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DREDGING GUIDELINES FOR MAJOR PORTS

GOVERNMENT OF INDIA
MINISTRY OF
PORTS, SHIPPING AND WATERWAYS
(2021)

SYNOPSIS

The Dredging Guidelines with Standard Operating Procedures (SOP)for undertaking Capital and Maintenance Projects at Major Ports was issued by Ministry of Ports, Shipping and Waterways in August 2016.

2. In accordance to Government of India disinvestment plan, Dredging Corporation of India Limited, a Central Public Sector Enterprise under Ministry of Ports, Shipping and Waterways was disinvested to instill transparency and improve optimum utilization of its dredgers resulting to increase its efficiency in dredging projects. With enactment / amendment of National Waterways Act, Environmental Act and Merchant Shipping Act, it was imperative for a dedicated research and development centre and there on, Ministry of Ports, Shipping and Waterways established National Technology Centre of Ports, Waterways and Coasts (NTCPWC) under the ambit of Sagarmala for coordinated activities with stakeholders for innovative techniques and up gradation to achieve optimum economical project delivery at Major Ports. This guideline to be followed by Major Ports to ensure implementation of dredging projects for cost effectiveness and delivery of projects as per schedule, this document shall be reference guidelines but is not exhaustive.

3. Globally, the international ports such as Rotterdam, Antwerp, Singapore adopt sustaining innovation and invention to modify their soil touching parts, dredge pumps and hydraulics etc. International dredging contractors adopt international standards to draft tender documents based on mitigation of risk management, prepare soil model for pre estimation in accordance to PIANC vis-à-vis utilization and reuse of dredged material for beneficial purpose, survey techniques based on IAPH / IHO requirements and CIRIA methodology for estimation of cost for dredging and reclamation projects. It is therefore pertinent to include appropriate process and procedure to achieve the above objectives and to minimize any potential dispute.

4. Dredging Guidelines at Major Ports 2021 shall address the objectives and include Dredging Policy for Major Ports. This shall supersede the Dredging Guidelines [August 2016] and Dredging Policy issued by the Ministry of Ports, Shipping and Waterways.

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CHAPTER 1

1.1 INTRODUCTION

Dredging is a process of removal of sediments and debris from the bottom of water bodies (river, estuaries, sea, etc.) using special devices “dredgers” for facilitating the safe movement of ships. Naturally occurring harbours normally face limitation of depths and economic potential, whereas sustainability of the water borne transport increases with increase in ship size i.e. larger the ship size the better energy efficiency and hence lesser carbon emission and more cost effective. In order to be benefited from scale of operations and harness efficiency, ship size continues to grow horizontally and vertically, forcing ports to provide deeper and wider channels, docks/quay to handle bigger ships. Therefore, dredging becomes an inevitable process for ports to sustain business, economy and environment.

Sediment transport or sediment movement and siltation characteristics of a place decides approximately how much sediment will deposit over a period of time in the navigational path. Depending on the rate of material deposition through natural processes, the sediment quantity or approximate reduction of available depth over a period of time can be estimated, which is required to be removed periodically to maintain the operational depth. This process of removing the deposited material is termed as **Maintenance Dredging**, which is a continuous process depending on the water body characteristics.

However, to receive larger ships, navigational channels, berths, harbour basin etc., may need to be deepened and widened further to a desired depth by cutting and removing virgin soil/ rock strata. Such dredging operation of removal of virgin soil is termed as **Capital dredging**. Hence, capital dredging is a one-time activity and expenditure on such dredging in Government accounting system is classified as capital expenditure. Every capital dredging activity will certainly lead to higher magnitude of maintenance dredging to maintain the created depth.

1.2 INDIAN DREDGING SCENARIO

During 2017-18 and 2018-19, dredging (maintenance and capital) of about 159.36 million cum was carried out across major ports of which, the capital dredging accounted for about 20%.The Table below may be referred:

APPROXIMATE SILTATION AT VARIOUS PORTS IN INDIA

Sl. No.	Name of the Port / Client	Approx. Siltation in Million CuM	Quantity dredged in Million Cum		
	Major Ports		**2017-18**	**2018-19**	**2019-20**
1	Syama Prasad Mookerjee Port Trust	11.10	9.30	10.90	7.80
2	Paradip Port Trust (incl. sand trap)	7.00	6.00	6.00	6.50
3	Visakhapatnam Port Trust	0.28	0.25	0.25	0.32
4	Kamarajar Port Limited (Ennore)	0.70	-	-	0.10
5	Cochin Port Trust	22.20	21.00	27.00	25.00
6	New Mangalore Port Trust	6.50	6.00	6.00	7.60
7	Mormugao Port Trust	2.20	1.40	1.40	1.80
8	Mumbai Port Trust	3.33	3.33	3.33	3.33
9	Jawaharlal Nehru Port Trust *	10.00	-	2.00	10.00
10	Deendayal Port Trust	14.95	12.30	14.95	14.95
11	Chennai Port Trust	0.2	-	-	-
12	V.O. Chidambaranar Port (Tuticorin)	-	-	-	-
	Sub Total (Major Ports)	**78.46**	**59.58**	**71.83**	**77.40**
	Others				
13	DGNP, Visakhapatnam	0.40	-	-	-
14	SNC, Kochi	1.80	1.50	1.40	1.80
15	WNC, Mumbai	1.60	-	1.35	2.00
16	CSL & KLPL	2.00	2.00	1.90	2.00
	Sub Total (Other):	**5.80**	**3.50**	**4.65**	**5.80**
	Capital				
17	Paradip Port Trust		0.80	0.20	1.00
18	Kamarajar Port Limited (Ennore)		-	1.00	-
19	Jawaharlal Nehru Port Trust		17.50	-	-
20	Kandla Port Trust		0.30	-	-
	Sub Total (Capital):	**-**	**18.60**	**1.20**	**1.00**
	Grand Total	**84.26**	**81.68**	**77.68**	**84.20**

*Maintenance dredging was not carried out at JNPT for the year 2017-18 as capital dredging was in progress.

It is foreseen that Major Ports shall deepen and widen their navigational channel to attract deep draft vessels and the forecast indicate, net dredging quantity may be approximately 3 billion cu m (1.6 billion cu m capital and 2.4 billion cu m maintenance) to be dredged in next 10 years(Source**). To dredge 3 billion cu m in next 10 years coupled with review of projects establish greater challenges and strict enforcement of certain process and procedure to achieve objectives of guidelines.

** Retail Equity Research, ICICI Securities Ltd.

1.3 BACKGROUND

Timely completion of any project is the key to its success and same goes true with dredging projects as well. Dredging is the key component of port and waterway development and operations; hence achievement of dredging targets (financially and physically) adds to the sustainability of a Port or navigable waterway.

Major Ports maintain navigational channels, harbor basins and alongside berth face depth by inviting either Domestic or Global tender or on nomination basis (to DCI, then Govt. PSU) and the contracts are based on one of the following criteria:

i. Quantity based on Pre and Post dredging depths.

ii. Guaranteed depth over a period of time.

iii. Depth assured contract.
iv. Per unit volume of dredged quantity i.e. rate.

v. Daily Chartering rate of dredger (specifying on hire and off hire rates).

vi. Lump Sum Contract.

Various models of assessment and responsibility are followed by Major ports for different types of dredging and some ports utilize third-party survey/ certification for pre- dredge and post dredging surveys, estimation, geo-technical investigations etc., and some use in-house capability for surveys, geotechnical investigations, estimation of dredging quantity etc.

Notwithstanding, variation do exist on various grounds that lead to potential disputes result for adjudication of disputes by any of the dispute resolution mechanism or by court of law. Root cause analysis establish inadequate estimation of dredging quantity, inconsistency in dredging soil type /strata encountered during dredging and information provided under tender, disputes under hydro-graphic surveys, incorrect selection of dredger, inaccurate pre estimates based on inadequate soil information or wrong interpretation by the contractor thereby variation in contract price and etc.

1.4 NEED FOR REVISED GUIDELINES

In order to streamline the dredging operation, the Ministry of Ports, Shipping and Waterways formulated dredging guidelines in August 2016. However, the following changes necessitated new guidelines:

i. Latest technological systems on survey and investigations recommended for capital dredging projects;
ii. To ascertain estimation of project cost is based on acceptable international standards by Major Port or schedule of rates by State Maritime Administration, such estimation of cost shall be dredger specific and based on principal particulars of dredgers. The need of the hour is to work out dredging cost scientifically taking into consideration the operation cost and the mobilization & demobilization along with other cost of dredgers;
iii. The need for engagement of two different agencies for Project Management Consultancy and Third Party Survey to avoid conflict of interest;
iv. The guidelines shall provide fair and equal opportunity for any new entrant to dredging industry as the same shall not be based either on Minor Ports Survey Organization (MPSO)Dredging Corporation of India DCI, the former company was closed and the later majority shares were disinvested; Concepts of Assured depth contract, EPC mode contract, annuity model / hybrid annuity model etc. needs to be considered as dredging option;
v. Beneficial use of dredged material has to be adequately explored.

To address above issues and minimize downtime, economic and environmental loss, avoid conflicts and achieve greater sustainability in dredging operations it is felt that lessons learnt elsewhere should be analyzed and positive aspects should be adopted by all major ports and waterway operators. The sustainability can be further achieved through meticulous planning and proper monitoring the dredging activity implementation.

In view of the above, it evolves for refinement for standardize processes and protocols connected with hydrographic survey and measurement techniques, employing hydrological characteristics and mathematical modeling in assessing sustainability, techno-economic assessment of optimum depth for a particular port / water way, evolving suitable business model, workable contract patterns etc.

Considering these aspects, Ministry of Ports, Shipping and Waterwaysvide OM No. DW-11012/1/2020-Development Wing dated 26th May, 2020 (**Annexure-I**) constituted a committee under chairmanship of the Additional Secretary, with following objectives:

1. To study the method of preparation of estimate for capital and maintenance dredging projects in the major ports of the world such as Colombo Port, Singapore Port and Dubai Port.

2. The method of preparation of detailed project report with engagement of project consultants with the dredging projects, best international practices being followed by the international Ports for determining the output of the dredging projects, or bringing efficiency, timely completion, etc.

3. The best system of tendering the dredging projects being followed by the international ports.

4. The latest technology adopted for survey including Hydrographic Survey, Geo-Technical Survey and Topographical survey, etc.

1.5 General Procedure applicable for Capital and Maintenance dredging projects:

1. The Major Ports having management control of Ports Owned Dredging Company may award the dredging works of the respective ports to the company on nomination basis on approval of Board of Trustees/ Directors of the Port. Whenever this route for award is followed the principle of competitive market price discovery for the same quality and conditions shall be followed (to ensure high efficiency incost, time and quality in execution of dredging projects).
2. The Major Ports may invite open competitive bidding for dredging projects after obtaining the approval of Board of Trustees/Directors.
3. The Circulars issued by the Ministry of Ports, Shipping and Waterways under the "AtmaNirbhar Bharat" or make-in-India or similar policies issued from time to time shall be followed.
4. The Major Ports should engage Project Management Consultant(PMC) for Capital Dredging Projects. The decision of engaging PMC may be taken by considering such as severity of the project, duration of the execution, cost of the project etc. Notionally, Rs. 100 crores may be considered to be a large enough project for engagement of a PMC. However, if the projects are critical and time sensitive or complex in nature, a qualified PMC may be required for smooth execution. The PMC shall be monitor execution of works as per all financial, quality and statutory requirements. The engagement of PMC for maintenance dredging project should be need based on project requirement assessed by Port;
5. Guidelines issued by Director General (Shipping), Mumbai from time to time in terms of relevant provisions of Merchant Shipping Act shall be applicable, except where such provisions are exempted by Government of India. The Ministry of Ports, Shipping and Waterways may in consultation with Director General (Shipping) provide exemptions from time to time as may be required.
6. All Major Ports should comply with the guidelines issued by the Central Vigilance Commission from time to time for processing the tenders in a transparent manner. Ports may ensure that pre-qualification criterion is fixed in advance and it should not be very stringent to restrict entry of potential Indian bidders. The prequalification conditions should be exhaustive yet specific. The prescribed

conditions should be clearly specified in the bid documents to ensure fair competition and transparency.

7. The Major Ports should upload past dredging project technical and financial details on their respective websites, including the soil dredged, volume dredged, duration for dredging work, borehole information, designed depth with tolerance and other applicable requisite details so as to ensure transparency in the implementation.

8. The guidelines issued by MoPSW for security clearance of the bidder for Port Project under PPP, including dredging project, shall also be applicable. Dredgers shall be bound to follow Indian Merchant Shipping Act and regulations, unless any specific provision is exempted by the Government of India.

9. All Major ports shall provide tentative dredging plan once in every 5 years to Indian Ports Association (IPA), New Delhi.

10. The Ministry of Ports, Shipping and Waterways reserves the right to assign in public interest, any contract for dredging work in any Major Port on nomination basis to Ports owned dredging company following due settlement process.

11. Dispute Resolution Committee consisting of dredging expert/s, officer of the Major Port and representative of the dredging company may be constituted by the port for resolving disputes to avoid arbitration /court cases.

12. The recycling of dredge material should be included in the bid documents of the dredging projects to ensure reuse of dredge material.

1.6 APPLICABILITY

1.6.1 These guidelines are applicable to all Major Ports for planning and execution of dredging projects.

1.6.2 LIMITATION

This document contains guidelines regarding the aspects of the dredging which may require more clarity in assessing the need of the dredging, quantity, best possible out-sourcing models, scope of recycling and reuse of dredged material, desired environmental practices etc.

CHAPTER 2

STANDARD OPERATING PROCEDURE FOR DREDGING PROJECTS

2.1 PROJECT FORMULATION

A generic road map for implementation of a Dredging project is to be created at the time of commencement of the planning exercise. In order to appreciate this, generic decision making flow chart for Maintenance and Capital dredging are provided as below (Fig. 2.1). As required, technical and commercial inputs from other Engineering works shall be taken prior to the cost benefit analysis.

