability**
- **Debris/ Loose Rock/ Vegetation**
- **Hardpan/ Rock Bottom**
- **Flexibility for Varying Conditions**
- **Thin Lift/ Residual Removal**

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# Production



	Mechanical Dredges	Hydraulic Dredges	Pnu.	Spec.	Diver	Dry Exc.
<b>Operating Production m3/hr</b>	50 - 2 cu m 95 - 4 cu m 145 - 6 cu m 190 - 8 cu m	70 - 15 cm 145 - 20 cm 200 - 25 cm 285 - 30 cm	Site Spec.	Equ. Spec.	10	Site Spec.

Hydraulic P = Dia x Vel x Slurry Solids/Insitu Solids (Used 15 fps; 10 % solids; sediment at 35% solids)

Mechanical P = Bucket size x % fill x cycle time (Used 80% fill; 2 min cycle)

Table 2 values are for sustained production rates, mostly pilots

Table 2 Range	8-31	31-64	12-56	15-61	19	25-450	2-103	12-48	
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# Percent Solids



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Percent Solids</b>	<b>90% In-Situ</b>	<b>80% In-Situ</b>	<b>80% In-Situ</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>15</b>	<b>Equip Spec.</b>	<b>10</b>	<b>Site Spec.</b>

Table 2 Range		44-48			8-22		17-50	15-70	2-4	
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# Vertical Accuracy



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Vertical Accuracy (cm)</b>	<b>15</b>	<b>15</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>15</b>	<b>Equip Spec</b>	<b>--</b>	<b>5</b>

Table 2 Range	20	2.5-5			3-15	5				
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DGPS vertical accuracy = 12 cm

KDGPS vertical accuracy = 2 to 3 cm

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# Horizontal Accuracy



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Horizontal Accuracy (cm)</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>-</b>	<b>5</b>

Table 2 Range				20	20					
---------------	--	--	--	----	----	--	--	--	--	--

DGPS horizontal accuracy = 7 cm

KDGPS horizontal accuracy = 1 to 2 cm

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# Maximum Digging Depth



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Maximum Digging Depth (m)</b>	<b>Stab Lim</b>	<b>Stab Lim</b>	<b>15</b>	<b>15</b>	<b>5</b>	<b>15</b>	<b>45</b>	<b>15</b>	<b>30</b>	<b>Stab Lim</b>

Table 2 Range	9-12	9-12		12	5-8	26	18-60	18-35		
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# Minimum Digging Depth



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Minimum Digging Depth (m)</b>	--	--	--	1	0.5	1	5	1	0.5	--

Table 2 Range										
---------------	--	--	--	--	--	--	--	--	--	--

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# Sediment Resuspension Control



Sediment Resuspension = dislodged sediment dispersed to the water column and subject to plume transport.

This factor relates to the potential to control resuspended sediment and associated release.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Sediment Resuspension</b>	Low	Med	Med	Med	Med	High	High	High	High	High

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## Contaminant Release Control

This factor relates to the ability to control releases to water and air.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Contaminant Release Control</b>	Low	High	High	Med	Med	Med	Med	Med	High	High

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## Residual Sediment/ Cleanup Levels

This factor relates to the efficiency of removal without leaving a residual, thereby meeting a set cleanup level.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Residual Sediment/ Cleanup level</b>	Low	Med	Med	Med	Med	Med	Med	Med	High	High

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# Transport by Pipeline



This factor relates to compatibility with pipeline transport.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Transport by Pipeline</b>	Med	Med	Med	High	High	High	High	High	High	Med

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# Transport by Barge



This factor relates to compatibility with barge transport.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Transport by Barge</b>	High	High	High	Med	Med	Med	Med	Med	Med	High

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# Positioning Control



Ability of the dredge to hold a desired position considering wind, current, or fluctuating tides.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Positioning Control</b> <b>(Stability)</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Med</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Med</b>	<b>High</b>

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# Maneuverability



Ability of the dredge to operate efficiently in close proximity or around utilities, infrastructure, narrow channels, obstructions, overhead restrictions, etc.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Maneuverability</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>High</b>	<b>Low</b>	<b>High</b>	<b>High</b>

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# Portability/ Access

Ability of the dredge to pass under bridges, through narrow channels, or be transported by truck and easily launched.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Portability/ Access</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Med</b>	<b>High</b>	<b>High</b>

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# Availability

Availability of the equipment to multiple U.S. contractors.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Availability</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Med</b>	<b>High</b>	<b>High</b>

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## Debris/Loose Rock/ Vegetation



Ability of the dredge to effectively remove sediment containing debris, etc. without excessive resuspension or downtime.



	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Debris/ Loose Rock/ Vegetation</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>High</b>

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## Hardpan/ Rock Bottom



Ability of the dredge to effectively remove sediment overlying hardpan or rock bottom.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Hardpan/ Rock Bottom</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Med</b>	<b>Med</b>	<b>Med</b>	<b>High</b>	<b>High</b>

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# Flexibility for Varying Conditions



Flexibility of the dredge in adapting to varying conditions such as sediment stiffness, variable cut thicknesses, and the overall ability to take thick cuts.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Flexibility for Varying Conditions</b>	<b>High</b>	<b>High</b>	<b>Med</b>	<b>High</b>	<b>Med</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>Low</b>	<b>High</b>

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# Thin Lift/ Residual Sediment



Ability of the dredge to remove thin layers without excessive overdredging.

	Clam	Enc Buck.	Art. Fixed Arm	Cutter	Auger	Plain Suc.	Pnu.	Spec.	Diver	Dry Exc.
<b>Thin Lift/ Residual Sediment</b>	<b>Low</b>	<b>Med</b>	<b>Med</b>	<b>Med</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>

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## Example Application of Table 1



- Consider Capabilities of Equipment Objectively
- Determine Most Critical Selection Factors and consider weighting those factors
- Eliminate equipment types with “Lows”
- Retain equipment types with “Mediums to Highs”
- Note that Table 1 is only for ID of equipment types for further evaluation, and is not for final selection
- Evaluate multiple equipment types or combinations as needed

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## Equipment Selection – Conclusions



- Equipment selection is one of several major considerations for environmental dredging
- Wide range of suitable equipment is available for environmental dredging
- No single dredge type is best for all projects
- Selection depends on a number of factors
  - Objectives, goals, and standards
  - Inherent capabilities of equipment
  - Site, sediment, and project conditions
- Evaluate/select based on field experience, predictive tools, and field trials as needed

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# QUESTIONS?



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