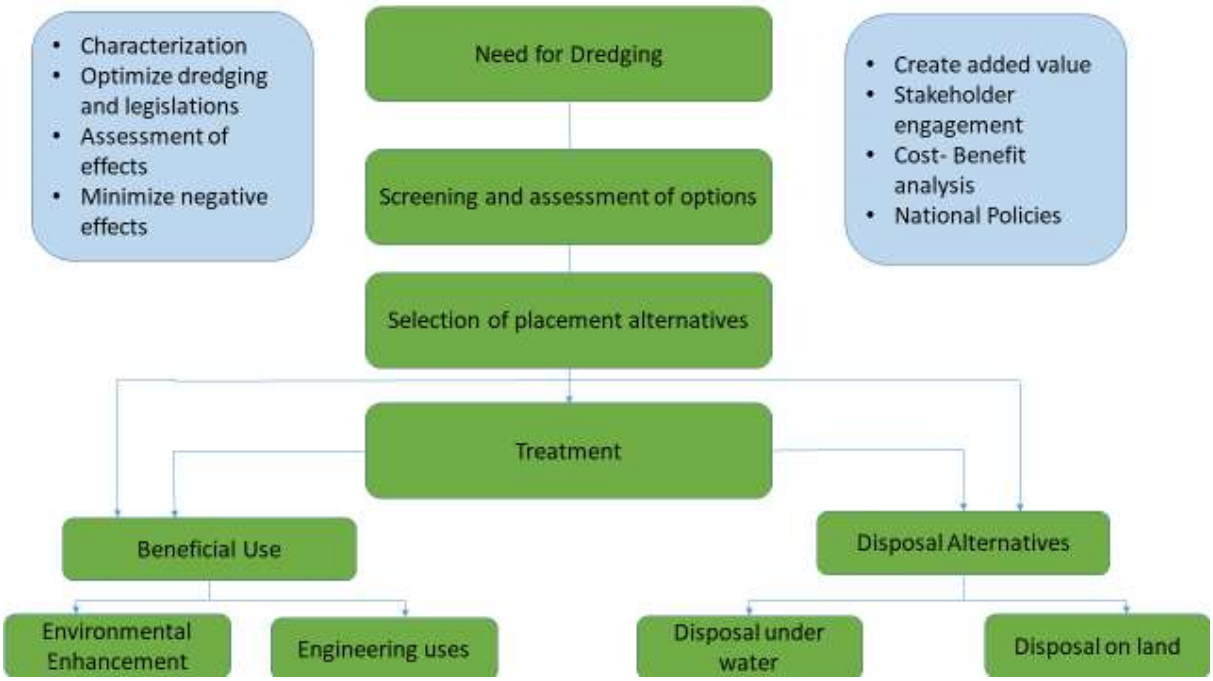

Fig.2.1 A generic Decision Making Flow Chart for Dredging

2.1.1 Phases of Dredging Projects

1. Planning stage:
   a. Assessment of bathymetry (bathymetric survey) and hydrological conditions (salinity, current, wind, wave etc.).
   b. Assessment of soil or sediment type and its characteristics.
   c. Possibility of reuse of the dredged sediment and overall cost benefit analysis of the options (including disposal in open sea) assigning environmental/ sediment weightage to the reuse option.
   d. Selection of disposal and/or reuse site.

e. Dredging quantity.
f. Cost estimates

2. Selection of dredging contractor (through bidding or nomination).

3. Project execution, monitoring and control.

4. Measurements and validation of depths.

Environmentally friendly dredging shall be a permanent element in dredging projects. Identification of the dredging projects, wherein the most appropriate disposal option for dredge material to be undertaken in a time bound manner with duration up to 10 years (2020-2030), could play as a key to this aspect. This exercise should be started by all Major Ports immediately in order to achieve the respective goals in terms of cost and environmental benefits.

The project team shall give due consideration to the following aspects during planning of the project.

a) For deepening and widening the navigational channel due consideration to determine designed depth shall be based on vessel draft, cargo capacity and on Ports business / investment model. Feasibility studies to determine designed depth, lines and levels shall have to backed by cargo analysis and capacity availability of infrastructure of the Port. Feasibility report may be prepared by any third party with sufficient prior experience and qualification to undertake such work. However, the feasibility report consultant involved in assessing the techno-economic feasibility of the capital dredging shall not qualify to participate either as PMC or Engineer for the same project. Terms of Reference (TOR) for Consultancy Services for Preparation of Detailed Project report (DPR) for Deepening of the existing channel in a Port is attached as **Annexure -2**.

b) Assessment of dredge volume based on desired depth.

c) Classification of soil for dredging purposes has to be carried out based on PIANC classification of Soils & Rocks for Maritime Dredging Process: Marcom – WG144 (JULY 2016).

d) The agency shall follow the process suggested in Fig.2.1 for overall planning and Fig.2.2 for executing the project.

e) Environmental clearance of capital dredging/ alternative disposal site.

f) Creating high / low density cloud to facilitate natural carrying by tide or flow of currents could be an option/effort to optimize dredging cost along with improving

required navigational depth in the channel. The factors influencing dredging plant are:

(i) Site Characteristics and Conditions
(ii) Nature of Soil to be excavated
(iii) The nature of dredged material to be transported
(iv) Environmental Factors

g) The aspect of reusing / recycling dredged material shall be part of Sustainable Dredging plan.

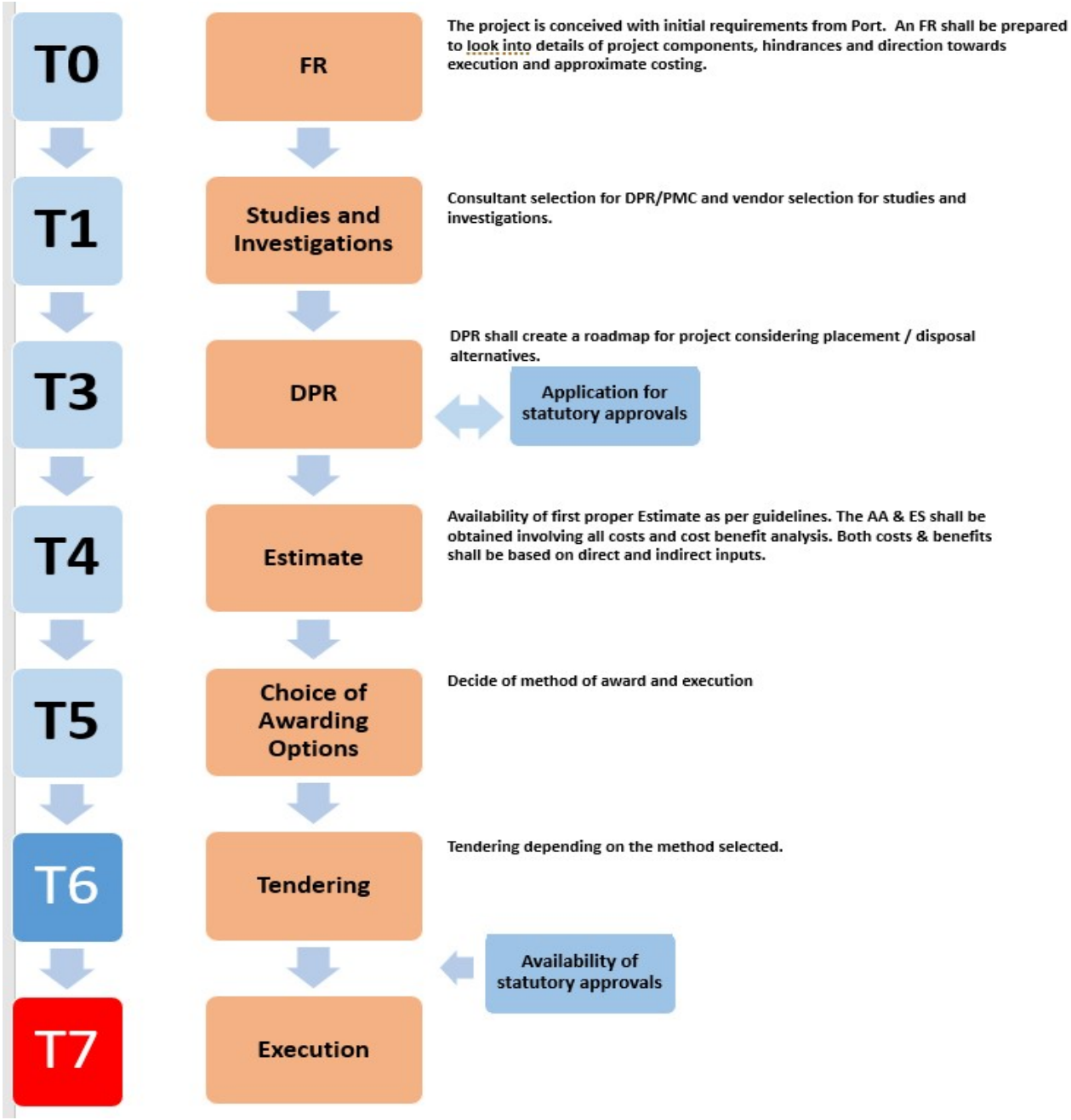

Fig.2.2 Major Tasks in Execution of the Dredging project

2.2 KEY ELEMENTS OF PROJECT

The various stages of project planning are provided in Fig.2.2 above. The following matrix outlines key aspects of project formulation. Only highlights of the project elements are given here. The later chapters of these guidelines provide additional requisite details about the project elements.

Table.2.1 Main Aspects to be taken into project formulation

Key aspects ⇩	**Maintenance Dredging**	**Capital Dredging**
Tasks in Fig.2.2	T4 to T7	T1 to T7
Hydrography	Yes	Yes
Geotechnical & Geophysical	No	Yes
Seabed Refraction studies needed	No	For extensive presence of hard strata with more than 20 Mpa strength.
EC requirement	As laid down	As laid down
Relevant codes / guidelines	Hydrography only. (Chapter 3)	Hydrography and Soil classification PIANC WG-144 (Chapter 3),
PMC	Not Required	Preferred
Preferred Tendering Mechanism	Assured Depth, EPC	Assured Depth, EPC
Delivery Mode	EPC, PPP	PPP, EPC
Engaging Agency whenever required for preparation of EIA.	Yes	Yes
Third Party Agency other than PMC for Pre, Post and dredging payment	Yes	Yes
Cost of all payment to survey contractor	By Port	By Port

Notes-

1. *Different teams of project management cell/ PMC should be used for planning and execution activities to avoid conflict of interest.*
2. *For DPR preparation / estimation, Hydrographic surveys could be conducted as per technical details in Chapter-3, preferably using multi-beam echo-sounders*
3. *Shallow seismic survey alone is not sufficient and refraction survey also to be done in respect of dredging in hard strata extensively.*
4. *Ports may prescribe the required essential parameter as measure of efficiency and monitor it essentially,*

5. *In case the dredged material is proposed to be disposed off in the sea due to non-suitability of the material, a detailed justification specifying reasons for not utilizing the dredged material including options considered, cost – benefit analysis including environmental cost shall be required to be made part of the DPR.*

2.3 Engagement of Project Management Consultants

The project management and control is the key to success of the project and a dedicated consultant or employee to perform such function is one of the most significant tasks in achieving the project targets/ goals. Project success depends on meticulous planning and effective monitoring of each and every sub - component of project activity. In order to efficiently manage dredging activities, a good Project Monitoring and Control Team (either from third party or the port's own employees) should be in place, which shouldn't have any conflict of interest, to perform following roles:

1. To work as representative of the Port before the dredging agency and representative of the dredging agency before the port.

2. To continuously coordinate between dredging agency and various departments of the Port and other parties / stakeholders to ensure dredging operation as planned.

3. Verify the quantity of dredging or the required depth on behalf of the Port authority and recommend for payment based on the qualifying criteria specified for payment under the agreement.

4. Continuously monitor and provide feedback to the Port about dredging operation and take necessary corrective and preventive action for any delay or any other eventuality which may arise during currency of the contract between project authority (Port)and the dredging company.

5. Advice on disputes, pre arbitration and post arbitration matters.

Considering the above primary functions of Project Management Cell / Project Management Consultant (PMC), appointment of PMC on contract for providing technical guidance to the Port in framing up of depth requirement, sediment characteristics, dredging quantity, selection of capable dredging company, monitoring and measurements etc., can be considered for specific item of work or the entire process. However, in no case the agency and persons involved, directly or indirectly, in planning stage be involved as PMC or as third party surveying /measurement entity (as verifier).

The following factors may be considered in deciding requirement, scope and timelines for the PMC:

1. Completed similar works in the last seven years. Availability of qualified, capable, experienced technical staff in the field of dredging within the port that can be available, completely for this job – Most valuable parameter to assess the requirement of outside agency as PMC. However, the teams for planning and execution should be different to avoid any conflict of interest.

2. Tentative quantity and period of dredging – to assess the work load for assess whether it can be managed by the port itself.

3. Tentative Cost of dredging – the work load converted in terms of cost can be another parameter to judge requirement of outside agency as PMC, but it may vary from port to port.

4. Responsibilities proposed to be bestowed with PMC for taking corrective and preventive actions to keep the project on track.

5. Checks to remove conflict of interest of PMC with dredging firms and / or technical survey Organization.

6. It is often found that PMCs are not adequately empowered or made accountable for a particular activity in the entire dredging operation, leading to shifting of responsibility, delays, technical lapses and arbitration.

7. Although role of PMC is crucial for the entire dredging project, the absence of absolute responsibility and authority to take corrective and preventive actions, make PMCs prone to be ineffective.

8. Accountability should be fixed on PMC for delays, wrong measurement/ assessment with penal provisions in the contract document.

9. It is often seen that services of PMC gets extended to cover the extended period of dredging, because of delays in dredging operation due to various reasons, leading to extra financial outgo to PMC in terms of continued work and payment thereof. These circumstances lead to time and cost overruns because of additional payment to the PMC and in turn favour the laxity in the monitoring and control by PMC or cushioned estimated period of dredging during planning stage.

10. To overcome such conflict of interest, the planning part should be handled by separate PMC or specific consultancy can be hired for specific component of the project planning (survey/ estimation/ geotechnical investigation etc.) and post award

work (execution, monitoring, measurement, and payment etc.) should be handled by separate PMC.

11. PMC should be made accountable for delays beyond certain period of time and a negative payment schedule/ penalty component should be considered while awarding project management consultancy. Example- 5% deduction from the eligible payment for first three months delay and thereafter 10% deduction for next 3 months.

12. For any delay beyond six months, the eligible payment to PMC with 15% deduction shall be recovered from due payments of the dredging contractor.

13. The main dredging contract should have the recovery clause proposed at point no.12 above, in addition to other penalty provisions.

CHAPTER 3

HYDROGRAPHIC AND SEABED INVESTIGATIONS FOR DREDGING PROJECTS

3.1 Survey Techniques / Requirements for Dredging Projects

Port authorities are mandated with developing and maintaining their harbours with regard to fairway use and the size of vessels the harbours are able to accommodate. This duty of maintenance covers several specific requirements, including the execution of hydrographic surveys. Further, the ports engage several agencies to collect and process the data prior to any dredging project. In the present context, there is a need to standardize the survey activities.

While the EIC sets out to conduct the survey, the following factors shall be kept in mind with regards to techniques to be used, the hardware and the costs.

Table.3.1 Survey Options for Dredging Projects

Parameter	Hardware	*see footer	Low	Medium	High	Very High		Typical Vertical	Notes
Bathymetry (High Resolution, High coverage)	Multibeam/interferometric echo sounder,motions ensors,RTK/PPK/ GPS	C						± 0.1 m	Needs High Accuracy positioning. Use of such systems is the norm for dredging projects. Swath width proportional to water depth (WD): 3 to 4 X WD for Multibeam, 8 to 10 X WD for interferometric. Resolution so good with some systems they can be used for object detection
		V							
		S							
		A							
Bathymetry (Lower resolution, less coverage)	Dual frequency, single beam echo sounder, motion senors, advanced DGPS	C						± 0.2 m	Data only provided immediately under the echo sounder. Use of two frequencies can provide an indication in to the thickness of layers of semi-consoliated sediment (sometimes termed fluid mud)
		V							
		S							
		A							
Bathymetry (Lower Resolution, less coverage)	Single Beam Echo Sounder, Water level data, GPS	C						± 1m	Data only provided immediately under the Echo Sounder. Low cost, low level of sophistication. Low accuracy (in terms of position as well as depth)
		V							
		S							
		A							
Swaths of Bathymetry/ Topography	LiDAR (of correct wavelength), DGPS, Inertial measurement unit (often mounted on aircraft)	C						± 0.15m	Costs relatively High, but large areas covered very quickly. Ground trothing essential. Useful for monitoring intertidal areas at low tide. Can be difficult to differentiate between water and sediment during processing of intertidal data. Depths to which bathymetric LiDAR can reach depend on turbidity and seabed type, this is restrictive
		V							
		S							
		A							
Topography	RTK/PPK GPS (rover carried by Backpack or on a vehicle)	C						± 0.03 m	Coverage footprint is small, so rates of data collection are moderate at best. Highest accuracy achieved with slowest data collection (i.e. on foot with a survey pole mounted cover). Capable of very high accuracy, though will not work if too many obstructions exist.
		V							
		S							
		A							
Topography	Laser scanner (static or mobile). Static mode- RTK/ PPK GPS or Total station also required. Mobile mode- motion (and sometimes) inertial navigation sensors also required.	C						± 0.03 m	Deployment from fixed locations or mobile platforms (e.g. vessel). Capable of generating large volumes of high quality data. Accuracy is lower with mobile platform deployment and over long ranges. Units with different ranges exist e.g. 50m vs 3-4 km
		V							
		S			**				
		A							

The dredging projects, being the lifeline of major ports, shall consider such options and take a call for the purpose dredging surveys.

3.1.1 Bathymetry or Seafloor Topography

Pre-dredging survey is carried out for understanding the order of depths and to visualize quantum of dredging required to reach desired depth. So, it is performed in a scale of 1:1000 or 1:2000 for line spacing 5-10 m with appropriate echo-sounders using such frequencies and DGPS control for accurate positioning of sounding lines. In order to avoid noise or wrong depths on account of oscillation of water in the form of waves generated due to constant wind, tides and cross currents, HEAVE COMPASATOR to be used in boat so that depth (plus or minus) due to oscillation of water may be directly arrived. Where there is a requirement of bathymetry surveys in shallow depth up to 2 to 4 m level below CD, any error more than 30 cm due to such oscillations for arriving at the quality of dredging may be noted. A standard hydrography survey and post-processing software as approved by the Engineer in Charge should be used for hydrographic data processing, editing, plotting, contouring, profiling and volume calculation and digitizing. To maintain consistency, the same software or methodology shall be used at all stages of the surveys and post-processing. Some standard features of the software shall be as below.

- Channel Design Facility
- Chart Plotting
- Clouding
- Cross Sections & Volumes
- Data Converter for 3rd Party Files
- Data Export facilities
- ENC Editor
- Geocoder
- Geodetic Utilities
- Line Planning and Preparation Editors
- Navigation, Vessel Positioning and AIS Support
- Remote Viewer
- Sounding Reduction Program
- Tide & Sound Velocity Corrections
- TIN Models

3.1.2 Single Beam Echo Sounder:

Single Beam Echo Sounder measures water depth along the vessel track below the transducer but not between the tracks. For normal surveys of sea floor mapping, bathymetry surveys are performed with such Echo sounders having frequencies of 200-220 KHz. In the areas where mud layers and hard surfaces are encountered, dual frequency namely 30/210 KHz Echo Sounders are used. High and Low frequencies are often used together to provide an indication of presence of hard bed and low density mud, the higher frequency indicating the low density(thick cloudy layers graphs) mud and low frequency indicating the hard bed(metallic line graph) in monitor or paper print –output device.

3.1.3 Multi beam Echo Sounder:

Multi-beam swath bathymetry system shall be used for obtaining the multi beam bathymetry data. The system shall be deployed using side pole. The bathymetric data along with roll, pitch and yaw shall be logged to data logging PC using standard data logging software. The minimum requirement to be met for specifications of the multibeam system shall be as under:

Technical Parameter	**Desirable specification**
Frequency:	300-450 kHz
Resolution:	1- 5 mm
Swath Coverage	128°-160°
Max Range/Depth:	100-400 m
Number of beams:	254 - 512
Along-Track Beam width:	0.9°-1.5°
Across-Track Beam width:	0.5°-1.5°
Accuracy:	IHO S-44 standard (4th edition) for special order surveys.
Operating Speed:	Up to 12 knots
Max. Update Rate:	60 pings/sec

Pre and post survey shall be conducted with the same frequency and same specifications.

a) Integrated data acquisition and processing system complete with peripherals such as graphics, colour display, printer, chart x-y plotter, fully operational including software. One copy of the software shall be made available for exclusive use of Engineer during the contract period.

b) Heave Compensator: Heave, Roll, Pitch (3 axis).

c) Sufficient number of spare parts and consumables for the above.

At the beginning of Hydrographic survey, the DGPS has to be calibrated to the accuracy of plus or minus 1.0 m in horizontal plane. To this effect, the contractor shall establish a fixed point (or fixed points) with known co-ordinates such that the survey boat can easily be positioned with the transducer of the echo-sounder always in the same position relative to the calibration point.

3.1.4 Calculation of dredging quantities

Dredged volume computation shall be based on BS standards or IAPH / IHO standards. The volume obtained from the processed data shall be physically cross checked by Simpson's rule on the full area, if possible or a part of the area

3.1.5 Calibration of Sounding Equipment

Echo sounding equipment shall be checked and calibrated at least daily before and after use, by means of a bar or plate suspended at known depth below the water surface. Checking shall be performed at the actual location of the survey and the Authority may require additional checks during surveying. Adjustments to the recordings/readings taken shall be made accordingly. Records of bar checks shall be retained at the start and end of the echo sounder record for the day of survey. The echo sounder should maintain a repeatable accuracy of better than 10 cms.

In case of Multibeam Echo sounder, a calibration procedure (Patch Test) has to be integrated with sub systems prior to actual survey.

3.1.6 Accuracy of Surveys

The accuracy of surveys in the horizontal plane, related to the relevant triangulation stations for the projects should be within 1.0m. The accuracy of surveys in the vertical plane includes:

a) The echo sounder which to be maintained with a repeatable accuracy better than 10 cm for measurements of distances between seabed and survey vessel waterline.

b) The registration of water levels by means of temporary tide gauges which should be within 5 cm. The water level plane between the tide gauges and the survey location can be assumed horizontal Survey Track lines on consecutive surveys should be sailed in the same direction. The survey lines to run at 20.0 m so as to have an overlap of minimum 20 m in between the lines for better accuracy. The coverage shall be managed in such a way to provide 100% insonification of the Seabed. If at the end of the survey any gap is observed, additional survey lines shall be run to fill up the gaps.

However, the Sounding grid shown on the drawings shall be as follows:

i. 5 m x 5m : For Sections[1]

[1] The Area to be inserted by Authority

ii. For Rock Patches : 5.0 x 5.0 m Closer grid survey shall be adopted

All survey lines shall be extended to a minimum distance of 50 m (in the horizontal plane) beyond the top of dredged slopes wherever possible.
All specified surveys shall be carried out jointly by the contractor and the Authority.

3.1.6.1 Digital recording and plotting

Interpretation of echo rolls, reduction of sounded depths for tidal heights obtained from tide gauges, corrections for squat and wave motions (to be made using appropriate observed data and/or compensating devices) and definition of bottom levels on the echograms are to be done to the satisfaction of the Authority. Each fix on the echo roll shall be annotated on the track plot chart of the survey vessel, and there should be at least one fix for every 10 m of cross section or as approved by the Engineer and the interpreted data shall be plotted.

3.1.6.2 Tide gauges[2]

The Contractor shall, at the commencement of the Contract install [TWO][3] number automatic self-controlled and self-recording tide Level Gauge to monitor and measure continuously the tides with respect to the Chart Datum at an approved location near the shore and maintain and keep daily records of the tide levels throughout the Contract period. These gauges shall be placed and calibrated at least 15 days before dredging is foreseen to commence. The area where the tide gauges are to be installed shall be properly illuminated. The existing two tide gauges are required to be operational. The Tide Gauge installed by the Contractor shall continue to remain with the Authority even after completion of the project.

3.1.6.3 Reduction of sounded depths

The Contractor shall place special stress on the accurate reduction of sounded depth in relation to the prevailing tidal levels.

3.2 Initial Surveys

For determination of the original seabed level, before commencing dredging operations, a joint survey of the seabed has to be undertaken jointly by the Contractor and the Engineer in charge. The services of an external survey agency as approved by Authority/Engineer may also be inducted for the Pre dredge surveys alongwith the representative of the Engineer, Authority and the Contractor.

All the dredging drawings shall be plotted on 1:2000 scale or as specified by the Engineer and these shall be constructed on UTM or WGS84.

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[2] If Authority has already installed Tide Gauge may prefer to allow same for taking reading by Contractor. The installation of Tide Gauge for the project shall be decided and in case it is necessary the specifications shall be adhered. If Authority has already installed Tide Gauge may prefer to same for taking reading by Contractor.
[3] Authority may decide.

On completion of the survey, the Contractor or the external agency shall prepare within 72 hours, survey charts and cross sections showing the full results of the survey. Drawings in Auto-cad should be submitted in soft and hard copies. On completion and agreement of the contents of the drawings, the Contractor, Engineer and Authority and Hydrographic Surveyor of external agency, incase survey conducted by external agency, shall sign the drawings, which shall form the basis for all the further measurement of the works undertaken in the course of the Contract.

3.3 Interim Surveys (Progress Surveys)

Interim surveys shall be carried out during the period of dredging works as and when directed by Engineer in Charge. Soundings shall be taken under the same configuration and settings as used for pre-dredging surveys. On completion of each survey, Contractor shall prepare and record drawings showing surface levels of the bed reduced to Chart Datum and submit the same to the Authority/Engineer for approval. These approved drawings shall be used for interim measurement and payment.

3.4 Final Survey (Out Survey)

The Post dredging survey equipment shall have the same configuration as used for Pre dredging survey.

On completion of all required dredging works and sweeping operation a post dredging final hydrographic survey will be conducted jointly by the contractor and the Authority on the same basis as specified for pre-dredging survey. [The services of an external survey agency as approved by Authority /Engineer may also be inducted for final surveys along with the representative of the Engineer, Authority and the Contractor.][4]

On completion of the survey, the Contractor or the external agency shall prepare survey charts and cross sections showing the full results of the survey. All the data, fair charts/plotting sheets, survey report, positioning data, tidal data, echo-traces, computation work sheets, and analysed charts (both hard and soft copies) shall be submitted to the Engineer/Authority. On completion and on agreement on the contents of the drawings and if the Engineer and Authority Representatives are satisfied on the works executed according to the Contract, then the Contractor, the Authority &Authority Representative and the Hydrographic Surveyor of external agency, incase survey is conducted by external agency, shall sign the drawings, which then shall acquire the status of “Post- dredging Survey”.

3.5 Geophysical Investigations:

[4] The Authority may include third Party independent agency for verification/witnessing the survey as per the policy if any and payment terms for third Party also

After the bathymetry surveys are completed and charts are prepared with above mentioned scales, project proponent (PP) may study the raw data and charts. If area is unknown from the point of view of sub-soil investigation, PP should first conduct geo-physical investigation as follows:

The Geophysical investigations are employed to identify and characterize layers of sediment or rock under sea floor. Normally, three systems are in use:

- High –Resolution reflection system(Remote Seismic)
- Seismic Reflection
- Electric Resistivity

3.5.1High –Resolution reflection system (Remote Seismic)

The system is similar in principle to echo-sounding where sound waves of low frequency and high energy are transmitted from the source at the water surface and reflected signals are received from inter-faces between soil and hard soil. This permit recording of the inter-face, but the vertical scale of recording as well as soil properties need to be determined from borings and testing.

A) Side Scan Sonar Surveys:

After completion of geo-physical surveys, PP is able to know the nature of sub-stratum along with some shapes or figures of objects found on sea bed or semi-buried position. Those objects may be either broken anchors, ships wreak, broken pipelines, sunken wrecks, shackles, spread rubbles escaped from neighbouring break waters or bunds, some debris or spilled solid cargos etc. So, if such details are not made available to dredging contractors, it will be difficult for them to carry out dredging as such unknown objects might damage edge or cutting tools of dredging machines.

Such objects may be removed or salvaged after pin pointing their locations based on the results of side scan sonar combing with results of geo-physical surveys. Side scan sonar provides an acoustic oblique photo image of sea floor. Side scan sonar is used to detect obstacles such as wreck, scarps, anchors, pipelines pieces etc found half buried or laid on sea bed surface where common echo sounder's rays can't identify the same. So, it is crucial to scan the area of dredging to check whether it is free from sunken ships, wrecks, broken anchors or such obstacles, Rock Outcrops, Ridges, boulders clusters and depressions in the bed of sea submerged in water. It could be located prior to dredging with the help of Side Scan Sonar.

B) Sub-Bottom Profiling:

Sub-bottom profiling systems are employed to identify and characterize layers of sediments or rock under sea floor. These systems are helpful in locating hard objects buried in the sea floor such as ship wrecks.

C) Installation and Testing

The High – Resolution reflection system (Remote Seismic) system shall be installed, tested and set to work for continuous operation during all dredging and survey operations. The system should be fully operational, before a minimum of 3 (three) days before surveying operations commencement including field Calibration by using known / established Port survey Stations.

Once operational, the system shall remain operational until the last Post-dredging survey is completed and the last Post-dredging survey drawings have been signed jointly by the Contractor and the Authority.

Failure of Differential Global Positioning System (DGPS)

If the DGPS fails or considered to be inaccurate by the Engineer, the Engineer may permit the use of an approved temporary back-up system or may order that the affected works or part be carried out after the system is again operational or the accuracy has been corrected. No extension of time for completion shall be granted by the Engineer to the Contractor on account of such discontinuity in the Works. Any expenditure incurred by the Contractor on account of this shall be deemed to be included in the rates and prices quoted by the Contractor and shall not be paid separately.

The Differential Global Positioning System (DGPS) should have one hundred percent in-built backup standby equipment to cater for the failure of any individual components.

The Differential Global Positioning System (DGPS) shall at all times maintain a repeatable accuracy, for any point within the work site of plus or minus 1.0 m in the horizontal plane.

3.5.2 Survey Charts

After each survey the contractor shall immediately prepare drawing which shall be recorded with the results of the survey in the form of plans, to a scale of 1:2000 or as directed by the Engineer and cross sections to a scale agreed by the Engineer.

All survey charts to be produced by the contractor shall be reduced to chart Datum (CD), and the depths and / or heights shall be plotted in meters and decimeters. The contractor shall place special stress on the accurate reduction of sounded depth in relation to the water depth. The charts are to be presented to the Engineer in the approval form and with sufficient required number of copies.

Furthermore, the charts shall incorporate all reference points, coast line, buoys, beacons, markers, gauges and benchmarks, together with the location and nature of obstructions, structure and facilities. Particular items of interest shall also be indicated on the Charts.
After the results, plotted on each drawing, have been checked and verified, the Contractor and Engineer shall put date and sign on each agreed drawing and these shall form the basis of the measurement of any Dredging Work executed. The Contractor shall submit four copies of the drawings in addition to the original recording of sounding field works etc., after the survey is completed at each state.

The contractor shall notify the Engineer, 48 hours in advance, of commencing any survey work.

3.5.3 Scale of Survey Charts

Data generated by the surveys shall be elaborated in accordance with sound topographic and hydrographic practices and be presented on survey charts of the site on a scale and format to be agreed upon by the Authority. All survey lines shall be shown on the charts with plot-intervals along the lines not exceeding [10][5] metres with intermediate plots, if necessary.

3.6 Recent Trends

3.6.1 International status

The Port of Rotterdam started a pilot project to produce S-57 ENCs of the area covered by the port more than ten years ago. The goal of this project is to produce daily high-density ENC updates that incorporated daily hydrographic surveys of the area. This product is to contribute to efficient port planning by taking advantages of accurate depth data and available 'over-depth' in the port's basins and fairways, which minimise under keel clearance (UKC) requirements. Currently, harbour masters, asset managers and marine pilots use this high-density ENC maps to operate a fleet of dredgers to keep the port open all year and for safe navigation.

In addition, some of the other the other challenges that are being frequently encountered by the Port administrators are:

a) Surveys slow down the busy heavy traffic and even causing accidents.
b) Vessels to carry out the survey in the shallow area.
c) The high cost for periodically channel survey.

[5]Authority can select the grid size depending on the requirement and follow the standard instructions and practices in Authority's Port

In Europe's second largest port, Antwerp is on trial an unmanned, autonomous hydrographic survey vessel called Echo-drone. This implies regular measurements of the water depths at berths and at other points in order to ensure safe passage and mooring for ships and to plan the necessary maintenance dredging work. This makes it more flexible and is able to even operate in heavy shipping traffic where the Echo would be unable to go. These soundings provide a view of the current water depth at moorings and enable maintenance dredging work to be scheduled if necessary.

High-tech monitoring for dredging will provide multifold benefits to the ports. Some of the expectations from these solutions are listed below:

1. Real time depth and dredging production at data centre / port.

2. Live transmission of data through telemetry to data centre / port.

3. Reduction in manning due to automation.

4. High resolution and frequent coverage of important areas in fairway / berths.

5. AI / ML tools for understanding and projecting future values.

6. Water depths, Water levels, Currents, Waves, Turbidity, Sea bed bulk density are some of the most important parameters. Apart from the above, environmental parameters important for each port shall be identified and included in the survey plans.

3.7 Continuous monitoring and maintenance of depths within the port area is of primary importance which requires regular measurements of the water depths at berths and at other points in order to ensure safe passage and mooring for ships and to plan the necessary maintenance dredging work. Unmanned Surface Vessel for Smart Hydrography is the most appropriate solution that is required for Port Administrators to measure the water depth and also to produce high density ENC's.

National Technology Centre for Ports, Waterways and Coasts (NTCPWC), IIT Madras designed an USV platform that can undertake autonomous surveys providing real-time data transmission with long distance video monitoring to carry out hydrographic and oceanographic surveys. The system equipped with single-beam echo sounder, GPS System, 360^0 Camera, LiDAR and broadband communication technology, is capable of delivering precise and accurate depth measurements even in very shallow waters. The technology involves collecting detailed information of water depths and transmitting the data to the cloud. The collected information will be made available online to the devices in the port through the cloud and then translated and summarized into usable information. The USV also has obstacle avoidance and route planning capabilities. The USV Platform concept can be initially checked at the two major ports available in Chennai namely

Chennai port and Kamarajar Port Limited and the inputs from the two ports can be taken into consideration before implementation in all Major Ports.

CHAPTER 4

DETAILED PROJECT REPORT FORMAT

The Detailed Project Report (DPR) of a dredging project is the document that covers detailed deliberations of the project components such as requirement, financial viability, basis for estimations, estimated quantity, time plan, technical details of the area proposed to be dredged, alternatives, most suitable equipment (subject to tender having some flexibility) etc. It also provides the road map for implementation of the project. Therefore, the DPR needs to encompass all related aspects of the project.

4.2. The DPR consultant, if appointed, shall ensure all guidelines are followed in preparation of DPR. Since, assured depth concept is prevalent, the DPR shall also focus on essential features of the measurable/ quantifiable deliverables.

Therefore, the DPR shall be prepared ensuring compliance of all guidelines and shall broadly contain the following:

a) INTRODUCTION

Project background, its need, scope, details of studies (such as investigations and surveys), outcome of feasibility etc(which are further detailed in DPR).

b) TRAFFIC STUDY

Review of Earlier Traffic Studies; Traffic studies revised and validated; Vessel size analysis; vessel traffic forecast; Identification of Design Vessel draft and beam.

c) SITE INFORMATION

Location; Meteorology; Met-Ocean Characteristics covering Waves, Currents and Tides; Wind velocity, Gust, Bathymetry; Existing siltation data; Geotechnical & Subsoil Profiles in relevant to Project Area; All investigations and recording of results / findings shall be as per dredging guidelines issued by Ministry of Ports, Shipping and Waterways.

d) NAVIGATOIN REQUIREMENTS & CHANNEL / HARBOUR DESIGNS

Identification and freezing of limiting environmental conditions for navigation; Initial design of channel, Tranquility condition, Anchorage, Berth pockets etc. as per PIANC guidelines & IS4651; Contribution of tide to navigation; Minimizing UKC by considering various weather and soil characteristics of the channel. Validation of initial design by Navigation simulation study, if required; Identification of two to three design alternatives, if required – they may be needed in cost benefit analysis.

e) ESTIMATION OF DREDGING VOLUMES

Establishment of dredge levels during previous capital dredging; Present bathymetry; Levels of weathered rocks – to be dredged without pre-treatment; Levels of Hard rocks – to be dredged after pre-treatment; Dredging tolerances as per guidelines; Volumes shall be assessed from previous actual dredge levels to propose design dredge levels; soil types. Weathered rocks and hard rocks shall be grouped separately as dredging methodology and rates will be different for them; results of mathematical model and / or physical model studies for optimum channel designs for safe navigation. Amount of siltation during implementation of capital dredging may be taken into account for assessing the dredging volume.

f) DREDGING METHODOLOGY / ALTERNATIVES

Two or three dredging methodology should be worked out to evaluate cost benefit analysis of different options; consider different combinations of equipment; estimate production rates; estimate total duration required; evaluate dredging cost; estimate production rate; estimate for dredged Material Management with time and cost; Alternatives for disposal of the Dredged Material etc.

g) RECYCLE / REUSE / DISPOSAL OF DREDGED MATERIAL

Assessment of physical and chemical characteristics of the soil, possibility of toxic contaminants, possible re-use/ recycle options, technical analysis of alternative uses, identification of use / disposal site, applicable model studies to assess impact of disposal or reuse of the dredged material, benefits extracted out of beneficial reuse of dredged material, techno-economic evaluation of reuse options and dredging equipment options (type of dredging equipment provide varying degree of freedom in selection of reuse options, hence it should be evaluated as integral part of the dredging option).

h) ENVIRONMENTAL ASSESSMENT

Impacton hydrodynamics and geomorphology of the channel and adjoining areas due to changed micro hydrodynamics and possible impact on adjacent coast/ bank, impact on sediment movement characteristics, erosion/ accretion phenomenon etc; confirmed through mathematical and/or physical models, impact on aquatic/ marine biota etc; and brief of relevant EMPs.

i) NAVIGATIONAL AIDS

Requirement of channel marking navigational aids, danger signs, lead marks / lights, Lateral markers, cardinal marks, safe water marks, VTMS approach and communication etc; for facilitating safe navigation.

j) PROJECT IMPLEMENTATION SCHEDULE

Dredging equipment; Dredging plan; Work plan with milestones, bar chart, PERT-CPM Charts etc.

k) PROJECT ECONOMICS

Capital Cost Estimate – for all available options; Financial Analysis; Different funding models; Project Economics; IRR etc.

CHAPTER 5

ENVIRONMENTAL CODE OF PRACTICE FOR DREDGING & DREDGED MATERIAL MANAGEMENT

5.1 Background

Environmentally, dredging is discouraged because it creates loss of ground for benthic organisms, loss of sediment, change in micro-hydrodynamics of the area leading to alteration in sediment movement characteristics, resulting into altered siltation pattern etc. The hydrological changes are more pronounced in hydrodynamically more active systems. Due to disposal of dredged material in open waters, the suspended portion of sediment dispersed along current and wave and creates further ecological disturbance in a wider area. The primary objective of environmental conservation is to achieve minimum disturbance to the ecosystem, and if disturbance to a place is unavoidable the efforts should be to compensate the loss and/ or restore the similar habitat at other places. Examples of some of impacts on ecology is given in graphical representation below (Fig1 Ref Enviornmental management for Dredging sediments- Journal of Environmental management).

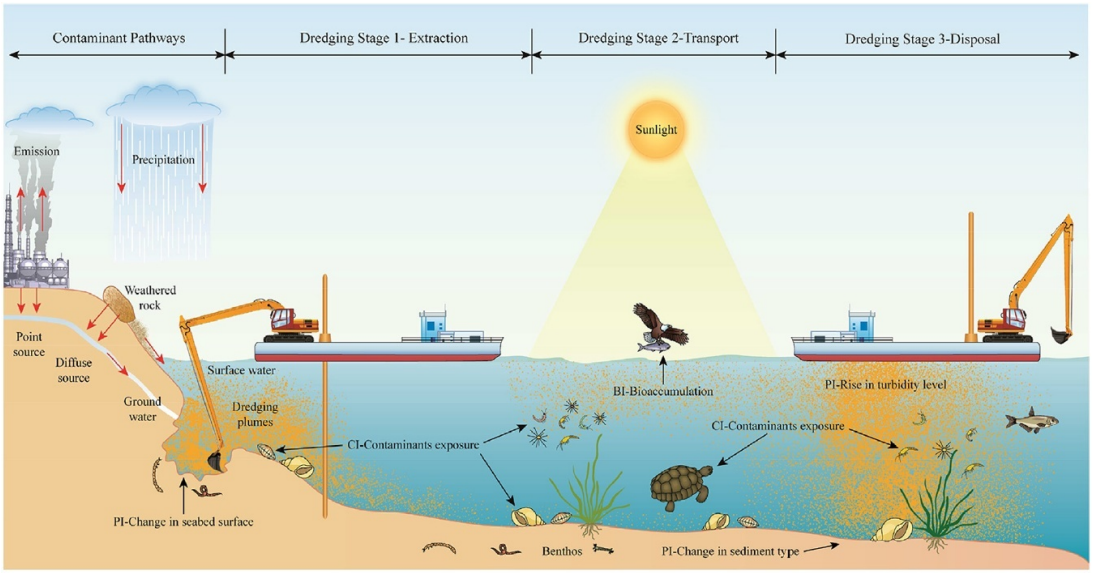


Fig 5.1. Impacts pathway of dredging operations

(McVeigh, Brendan. (2018). Ecological and Economic Viability of Beneficially Using Dredged Materials for Reclamation Projects. 10.13140/RG.2.2.34230.75840.)

5.2 Environmental aspects to be considered at planning stage

For creation of new channel, there can be a possibility of evaluation alternatives, but those alternatives may not serve technical purpose due to various other limiting factors such as technical, operational, financial etc., whereas, in an operational port possibility of selecting alternate site of dredging is ruled out. In such an event the selection of appropriate disposal site becomes an important aspect to limit the environmental risk. Therefore, while conducting EIA study for the dredging operation the priority should be given for re-use of the dredged material either directly or after minor treatment.

Although, disposal in open sea/water has been found to be the most simple and can be performed without much of monitoring and control, however, open sea/ open water disposal not only creates negative impacts to the receiving area but also creates loss of sediment. If the dredged material is utilised for beneficial use, equivalent amount of resource can be saved and in most of cases the process adds to environmental conservation, by recycling waste and conserving fresh resource. Environmentally, reuse of dredged material, either of engineering applications or non-engineering applications including use for restoration of habitats etc, is preferred. However, irrespective of site of disposal or use (land based or water based) an environmental impact assessment of the dredging site and disposal site must be carried out and prior environmental clearance becomes due for any capital dredging and even for maintenance dredging (one time approval) once the disposal site changes due to any reason.

Therefore, while planning dredging and evaluating costs, reuse options should be evaluated and cost benefit analysis should be considered as integral part of the dredging and alternative engineering / non-engineering work. In isolation the re-use work would always be a costly affair. Even for open sea disposal, the disposal site should preferably have more than 30 m depth, with very less current etc so that the disposed material can settle quickly in a smaller area, minimizing impact on marine ecology of the adjacent areas. While conducting EIA studies two – three alternatives should be considered not only on the basis of economic aspects but also in terms of net impact on ecology. Suspended sediment dispersion / settling studies should be conducted with the aid of mathematical models to ascertain the area likely to be impacted with dredging and disposal activities.

5.3 Environmental Risk Assessment & Management

(a) The environmental risk of dredging operation increases with increase in dredging depth, volume of dredging etc and environment management is not limited with monitoring of water quality or sediment characteristics but finding a sustainable balance between quantified risk and its abatement options. For example, dredging volume can be reduced by revisiting the differences among declared depth, design depth and required depth, by appropriately computing

safe under keel clearance (UKC) for specific size of ship, bottom parameters, impact of wind, current and wave on ship movements, affecting actual UKC requirement etc.

(b) Assessment of environmental risk should be an integral part of all capital dredging activity, where risk is higher for new channels and berths compared to existing channels. Environmental risks may be categorised into physical, chemical and biological risks. Physical risks are associated with hydrological changes and their impacts, which can be accessed through mathematical and GIS models, whereas chemical and biological risks are associated with dredging sediment, dredging technology and the ecology of the surrounding area (dredging and disposal sites).

(c) Protection of sensitive habitats in vicinity of dredging or disposal site. Chemical and biological risks on ecology and biota can be addressed by avoiding the sensitive habitats, undertaking preparatory works to prevent sensitive organism to enter in the affected zone etc.

(d) The risk-based approach of management & monitoring design is considered most effective and leading practice.

5.4 Recycle and Reuse of dredged material

(i) Most of the dredged material can be used for one or other application addressing the technical gap in logistics, availability of suitable site, true hydrological data to understand sediment dynamics of the dredging and disposal sites, environmental impact of the proposed use, regulatory permissions, more detailed project planning at the beginning of the dredging plan etc. Therefore, use of dredged material for specific purpose should be taken as project activity following all studies, surveys, investigations, obtaining necessary environmental permissions along with planning of the dredging and before inviting tenders for the dredging.

(ii) Relocation or reuse of dredged material can be an option to improve environmental performance and sometimes economic performance of the dredging operation. Dredged material from river bed / estuarine sites (eg. SPMPT) can be used for various engineering and agricultural applications with minor treatment or no pre-treatment.

(iii) Wide range of beneficial uses of dredged material have been practiced world over; these may generally be grouped into:

a) **Engineering uses:** Involves beneficially using Dredging Material typically as an alternative to land based resources (for example quarry

aggregate) and is common in many engineering projects, e.g. land reclamation, beach nourishment and coastal protection works, road construction etc and equivalent amount of fresh earth work can be avoided.

b) **Environmental Enhancement:** Involves using Dredging material as a resource with the potential for environmental enhancement when managed in a sustainable manner, e.g. habitat creation or sediment cell maintenance.

c) **Agricultural and Product uses:** Suitable Dredging material may be used to form useful products or in the agricultural sector once the appropriate physical, chemical and biological properties comply with the appropriate industry standards, e.g. manufactured topsoil, landfill cover or production of ceramics/bricks/concrete etc. Clay rich sediments that are uncontaminated can be reused as topsoil following blending with other soil components, or in land reclamation of open water areas. Uncontaminated and moderately contaminated dredged sediment may also be used as fill and/or in reclamation of abandoned mines.

(iv) A generalised categorisation of soil types and probable use is given below (**Table 1**) which can be used to evaluate possible reuse option based on dredged sediment quality.

Table 1

	Dredged Material Sediment Type				
Beneficial Use Options	Rock	Gravel & Sand	Consolidated Clay	Silt/Soft Clay	Mixture
A. Engineering Uses					
Land Creation	X	X	X	X	x
Land Improvement	X	X	X	X	x
Berm Breakwater Creation	X	X	X		x
Shore Protection	X	X	X		
Replacement Fill	X	X			x
Beach Nourishment		X			
Capping		X	X		x
Feeder Berm Breakwater		X		X	
B. Agricultural/ Product Uses					
Construction Materials	X	X	X	X	x
Aquaculture			X	X	x
Topsoil				X	x
C. Environmental Enhancement					
Wildlife Habitats	X	X	X	X	x
Fisheries Improvement	X	X	X	X	x
Wetland Restoration			X	X	x

(v) Segregation/ isolation/ washing principles can be used to convert silty dredged spoil as commercially exploitable sand. For example, at SPMPT, the dredged material consists of more than 72% Sand, 24% Clay and 4% Silt at specific location in 2010. The quality of dredged material is likely to remain same with minor seasonal fluctuations. This dredged material can easily be processed to recover sand which can be exploited commercially. The available inline separation system can be tested on pilot project basis, for estimating actual operational efficiency and quality of material. Even clay component can be used in later cycles to meet clay demand of the local people.

(vi) Suitability of land based or water based systems of sediment washing/pre-treatment should be analysed based on the technical feasibility of transporting the dredged material to shore, space for storage and treatment, cost of such transportation, O&M cost of land based system vis-a-vis capital and O&M cost of water based pre-treatment / washing/ segregation options.

(vii) Sand mining from river is a prohibited activity, because sand mining disturbs the hydrodynamics of the place leading to secondary complications and loss of habitat/ coast/ bank etc, whereas removal of deposited sediment/ sand / soil for facilitation of entry of vessel to the port during dredging is a permissible activity, because it is unavoidable and hydrodynamic aspects are addressed to some extent while planning of dredging.

(viii) Due to ban on sand mining in most of the rivers, crushed stone dust is being used for construction activities which is costly and creates negative impacts on terrestrial environment. Similarly, clay content is also in high demand.

(ix) Similarly, in coastal areas where there is acute shortage of sand where the dredged material having major component as sand, coastal bunds/ dykes beyond high water line can be created to fill dredged material for natural drying and washing during rains. After one cycle of washing such material can be used for various engineering and non-engineering applications with proper design mix.

(x) Many of the marine applications don't require any pre-treatment such as wetland restoration, habitat restoration or new creation can be used to create positive impact on society, environmental groups and regulatory compliance. Even such work can be planned in cooperation with MoEFCC. For example, dredged material from DPT can be applied for wetland restoration of the degraded wetlands as part of environmental management plans to strengthen green belt and environmental impact of the port operation.

(xi) Following table shows existing dredging data and efforts taken by major ports to reuse the dredged material: (**Table 2**)

Table 2

No.	Major Port	Annual Maintenance dredging Load	Capital Dredging	Characteristics of the dredged material	Present system of disposal
1	JNPT	10 to 12 Million Cu.m	Capital Dredging for Coastal Berths for 10 m draft vessel is in progress	Silty Clay Gravel - 0-3.85% Sand - 4.89 -12 % Silt - 32 - 37.9 % Clay - 51 - 59 %	Open Sea disposal
2	MbPT	3 MillionCu.m	Proposed: Soft soil - 8 lakhs cum, Rock - 1.4 Lakh Cu m	Clay & Fine Silt.	Open Sea disposal
3	MgPT	3 Million cu m	Nil	Soft -Silty Clay	Open Sea disposal
4	CoPT	Average : 26 Million Cu m - 2018-19 - 27.00 Million Cu.m. - 2019-20 - 24.80 Million Cu.m.)	a) Multi User Liquid Terminal Basin: 1.225 Million Cu. m b) ICTT, Vallarpadam,- 27.00 Million Cu.m	Channel - clay, slit and sand of 2 to 20 micron, whereas in the LNG basin it is predominantly sand.	Majority Open Sea disposal. Sand is auctioned
5	VPT	Average – 0.14 Million cu m (145000 cu m)	Nil	Predominantly sandy except at berths, which is Silt and clay.	More than 60% of the dredged material from Outer Harbour is being used for Beach nourishment. Rest is disposed in open sea.
6	NMPT	6.5 Million Cu m	Nil	Clay- Silt >80% Silt, 12-15% Clay 3-8 % Sand	Open Sea disposal
7	DPT	9.57 Million cu m	1.835 Million cu m and proposed to be disposed at sea.	Silty Clay Sand - 2 - 8.4 % Silt - 35 - 41 % Clay - 53 - 62 % TOC - 3.7%	Open Sea disposal

8	VoCPT	NIL	NTCPWC has proposed the phase wise plan of dredging.	Mainly Rocks with hard clay	Reclamation and open sea disposal
9	PPT	7 million cu m	4 million cu m (on going) Agency : DCIL Expected to be completed by December 2020.	Mix of sand, clay and silt.	Maintenance dredging material is disposed in open sea, whereas the Capital Dredging material is used for shore nourishment.
10	ChPT	0.2 Million cu m	Nil	Mix of sand, clay and silt.	Open Sea disposal
11	SPMPT (KoPT)	10.5 Million cu meter	Nil	Sand - 70 % Silt – 4 % Clay – 24 %	Open Sea disposal
12	KPL	0.1 Million Cu Mts	Nil	Mix of sand, clay and silt.	Open Sea disposal

(xii) From the above table, it can be seen that a few ports have tried to utilize the dredged material for engineering applications, but majority of material is being disposed in sea, whereas, other options where dredged material can be used directly or with minor treatments need to be explored, as per the matrix provided in table 1.

(xiii) However, each dredging operation bears unique characteristics in terms of hydrological, biological, geo-physical, geo-technical, ecological feature and requires detailed analysis of the sediment, transport logistics, local demand of the aggregates, physical characteristics of the dredging site, possibility of storage and treatment/ options of use for engineering, agriculture or environmental applications with or without treatment etc. to device best possible reuse option or suggest combination of options. Therefore, it would be necessary that detailed assessment of each port may be carried out by the port itself or by engaging domain specialists to device best possible solution for dredged spoil management.

(xiv) In order to minimize overall impact on ecosystem, sustained efforts are required to re-use the dredged material.

(xv) The Major Ports may invite Expression of Interest (EOI) for disposal/reuse of the dredged material to ensure environment friendly and viable disposal of dredged material.

5.5 Environmental Clearance (EC)

(i) Prior EC is mandatory only in case of capital dredging projects.

(ii) In some cases where channel or berthing face requires maintenance dredging due to accumulation of sediment/sand or other material over a period, and proposed dredging is limited to only removal of deposited sediment without changing the preconstruction bed level, but the activity has not been approved as part of port project, fresh EC shall have to be obtained from MoEFCC.

(iii) There is no specific regulatory provision in India to deal with dredged material or to suggest dumping site criteria. It becomes responsibility of the project proponent to consider various options and adopt environmentally most suitable one. These options are essentially required to be outlined in the EC procedure.

(iv) Any type of reclamation for port and foreshore activities is environmentally permissible.

(v) Environment Impact Assessment (EIA) / Environmental Management Plan (EMP) work should not be given to the PMC or Turnkey/ EPC contractor.

(vi) EIA/EMP Consultant must be an accredited consultant for port and harbour sector. Ports may verify their accreditation status from MoEFCC website before awarding the work.

5.6 Environment Monitoring Plan

The execution phase of a dredging and relocation activity involves the implementation of a range of environmental management measures. Dredging operations are based on the earlier planned work, including hydrographic surveys, identification of priority areas, and selection of dredging techniques and equipment. An Environmental Management Plan (EMP) is usually used to guide dredging operations giving actual feedback of environmental component to dredging controllers.

Dredging EMPs should essentially contain:

i. a description of the dredging activity
ii. roles and responsibilities
iii. details of the environmental values and risks
iv. prescribed avoidance and “no go” areas/activities
v. environmental management measures, controls and performance targets

vi. environmental management maps and diagrams

vii. monitoring activities and trigger levels about water quality at dredging and disposal sites within predicted zones to conform to the targets,

viii. corrective actions and non-compliance reporting to top management

ix. timing schedules

x. auditing, evaluation and reporting procedures.

Environmental monitoring and supervision should either be done directly by the port or by third party other than PMC and dredging company to establish unbiased reporting.

CHAPTER 6

STANDARDISED PROCEDURE FOR ESTIMATING THE COST OF DREDGING PROJECTS

6.1 INTRODUCTION

The outline stages of preparation of procurement documents for Dredging will follow the broad steps explained in this chapter. The key stages are to be handled by the EIC and certified with due consideration by respective HoDsof the Major Ports. When non-scheduled items are encountered, appropriate market rates shall be obtained by a suitable rate analysis.

The earlier Dredging guidelines and Draft guidelines state that CVC guidelines are to be complied with. The CVC guidelines stresses that, rates shall be supported by proper documents and detailed rate analysis. This has become a practice in regular engineering works and guided by SoPs for CPWD Works Manual. While CVC guidelines is clear about the intention of obtaining proper DE based on justified rates, this guideline provides the way and means by which Detailed Estimates for dredging projects could be obtained.

For further reading, the Engineers In-Charge are encouraged to refer to ICE (Institution of Civil Engineers, UK) and FIDIC (International Federation of Consulting Engineers) documents. It is also to be kept in mind that, only “ICE Design and Practice Guide for Dredging: Chapter 3” deals with the detailed estimate for dredging. FIDIC Blue Book deals with standard contract forms for dredging. In addition to ICE, ASPE (American Society of Professional Estimators) also have cost estimating methods in their certification programs. Both ICE and ASPE prescribe the cost and production based estimation of dredging rates.

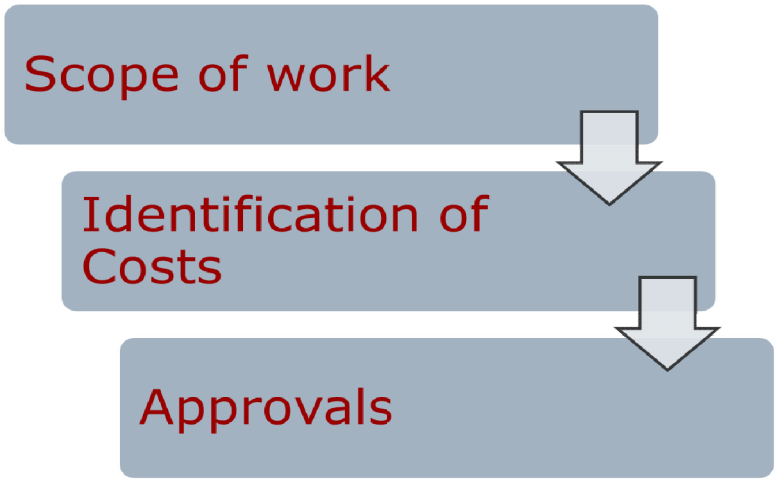


Fig.6.1 Key stages preparation of estimate for Dredging Works.

As a general principle, the following aspects shall be kept in consideration while going through the key stages of estimate preparation:

(i) The consultants have only an advisory role.
(ii) Sufficient brainstorming and questioning are needed by the EIC while reviewing the work of consultants in the interest of the department / port.
(iii) As stressed by CVC it is the responsibility of EIC to review, examine and accept the reasonability of detailed estimate.
(iv) Dredging market has limited suppliers. The determination of dredging cost inherently shall take into account the methodology to be adopted by dredging contractor as the costs are sensitive to methodology eventually finalized by EIC and accepted by Tender Accepting authority.
(v) The Methodology should NOT be such that available pool of contractors is curtailed.
(vi) The Methodology should be balanced b/w time, cost & IRR. It shall not be a sole decision of consultant. There should be proper brainstorming discussion between consultants and department / EIC to identify suitable methodologies keeping in view the time frame and revenue generation.
(vii) It will be a good idea to determine 2-3 methodologies of dredging and identify the optimal methodology and estimate.
(viii) Where heterogeneous materials are present careful selection of methodology is required.
(ix) The PQ requirements shall be based on the optimal methodology and should be sufficient enough to get a capable contractor.
(x) Where there is a JV or Consortium, guidelines of CVC / Competition Commission shall be adhered to.
(xi) The budgetary quotes are not a true reflection of market rates. Between themselves, they vary significantly.
(xii) A proper rate analysis shall include all cost and production estimates.

6.2 MARKET RATE

The Engineer In Charge may review and arrive at the approximate technical specifications of the dredging equipment suitable for deployment in execution of the dredging work. In the case of a cutter suction dredger, para meters such as dredging depth, cutter drive power / number and power of dredge pumps are to be listed. Similarly, in the case of a trailer suction hopper dredger, hopper volume, dredging depth, total propulsion power, number and power of dredge pumps, shore pumping facility, etc, are to be listed. Thus, identification of the correct type of dredging equipment and technical specification of the dredger (s) for the proposed project, soil strata, distance between dredging and disposal area, required production rate to meet project schedule are vital for estimating the market rate.

The best estimate for any work shall rely on scientifically determined Market Rate. Using this principle, the rate for dredging is can be defined as below:

$$\text{Rate (R)} = \frac{Total\ Cost\ of\ Dredging\ Plant\ and\ its\ operation\ (C)}{Total\ Quantitiy\ to\ be\ dredged\ (V)}$$

I. The total cost, C, shall include
   (i) Depreciation and Interest for the dredger to be deployed for the project duration (c1)
   (ii) Maintenance and Repair costs for the duration of deployment (c2)
   (iii) Fuel & Lube oil costs (c3)
   (iv) Insurance (c4)
   (v) Manning costs (c5)
   (vi) Idle time charges (c6), depending on the dredger deployment plan.
   (vii) Mob & Demob (c7)

In order to obtain the values of c1 to c7 the method proposed in the manual shall be used.

II. The total volume, V, shall be realistic assessment of production of dredger during deployment time as per cost C.
   (i) Depending on sea bed strata and type of dredging, this will change from site to site.

   (ii) A realistic estimate of V shall be based on field data. Data is available for most major ports in India, for both maintenance and capital dredging. Consultants shall take inputs from past data and estimate production depending on dredging plan.

   (iii) As the rate, R, is very sensitive to V, at most care shall be taken in arriving at this value.

6.2.1 The value of C

It is recommended to use the value of c1-c7 as per the schedule below.

Cost Item	Guideline	Remarks
c1, Depreciation + Interest (D+i) on capital equipment	As per CIRIA manual (or) Obtained from Dredging contractors by a Rate Tender.	Rate Tender could be done annually. Such rates shall not exceed CIRIA value of capital equipment.
c2, Maintenance + Repair (M+i) for deployment period	As per CIRIA manual (or) Obtained from Dredging contractors by a Rate Tender.	For the days of operation excepting any idle times. Such rates shall not exceed 80% CIRIA rates for Indian conditions.

c3, Fuel + Lube oil costs	To be worked out using method stated in this manual (or) to be obtained as part of Rate Tender.	
c4, Insurance	1.6% of c1	
c5, Manning Costs	To be worked out using method stated in this manual (or) to be obtained as part of Rate Tender.	
c6, Idle time charges	Simply c1, only for those idle days.	When c6 is applied, c1, c2, c3 will not be applied.
c7, Mob and Demob	10% of project cost for capital dredging. 7.5% of project cost for Maintenance Dredging.	This shall not be treated as Mobilization advance. This is a provision in estimate for cost incurred by contractor during all pre & post dredging activities.

Note: c1 & c2 may be considered to be included costs of support crafts which are least for maintenance dredging. In case of capital dredging, they need to be considered separately depending of dredging plan.

6.2.2 The value of V

The foregoing discussions indicate that C and V are the most important values in estimate. The value of V for a given equipment and for a given strata shall be estimated with due care. In order to classify the type of strata and arrive at the production estimate, the geotechnical and geophysical data shall be used as the backbone. The key information is compiled and projected in **Annexure 3**.

Ports could use services of expert agencies to arrive at the value of V. However, past dredging data is most important in arriving this value. In the past, production details were not available with ports. Presently, production estimates are available at all the ports for all types of soils. NTCPWC has created a data base repository of production. Such data should be used by ports ad consultants to fix production values for a given project.

6.3 CLOSURE

This chapter has brought out the important aspects and procedure for estimating the dredging costs. While doing the estimates, the costs (C) and production volumes (V) shall be brought out carefully using the principle provided in this chapter. The estimate also shall differentiate the strata in a minimum of 3 main categories, soils, weathered rock and hard rock.

CHAPTER 7

GUIDELINES FOR TENDERING OF DREDGING WORK

7.1 Pre-qualification Criteria of dredging firms

For formulating prequalification criteria, order of Ministry of commerce and industry, Department of industrial policy and promotion No.P-45021/2/2017-BE-II dated 15 June 2017 may be followed along with (Preference to Make in India) issued under Make in India Policy and "Atmanirbar Bharat Abhiyan", a campaign to make country self-reliant and become "local mein vocal" (vocal about local) while evaluation of offers.

The pre-qualification (PQ)/ Minimum eligibility criteria shall be based on the dredging firm's experience considering both Quantity and Value based criteria of successfully executed dredging projects and in adherence to CVC guidelines.

Experience can be considered as successfully undertaken of similar dredging works during the last seven years as follows-

- Three similar completed works costing not less than the amount equal to 40% of the estimated cost / quantity of work put to tender.
- Two similar completed works costing not less than the amount equal to 50% of the estimated cost / quantity of work put to tender.
- One similar completed works costing not less than the amount equal to 80% of the estimated cost / quantity of work put to tender.

Definition of "similar work" shall be clearly defined by the port.

The average annual financial turnover during the last 3 years ending previous financial year shall be atleast30% of the estimated cost put to tender.

The dredger to be deployed for the project may be of absolute ownership, despondent ownership, time charter and bare boat charter and hiring of dredgers shall be considered.

7.2 Efficiency parameters of dredgers

Snapshot of application functionalities	***Type of dredger***						
	Bucket	***Grab***	***Backhoe***	***Suction***	***Cutter***	***Trailer***	***Hopper***
Dredging sandy materials	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Dredging clayey materials	*Yes*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*No*
Dredging rocky materials	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*No*
Anchoring wires	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*No*	*Yes*
Max dredging depth (m)	*30*	*>100*	*20*	*70*	*25*	*100*	*50*
Accurate dredging possible	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*No*
Working under offshore conditions	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*Yes*
Transport via pipeline	*No*	*No*	*No*	*Yes*	*Yes*	*No*	*No*
Dredging in situ possible	*Yes*	*Yes*	*Yes*	*No*	*Limited*	*No*	*No*

7.3 Trailing Suction Hopper Dredgers (TSHDs)

- It should be fitted with twin screw with bow thrusters.

- The load and draft indicators shall be inspected and certified by a Classification Society being a member of IACS. The certificate issue date should be within a years' period or the certificate needs to be renewed annually.

- It should have efficient Dredge position control monitoring system consisting of DGPS, necessary software capable of being loaded with survey data like Hypack or similar software.

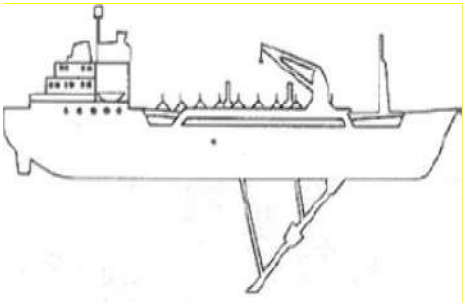
- It should have efficient dehoppering /dewatering system

- It should have preferably 2 suction pipes capable of dredging to a depth equal to the design depth plus 4mtrs.

- It should have the capability to produce jet pressure of 6 bars for maintenance dredging and 10 bars for capital dredging projects.

- It should have the capability to maintain an average speed of 8 knots.

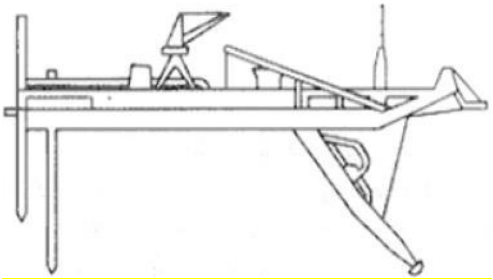
- TSHDs engaged for shore pumping / reclamation works whether by rain bowing or through pipe line need to have required equipment and capacity.



Typical schematic of TSHD

7.4 Cutter Suction Dredgers (CSDs)

- It should have adequate cutter power for dredging of the specified soil
- The dredge pumps should be capable of pumping to a distance to reach the reclamation / discharge area.
- It should have efficient Dredge Position control Monitoring System consisting of DGPS, necessary software capable of being loaded with survey data and track plotter and recorder.



Typical schematic of CSD

In case the dredging firm does not own the dredger and plan to execute the capital/maintenance dredging works by other modes of arranging the dredger by wet leasing, hiring etc., the above firm has to pay additional security deposit of 5% of the project cost, in addition to the security deposit indicated in the tender which will be returned without interest after satisfactory completion of dredging work, in case the firm gets the contract. In addition to above, the details of arranging the dredgers for the work with “Irrevocable Letter of Authority” from the owner to be produced by the bidder to the effect that the dredger so charted/hired shall not be withdrawn till completion of the work.

If the work includes rock dredging, the pre-qualification criteria, apart from above, shall also include experience of rock dredging of at least 10% of the estimated quantity of rock

dredging under the project, or such experience in rock dredging linked to specific equipment for ensuring high productivity as may be decided by the port. The contractor shall have necessary equipment considering the classification of rock either by own or by hiring and in that case the assurance letter from the owner about sparing the dredging equipment shall be furnished at the time of pre-qualification.

Ports may ensure that a prequalification criterion is fixed in advance and should not be very stringent to restrict entry of certain potential Indian bidders. The prequalification conditions should be exhaustive yet specific. The prescribed conditions should be clearly specified in the bid documents to ensure fair competition and transparency.

Most of the ports across the world operate with Captive dredger or by sharing common dredger for eg – Australia Port, Chinese Port, Panama Canal, Suez Canal. Even in India, Private ports / Non-Major ports mostly executes works through captive dredger or sharing of the common dredger among themselves.

While fixing prequalification criterion 1st preference should be always be granted to dredgers built in India under Make in India concept availing subsidy.

7.5 Rate reasonableness mechanism

Operational cost of dredger is an important factor in identifying the optimum hopper capacity of the dredger that can be deployed at the ports. Hence, it becomes important to assess the average cost incurred per cubic meter of dredged material at different levels of utilization of the dredgers. Based on various parameters such as the fuel consumption, crew cost, power consumption etc

Cost can be calculated based on the average dredging cost per cubic meter of dredged material at different levels of utilization of dredgers. Here, the level of utilization for a dredger is the amount of time it was dredging out of the total available days for dredging after consideration of annual repairs and maintenance days, dry dock days and voyage period.

The various assumptions used and their basis is explained below:

The average annual dry dock days, average annual maintenance days and the mobilization – demobilization (mob – demob) days per year are assumed after taking into consideration the targeted days for current fleet of dredgers. Based on these assumptions, the available days for a dredger work out to be 250 days to 325 days per year.

Further based on the availability of contracts, the utilization of the dredger in the base case as taken as 80%.

Dredge distance is taken after considering the distance of disposal ground at most of the major ports. Dumping distance of Disposal Ground at Major Ports in India are shown in table below:

Port	***Average disposal ground distance (Km)***	***Annual Maintenance dredging volumes (MCM)***
Deendayal Port	*13.5*	*10.5*
JNPT port	*35*	*5.5*
Mumbai Port	*30*	*2*
Mormugao Port	*7*	*3.1*
New Mangalore Port	*7 .5*	*6*
Cochin Port	*8*	*21*
Chennai Port	*7*	*0.25*
Vishakhapatnam Port	*12*	*0.1*
Paradip Port	*12*	*6*
Weighted average Dum ping distance	***17 Km or 9 NM***	

7.6Operational Parameters to Be Considered for vessel (7000 to 12000 McM)

SNo	***Parameter***	***Value***	***Unit***
1	*Dredging Days*	*310 For first 5 years* *290 for next 5 years* *270 subsequently*	*days*
2	*Working hours/ Day*	*24*	*Hours*
3	*Hopper Loading time in one dredge cycle*	*60*	*Minutes*
4	*Unloading time (Bottom doors)*	*10*	*Minutes*
5	*Dredge disposal distance - Average*	*9*	*NM*
6	*Average speed during dredging cycle*	*7*	*Knots*
7	*Travel time – To &Fro*	*2.57*	*Hours*
8	*Cycle Time*	*3.49*	*Hours*
9	*Cycles per day*	*5- 8*	*Nos.*
10	*Efficiency*	*65% - 80%*	*-*

7.7 Technical Specifications of Different Dredgers

Parameters	***7500 m3***	***9000 m3***	***11,750 m3***	***14,000 m3***
Deadweight	*11,800*	*14,060*	*17,620*	*26,530*
Loaded Draught (m)	*8.15*	*8.95*	*9.7*	*11.2*
Dredge Pump (KW)	*2000*	*3100*	*3700*	*4000*

Propulsion power (KW)	*8000*	*10,560*	*12,400*	*14,400*
Speed (Knots)	*14*	*14*	*15*	*15*
Capital Cost (Million Euro)	*60*	*70*	*90*	*110*

Above parameters can be considered while arriving at operational, financial and technical costs, the specific fuel consumption, propulsion machinery utilization, generator fuel consumption per day etc., for the dredgers need to be considered after conducting primary surveys with Port.

7.8 Dredging Parameter for All Dredgers

S. No	***Parameters***	***Unit***	***7500 m3***	***9000 m3***	***11,750 m3***	***14,000 m3***
A	*Dredging volume per day*	*CuM*	*51604*	*61925*	*80846*	*96328*
B	*Reported Quantity/ Day*	*CuM*	*30,446*	*36,536*	*47,699*	*56,833*
C	*Specific fuel consumption*	*gm per KWH*	*175*	*175*	*175*	*175*
D	*Dredge Pump power*	*KW*	*2000*	*3100*	*3700*	*4000*
E	*Propulsion power*	*KW*	*8000*	*10,560*	*12,400*	*14,400*
F	*Fuel consumption per day - dredge pump*	*Tonnes*	*1.81*	*2.80*	*3.34*	*3.61*
G	*Fuel consumption per day - Propulsion*	*Tonnes*	*33.6*	*44.35*	*52.08*	*60.48*
H	*Fuel consumption per year - dredge pump*	*Tonnes*	*387*	*599*	*715*	*773*
I	*Propulsion power while dredging (% of MCR)*	*%*	*40*	*40*	*40*	*40*
J	*Fuel Consumption per year - Propulsion – dredging*	*Tonnes*	*2873*	*3792*	*4453*	*5171*
K	*Fuel Consumption per year - Propulsion - non-dredging*	*Tonnes*	*2083*	*2750*	*3229*	*3750*
L	*Fuel Consumption per year - Propulsion*	*Tonnes*	*4956*	*6542*	*7682*	*8921*
M	*Fuel consumption per day - Generator*	*Tonnes*	*1.5*	*1.5*	*1.5*	*1.5*
N	*Fuel Consumption per year – Generator*	*Tonnes*	*520*	*520*	*520*	*520*

Port	Period of dredging												Estimated Quantity in Million CuM
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	
Haldia / Kolkata Port													8.60
Paradip Port													7.00
Visakhapatnam Port													0.28
Chennai Port													0.00
Kamarajar Port- Ennore*													4.00
V.O.C. Port- Tuticorin													0.00
Cochin Port													22.20
New Mangalore Port													6.20
Mormugao Port													3.00
Mumbai Port													3.33
JNPT													10.00
Deendayal Port- Kandla													14.95
												Total:	79.56

* Not Regular

Cost Estimate and budgetary cost preparation shall be based on CIRIA estimation of cost for dredgers.

Mobilization & Demobilization charges to be indicated separately instead of clubbing with dredging unit rates. The maximum charges of Mobilization & Demobilization charges are 7.5% & 2.5% respectively. Mobilization charges will be paid after completion of 5% of dredging. Demobilization charges should be paid after issuing of completion certificate by the port, provision for idle time may be made in case necessary.

When there is a mix of soft soil & hard soil/rock, the composite Rates are used. The composite Rates may be used when one of the materials is expected to be around 90% or more.

Survey details available with the Port should be furnished to the technically qualified dredging firms in digital form.

The price adjustment for fuel price shall be allowed irrespective of contract duration and contract value.

The siltation forecasted during the contract period for capital dredging project shall be considered while assessing the tender value.

Ministry of Ports, Shipping and Waterways reserves the right to assign, in public interest, any contract for dredging work in any of the ports on nomination basis.

Tendering Procedure through EPC mode for Assured Depth Contract

7.9 EPC (Engineering, Procurement and Construction)

Contractor assumes work of Engineering, Vessel Procurement and Dredging. It includes development or operation of the Navigation / Shipping Channel for the desired quantity / depth. Could be done for Capital or Maintenance dredging or both.

Framework –

- Type of Contract : EPC
- Term : 30 days to 1 year
- Mode : Through Contractor
- Contract value : Based on Last Contract / CIRIA Manual
- Financing : Contractor / Port.
- Payment : Could be based on Period / Quantity based / Lumpsum.
- Target : 100% completion with LD for remaining quantity
- Timelines : within the targeted time +/- 10%
- Risk & Responsibility: will be borne by the contractor.
- Outcome : Achieve desired depth
- Quality / Quantity Certification: PMC / Port Marine department / Contractor
- Benefits : Dredging depth
- Example / Earlier done at : Indian Ports (For EPC only)
- Frequency of Check for depth: To be decided by port based on volume

CHAPTER 8

MONITORING MECHANISM AND PERIODICAL REVIEW OF DREDGING WORKS AND INFORMATION SYSTEM ON DREDGING PROJECT

8.1 Monitoring mechanism and periodical review of dredging works

The project monitoring and control is key to success of the project and a dedicated consultant or employee to perform such function is the most significant task in achieving the project targets/ goal. Project success depends on meticulous planning of each and every sub- component of project activity.

Measurements and validation of depths is paramount for the success of the government objective to provide desired depth on sustainable basis for port operations across all the ports of the country.

In order to effectively manage dredging activities, a strong Monitoring Team (either from third party or the ports it‘s own employees) should be available to perform following roles:

1. To work as representative of the Port and dredging agency.
2. To continuously coordinate between dredging agency and various departments of the Port and other interested parties to ensure that dredging operation continues as planned.
3. Verify the quantity of dredging or the required depth on behalf of the port authority and recommend for payment based on the qualifying criteria specified for payment under the agreement.
4. Continuously monitor and provide feedback to the port about dredging operation and take necessary corrective and preventive action for any delay or any other eventuality which may arise during currency of the contract between project authority and the dredging company

Considering the above primary functions of PMC, appointment of PMC on contract (project management consultant) for providing technical guidance to the Port in framing up of depth requirement, sediment characteristics, dredging quantity, selection of capable dredging company, monitoring and measurements etc. can be considered for specific item of work or the entire process.

Monitor mechanism can be classified for based on type of Contract i.e.

1. Quantity Based
2. Depth Based
3. Lump Sum

Parameter for monitoring of erosion, sedimentation and environmental impact survey could include

- Sea Water Temperature
- Sea Water Salinity
- Density
- Turbidity
- Chemical constituents of water
- Pollution

In order to optimize cost, monitoring of maintenance dredging activities shall be carried out by reputed organisation once in every 3 years covering full cycle of seasons.

An independent Project Management Consultant may also be engaged, if necessary, to monitor the dredging activities.

Monitoring by:

The contract part	: Civil Engineering Department, Port.
Hydrographic Survey	: Marine Department, Port
Pre & post survey navigational charts	: Sign by Marine Department
Overall supervision	: Deputy Chairman
PMC	: Preferably every 3 years

The monitoring survey for the progress may be carried out in the survey boats of dredging contractor.

While carrying out capital/maintenance dredging in the Port area, minimum hours per day for ship movements have to be identified with the minimum number of hours per day available for dredging in one or two spells depending upon the ship movements during the period of dredging works. The same may be indicated in the tender papers and has to be monitored during execution.

Specific dredging targets considering the period of completion of dredging has to be indicated in the tender documents and the Engineer appointed for the contract / Project Management Consultant if any has to monitor the progress and give recommendations on monthly payments.

The guidelines on Pre and Post Dredging surveys issued by Naval Hydrographic office (NHO), Dehradun dated 16.7.2014 may be adopted for pre and post dredging surveys in addition to port specific recommendations.

Pre and post dredging hydro graphic surveys pertaining to capital and maintenance dredging works can be witnessed and certified by Third Party Survey agencies. The periodicity of survey, type of echo sounder to be used whether multi beam or Dual frequency echo sounder shall be decided and incorporated in the tender itself by the individual ports. The frequency of the survey should not vary between Pre and Post dredging surveys.

The cost of all payment surveys to the dredging contractor may be borne by the port. The surveys shall be carried out in the owned/hired steel /FRP survey boats of third survey agency with hull mounted transducer, with survey boats having maximum speed of 10 knots. The monitoring survey for the progress etc., may be carried out in the survey boats of dredging contractor.

The navigational survey charts for payments have to be signed by the dredging contractor, representative of the port, PMC (if any) or Third Party survey agencies if any.

8.2 Transparency of dredging process:

The Major Ports are required to maintain transparency in execution of the dredging projects to ensure maximum efficiency. In order to avoid any conflicts, it is advisable to maintain data on dredging project in the website of the Major Ports as well as IPA. In this regard, the Major Ports are required to maintain comprehensive data related to hydrographic survey including the maps on suitable scale, geotechnical data containing the bed material based on geotechnical investigation in the channels, basin, berthing area and other operational area. Further, the details on payment made to contractor for the volume of work done and also pending works to be undertaken with the timeline should be projected in the website so as to ensure timely completion of the project without cost overrun.

The Major Ports may also put relevant data on the website on the previous dredging projects undertaken and also the dredging projects planned for taking up relevant measures by the potential dredging companies as well as user agencies of the port.

CHAPTER 9

QUALITY ASSURANCE PLAN

A good Quality Assurance Plan (QAP) is essential for ensuring quality of project execution and avoid disputes where possible. The following aspects may be covered in the QAP.

1 Introduction
- 1.1 Purpose of Document
- 1.2 Scope

2 Documents

3 Project Quality Plan
- 3.1 Control of Project Quality Plan
- 3.2 Implementation of Project Quality Plan
- 3.3 Codes and Standards
- 3.4 Client Specifications
- 3.5 General Requirements
- 3.6 Policy Statement
- 3.7 Quality Objectives

4 Contractor's Quality Management System
- 4.1 Policy and Procedures

5 Human Resource Management
- 5.1 Setting up the Project Organisation
- 5.2 Competence, Training and Awareness
- 5.3 Quality organization
- 5.4 Specific responsibilities
- 5.5 Infrastructure

6 Project Information Review and Analysis
- 6.1 Principles
- 6.2 Responsibility for identification of requirements

7 Control and Supervision of Subcontractors
- 7.1 Selection of suppliers/ subcontractors
- 7.2 Appointed subcontractors
- 7.4 Project Site Coordination Meeting
- 7.7 Programs and Progress
- 7.8 Reporting
- 7.9 Evaluation

8 Quality Assurance / Quality Control
- 8.1 Principles of QA/QC
- 8.2 Inspection and Test Plan
- 8.2.1 Preparation and approval
- 8.2.2 Records
- 8.3 Incoming inspections of products
- 8.4 Testing and Calibration

9 Non-conformance Control
- 9.1 NCR Focal Point (NCR-Non-Conformance Report)
- 9.2 Recipients / action owner
- 9.3 NCR request for response
- 9.4 Product NCR
- 9.5 Establish effectiveness of corrective and preventive action
- 9.6 Records

10 Control of documents and data
- 10.1 General Correspondence
- 10.2 As built documentation and deliverables
- 10.3 Technical Queries and Deviations
- 10.3.1 Technical Query
- 10.3.2 Technical Deviations
- 10.4 Control of records

11 Auditing
- 11.1 Principles of auditing
- 11.2 Audits by Client

12 Continual Improvement

Appendices: The Appendices may contain the following.

Overview list appointed Subcontractors
Inspection and Test Plan flowchart
Format Inspection and Test Record (ITR)
Format Inspection and Test Plan (ITR)
Non-conformance form system NCR
Non-conformance form product NCR
Format NCR Register
Template audit planning
Template Release Note
Template Punchlist
Template Supplier / Subcontractor Evaluation Form
ANY OTHER RELEVANT FORMS

CHAPTER 10

PUBLIC PRIVATE PARTNERSHIP (PPP) MODE OF PROJECT FOR DREDGING.

It is expected that 15% fleet is with more than 20,000 TEUs capacity currently and it is expected to grow at accelerated pace in the next 10 years. Most of the Indian container berths have lower draft as compared to International ports. Further, there is wide variation in berth wise draft across ports. The International Ports such as Colombo Port has maximum draft of 18 meter at container berth, Singapore Port has 18 metre and port Kelang has 19 metres. In comparison the JNPT has 16.2 metre; Kamarajar Port has 16 metres, Cochin Port 14.5 metre and Chennai 16.5metre. In order to accommodate higher capacity container vessels, it may be necessary to have container berths with at least 25,000 TEU handling capabilities. Hence, there is a need to increase the draft by 2 -3 metre up to 17 metre draft in order to handle higher capacity container vessels. The reduction in transportation cost is also observed with economies of scale as the cargo movement is shifted from Panamax to Capesize vessels for bulk cargo handling berths.

In order to increase the draft by Capital dredging, the capital expenditure required would be of high order. In this regard, the Major Ports may adopt Public Private Partnership mode of execution so as to ensure funding from the private agencies with support from the Major Ports. However, the berths in the Major Ports have been developed during the last 20 years with draft requirement of 12-14 metre only. The additional dredging in the capital dredging project may pose a problem for the foundation structure of the berths with reduction in the embedment of the piles which act as foundation for the berth. The Major Ports may have to carry out technical investigation for the safety of berth before undertaking capital dredging project for increasing the draft of the channels and the basin.

It may be concluded that significant Capital dredging may be required at the Major Ports in 3-5 years to handle the anticipated container vessels of size 20,000 TEUs and bulk cargo carrying Capesize vessels. The PPP model emerges as a potential option with limited investment from the Major Ports.

The key advantages of the PPP mode in capital dredging are as follows:

(i) Dredging is taken up as a service requirement for the project;

(ii) Minimal operation burden with Port Authority;

(iii) The PPP model may be adopted for capital as well as maintenance dredging with hybrid model of capital dredging followed by maintenance dredging for a period of 10 years atleast.

The key risk elements identified in PPP mode for dredging projects are:

(i) The complex traffic structure to be developed by Major Ports for different berth operator with different category of cargo;

(ii) The Major Ports may have limited flexibility to change the parameters during the concession period which may have restrictions on channel dimensions for a period of time;

In order to bring in PPP mode in dredging, the following factors to be considered by the Major Ports keeping in mind the advantages and risk involved:

(i) It should be design for adequate duration to ensure PPP project viability throughout the period of concession;

(ii) The Major Ports should keep pace with the changes in the post port master plan and ensure that adequacy of draft is met the dredging project through PPP mode.

(iii) The Major Ports should arrive at measureable performance indicator which may include assured depth during the period of concession and adequate financial returns as per the financial viability structure.

(iv) The Major Ports may also develop concessionaire performing monitoring system to ensure efficiency and cost effectiveness during the concession period.

(v) The Major Ports may take into consideration key social and political implication due to PPP project and may adequately design the project to overcome any hurdles/set back.

A PPP model may be worked out for the dredging projects with the hybrid model of combining the Capital dredging with Maintenance of the same for 10-20 years. The revenue share between Major Ports and PPP operator may be the bidding parameter for floating the PPP projects. The existing PPP operators of the berth may share proportionate cost based on the volume of cargo handled along with the berths operated by Major Ports themselves.

Annexure - 1

Government of India
Ministry of Shipping
(Development Wing)

No. DW-11012/1/2020-Development Wing Dated: 26th May, 2020

OFFICE MEMORANDUM

Subject: Committee to study the requirements of dredging projects at Major Ports as per the best international practices – reg.

The undersigned is directed to say that it is required to study the requirements for the dredging projects as per the best international practices in major transhipment hubs such as Colombo Port in Sri Lanka, Dubai Port and Singapore Port by a Committee under the chairmanship of Additional Secretary (Shipping) with the following members:

(i)	Additional Secretary (Shipping)	-	Chairman
(ii)	Joint Secretary (Ports)	-	Member
(iii)	Development Advisor	-	Member
(iv)	MD, IPA	-	Member
(v)	Prof. Murali, IIT Madras	-	Member
(vi)	Chairman, JNPT	-	Member
(vii)	Chairman Kolkata Port	-	Member

2. The Committee would be undertaking the following aspects:

(i) To study the method of preparation of estimate for capital and maintenance dredging projects in the major ports of the world such as Colombo Port, Singapore Port and Dubai Port.

(ii) The method of preparation of detailed project report with engagement of project consultants with the dredging projects best international practices being followed by the International Ports for determining the output of the dredging projects for bringing efficiency timely completion, etc.

(iii) The best system of tendering the dredging projects being followed by the international ports.

(iv) The latest technology adopted for survey including Hydrographic Survey, Geo Technical Survey and Topographical survey, etc.

3. The Committee to give a report within a time duration of 2 months for making any recommendations based on the study.

(Anil Pruthi)
Director (Engineering)

Copy to

(1) PS to Secretary (Shipping) for information.

(2) PS to Additional Secretary (Shipping) for information.

(3) Members of the Committee.

(4) Office copy.

Government of India
Ministry of Shipping
(Development Wing)

No. DW-11012/1/2020-Development Wing Dated: 29th May, 2020

OFFICE MEMORANDUM

Subject: Committee to study the requirements of dredging projects at Major Ports as per the best international practices – reg.

In continuation to this Ministry's letter of even no. dated 26.05.2020 on the above mentioned subject (copy enclosed) and to say that with approval of Competent Authority, the following co-opted members have been included in the committee constituted to study the requirements for the dredging projects as per the best international practices in major transshipment hubs such as Colombo Port in Sri Lanka, Dubai Port and Singapore Port:-

(i)	Shri Rajesh Tripathi	–	MD, DCIL
(ii)	Shri Sanjay Kumar Gangwar	–	Member (Technical), IWAI
(iii)	Shri Khushal Chand	–	Chief Engineer, MoRTH

2. The other terms and conditions of the committee will remain same as mentioned in Para 2 of the letter of even no. dated 26.05.2020.

(Anil Pruthi)
Director (Engineering)

Copy to

(1) PS to Secretary (Shipping) for information.

(2) PS to Additional Secretary (Shipping) for information.

(3) PS to JS (P)/ PS to DA (P) for information.

(4) Chairman, Kolkata Port Trust, 15 Strand Road, Kolkata-700001

(5) Chairman, Jawaharlal Nehru Port Trust, Port Office, Administration Bldg., Sheva, Navi Mumbai-400707

(6) Managing Director, Indian Ports Association, 1st floor, South Tower, NBCC place, Bhisham Pitamah Marg, Lodi Road, New Delhi 110 003

(7) Dr. K Murali, Professor, Department of Ocean Engineering, Indian Institute of Technology Madras, Chennai - 600 036

(8) Shri Khushal Chand, Chief Engineer, Ministry of Road Transport and Highways, Transport Bhawan, New Delhi-110001

(9) Shri Sanjay Kumar Gangwar, Member (Technical), Inland Waterways Authority of India, A-13, Sector-1, Noida-201301

(10) Shri Rajesh Tripathi, Managing Director, Dredging Corporation of India Ltd, Dredge House Port Area, Visakhapatnam-530035.

(11) Office copy.

Annexure-2

Terms of Reference (TOR) for Consultancy Services for Preparation of Detailed Project report (DPR) for Deepening of the existing channel in a Port

[*"Deepening and Widening of Harbour / Port Channel"*][1]

1. **General Information of the Project:**

Background information[2]:

2. **Aim and Objectives of assignment:**

The aim of this assignment is to examine the qualitative and quantitative requirements of improving the approach channels and navigational area to enable the port to handle large size vessels[3]. [The study involves review of the existing reports/surveys, as available with the Port, and analysis thereof to ascertain likely growth of traffic and the number and size of vessels likely to call on the port upto the year 0000, examining the requirements of widening and deepening of the channel, study the existing navigational aids and VTMS operating in the harbour and its adequacy or otherwise in the long run requisite augmentations/additions.][4] Navigational aspects have to be studied from point of view of congestion as well as safety primarily keeping in mind that Port has to service. Navigational area has to be studied in its totality including requirements of providing adequate turning circles and anchorages. Cost estimates, implementation schedule, possible investment models, preparation of documents for inviting bids for selection of executing agency shall also form part of this assignment.

3. ***Scope of consultancy services:***

The scope of consultancy services shall include but not necessarily be limited to the following activities:

3.1 Preliminary Site Investigation:

The consultant shall make preliminary site investigation at the project site if necessary. Also, the consultants shall study and refer available soil investigation and other relevant reports/ data available with the Port.

3.2 “Detailed Project Report” is required to be finalized in following stages:

1. Inception report, on the basis review of existing report if any, other available reports, of survey of available documents, inspection of site and preliminary discussions with the Port officials, Govt. officials, present and potential customers, other groups/agencies likely to have interest in this project. The Consultant shall study and explore/ suggest alternative / innovative options to handle larger vessels in Harbour.

2. Evaluation of quantitative and qualitative requirements of vessels likely to call at Port based on Traffic forecast shall be done for the study period of YYYY.

3. Selection of parameters of design vessel/s for assessing requirement of navigational area i.e. approach channel, turning circle/s, anchorages etc.

4. Study of the existing meteorological and hydraulic regime within the Port Harbour vis-à-vis the navigational characteristics of the design vessel/s to identify the requirements for safe navigation and manoeuvring of the vessels at all times.

5. Review the existing regime of the Port Harbour channel and channel and analyze its suitability for the design vessel/s. Also, analyze vessel handling capacity of the entire channel taking into consideration various sizes of vessels reporting and likely to report in neighbouring ports if any, and other such organizations who are using common user channel.

6. Examine and suggest alternative geometric designs of the navigational areas bringing out the requirements of widening and deepening either in one go or in stages for the design vessel/s with and without available tidal windows.

7. Examine the existing navigational aids and VTMS provided in the harbour for optimal utilization and propose augmentations/improvements as necessary for 24-hour movement of design vessel/s through the navigational area.

8. Propose and draw up terms of reference for additional studies for assessing suitability of the proposed design of the navigational area which will be got done by PORT.

9. Examine the suitability and adequacy of existing dredge spoil dump grounds located off shore and make recommendations for possible locations for dumping dredged materials.

10. Prepare detailed cost estimates for various alternatives with assessment of dredging quantities for each alternative.

11. Make recommendations for selection of preferred alternative/s.

12. Financial Feasibility and project structuring: The consultant shall work out various options / alternatives structures for carrying out the project including the Port undertaking the project on its own or port having Joint Venture with Public Sector unit or PPP/ formation of Special Purpose Vehicle (SPV) or annuity basis or any other option for the execution of this project.

13. Carry out financial and economic viability studies of the project for the preferred alternative/s. Examine possible investment and cost recovery models and prepare sensitivity analysis.

14. Prepare a realistic implementation schedule for the project.

15. After submission of the final DPR, Consultants would be required to assist port authorities in clarifying the queries of Govt of India on the DPR.

4. **The scope of work for preparation of DPR shall include (but not limited to) the following activities**:

(a) Review of following reports/proposals prepared by the Port in the past:

[Any other documents or old reports, as available with the Port and accessed by the consultants][5].

a. Consultations with

- Port officials of PORT.
- Govt. of India officials (Ministry of Ports, Shipping and Waterways, Ministry of Commerce & Industries etc).
- Shipping lines.
- Freight forwarders.
- Chamber of Commerce & Industries etc.
- Confederations of Industry, Petroleum Industry, Natural Gas, Agriculture, Fertilizers etc.

b. Site Inspection/Field visits

5. **The documents/reports to be delivered by the consultants shall be as under:**

a. Inception Report.

b. Traffic Analysis (forecast): Traffic studies covering traffic forecast and vessel size up to the year 2030.

c. Report on technical aspects like field data, dredging studies, navigational study etc.

d. Financial Feasibility and Structuring the project with Financial and economic analysis of proposal/s. Report on possible investment and cost recovery models.

e. Executive summary covering the above.

6. **Reports:**

All reports and documents prepared by the Consultants shall be professional, precise and objective. The report formats shall be finalized in Consultation with the Employer officials. The Consultants shall provide three copies/sets each of the following reports to PORT:

Sr. No.	Description	No. of Copies	Period
i	Inception report	5 copies	Within [45] days from award of assignment excluding 15 days as mobilization period
ii	Draft DPR	10 copies	Within [90] days from submission of Inception report
iii	Draft Final DPR	10 copies and soft copy.	Within [75] days from submission of Draft DPR
iv	Final DPR	10 copies and soft copy.	Within [30][6] days from submission of Draft Final DPR

Note: The Time period indicated for assignment shall excludes the time taken by the Employer and Government for various Government approvals.

7. Facilities to be provided by the consultant

The Consultants shall make their own arrangements for transport (vehicle) at the project site. The Consultants shall give details in the Technical Proposal and price in the Financial Proposal all facilities, equipment (engineering and office), transport, supplies, computer hardware and peripherals, computer software, communication system (telephone, fax, e-mail/ Internet) and support staff which they consider to carry out the services. After completion of the contract, all articles deployed by the Consultant shall remain as their property.

****

[1] Name of work to be inserted
[2] Port to provide information on the project and about Port Navigational aspects
[3] Give details of vessels calling at present and what is expected from this project
[4] The details to be retained if required and basic data is available
[5] Port to indicate existing available documents in the Port which will be part of the study including traffic and master plan of ports
[6] Port to indicate Period in this Table

Annexure-3

Geotechnical / Geophysical investigation and Equipment

In Maintenance dredging

In Maintenance dredging, there is no need for geotechnical investigations. Bathymetric surveys to define the water depths in and around dredging area and disposal site are essential to quantify extent and quantum of dredging volume.

In Capital dredging

When capital dredging has to be carried out like Dredging in front of berths, deepening of harbor basin, channel etc., the following pre-dredging surveys /studies/ investigations may be carried out by the Port at the time of estimation and form part of the tender document.

i. Bathymetric surveys to define the water depths in and around dredging area and disposal site.

ii. Geo technical investigations of the sea bed to identify the type of soil and rock to be dredged and to define physical and mechanical properties like particle size, bulk density standard penetration test value (SPT-N value) etc.

iii. Geo-physical investigations like Side Scan Sonar, Sub-bottom profiling and Magnetometer surveys to identify obstacles on or under the sea-bed (shipwrecks, pipes, debris, etc.).

iv. Shallow seismic survey alone is not sufficient and refraction survey also to be done in respect of rock dredging. This is a must for capital dredging projects, unless there is sufficient previous data available for non-presence of rocky strata.

v. Classification of soil for dredging purposes has to be updated based on PIANC classification of Soils & Rocks for Maritime Dredging Process: Marcom – WG144 (JULY 2016).

As per the proposed method of estimation, it would be essential for the EIC identify the equipment to be used in a particular work. PIANC Marcom WG144 deals extensively with this. The users of this guideline are encouraged to make themselves familiar with all details in the PIANC guideline so that they could plan for geo-technical and geo-physical investigations suitably. Some of the highlights are provided here for clarity, by reproducing from PIANC Marcom-WG144. They are in no means complete, but only provide snippets in to the important aspects. For complete understanding, the EIC or consultant shall refer to WG144 and apply fully.

As for the intensity of the field investigation, there are no firm guidelines as to the number of borings or their spacing. This will depend on the geological complexity of the site and the availability of other qualitative data (geophysical, etc.) and can vary greatly from one location to another. However, the following formulae have been suggested for planning the number of borings, in the case of a simple layer situation, such as a sandlayer. This may be increased suitably to understand variation in strata in terms of strength and classification.

	N	=	$[3 + (A^{½} \cdot D^{⅓})] / 50$	Bates (1981)
	N	=	$3 + (A^{½}) / 25$	Verbeek (1984)
where	N	=	number of borings	
	A	=	area to be dredged, m^2	
	D	=	average depth to be dredged, m	

The sampling method is another key factor, and the following may be adopted depending the strata.

		Sampling category	Sampling method
Soil	without flushing medium	**Hammer driving linkage with tube sampler** (see ISO 22475-1, table 2, line 9) only to be used for small depths, above water surface f.e. in tidal areas	
		B	cohesive soils of stiff to very stiff consistency
		C	soils with coarse particles < d/2[1]
		Percussion clay cutter with cutting edge inside[2] (see ISO 22475-1, table 2, line 7) unsuitable for laminated soils and soils with coarse particles < d/3[1]	
		A	cohesive soils up to very stiff consistency
		B	cohesionless soils
		Open-tube sampler, thin-walled (see ISO 22475-1, table 3, line 1) (unsuitable for gravel, sand below water surface, hard cohesive soils, soils including coarse particles)	
		A	cohesive or organic soils of soft to very stiff consistency
		Open-tube sampler, thick-walled[2] (see ISO 22475-1, table 3, line 2)	
		B	cohesive or organic soils of very stiff to hard consistency
		Rotary core drilling (unsuitable for cohesionless soils)	
		B	**Single-tube corebarrel**[2] (see ISO 22475-1, table 2, line 1) cohesive soil and weathered rock
Rock	with flushing medium	**A**	**Double/triple-tube corebarrel with extended inner tube**[2] (see ISO 22475-1, table 2, line 3) cohesive soils of very stiff to hard consistency
		A	**Wireline core drilling with liner**[2] (see ISO 22475-1, table 5, line 5) cohesive soils of very stiff to hard consistency
		A	**Double-tube corebarrel** (see ISO 22475-1, table 5, line 3) all rocks
		A	**Triple-tube core barrel** (see ISO 22475-1, table 5, line 4) all rocks
		A	**Wireline core drilling without liner** (see ISO 22475-1, table 5, line 5) all rocks
		A	**Wireline core drilling with liner** (see ISO 22475-1, table 2, line 5) all rocks
[1] d: internal diameter of the sampling tool [2] also suitable for ***Intermediate material***			

Table 2.2: Common sampling methods and achievable sampling categories according to ISO 22475-1:2006

The salient tests to be carried out for dredging works, in order to understand the strata and identification of type and strength of materials, are summarized below.

Parameters	Material	Excavation	Transport	Loading and unloading	Re-Use
Particle size distribution	C, S, G, O, R				
Particle shape	R, S, G				
Unit weight	C, S, G, R				
Density (min, max, relative)	S, G, R				
Water content	C, S, G, O, R				
Atterberg limit (plasticity)	C, O				
Undrained shear strength	C, O				
Carbonate content	S, G, O, R				
Organic content	C, O, S				
Permeability	C, S, O, G				
Mineralogy	C, S, G, R				
Crushability	S, G, R				
Rheology	C, O				
Fibrousness	O				
Internal angle of friction	S, G				
Petrographic	R				
Unconfined compressive strength	R				
Static modulus of elasticity	R				
Brazilian split test (Tensile strength)	R				
Point load	R				
Seismic velocity	R				
Drillability	R				
Discontinuity and spacing	R				

Legend: R: Rock; G: Gravel, S: Sand and cohesion less Silt; C: Clay and cohesive Silt; O: Peat and Organic Soils

Table 1.1: Parameters relevant to dredging works

In case rocky or hard strata are expected to be encountered, a geophysical survey could precede the geo-technical investigations, to understand the extent and levels of such strata (Section 2.4, WG144). For projects of more than Rs. 200 crores in value and with heterogeneous, refraction studies may be conducted.

Section 3.2 of WG144 deals with classification of soils. Para 3.4 shall be referred to for understanding various aspects of laboratory testing. This chapter shall be referred to, for completion of classification and understanding various physical and strength parameters and their ranges.

In case of soft and sandy bed, the decision on choice of dredger is easier. However, in case of hard strata, it is trickier to decide on the equipment to be used. For this purpose, PIANC WG144 Fig.B.3 provides for identification of dredging methodology with regard to method of removing the material or underwater excavation. The figure identifies the method of disintegrating hard strata. There shall be clarity on what is the type of bed to be dredged.

Important: ***Usually, engineers / consultants check only Rock Strength and decide on a type of dredger. This approach in insufficient and defective. As per PIANC WG144 (Refer Table 6.1 below), the discontinuity spacing in rock strata is also important. The discontinuity spacing is indicated as RQD (Rock Quality Designation) and FI (Fracture Intensity) in geotechnical reports. Therefore, in Fig.B.3 is considered as another most important parameter along with rock strength.***

Further, in Fig. B.4, we can see the regions of application of four dredging techniques such as digging, ripping, cutting and scrapping. Better understanding of dredgeability of any particular strata by different dredgers could be obtained by the following para, reproduced from PIANC WG 144-2014 report.

"*The basic excavation mechanisms (digging, ripping, cutting and scraping) are plotted in Figure B.4. Many factors influence the excavation mechanism fields in the chart. As said, the limiting block size at which ripping still can be a dominating process during rock dredging does not only depend on the block size as such, but also on the size of the cutting tool. So, the larger the tyne or the pick point, the larger blocks can be ripped, provided the machine has enough power to loosen the blocks. If the blocks have to be transported hydraulically through a pump and pipeline by a Trailer Suction Hopper Dredger or by a Cutter Suction Dredger, the maximum size of the blocks that can be dredged is defined by the capacity and design of the drag head or cutterhead and the pumps and pipelines of these vessels.*

For a cutter suction dredger a limiting discontinuity spacing is related to the thickness of the cut that is made by the cutter, which is a function of the rotation speed of the cutter and the haulage velocity of the cutter ladder (Verhoef, 1997). This limiting thickness of cut in a certain setting is a function of the size and power of the cutter dredger. This limiting thickness can be compared to the spacing of the rock discontinuities, to judge whether ripping, cutting or a hybrid mode of excavation will occur. For each dredging vessel, be it a backhoe, TSHD or a cutter dredger, diagrams based upon block size and rock strength may be developed that show the range of economic working performance of the dredger type, similar to the diagrams existing for ripper bulldozers. Sufficient information on: rock material strength; discontinuity spacing and distribution in the rock mass; and seismic velocity (from refraction surveys), together help to direct the contractor to the right type and size of equipment to be used for the job at hand."

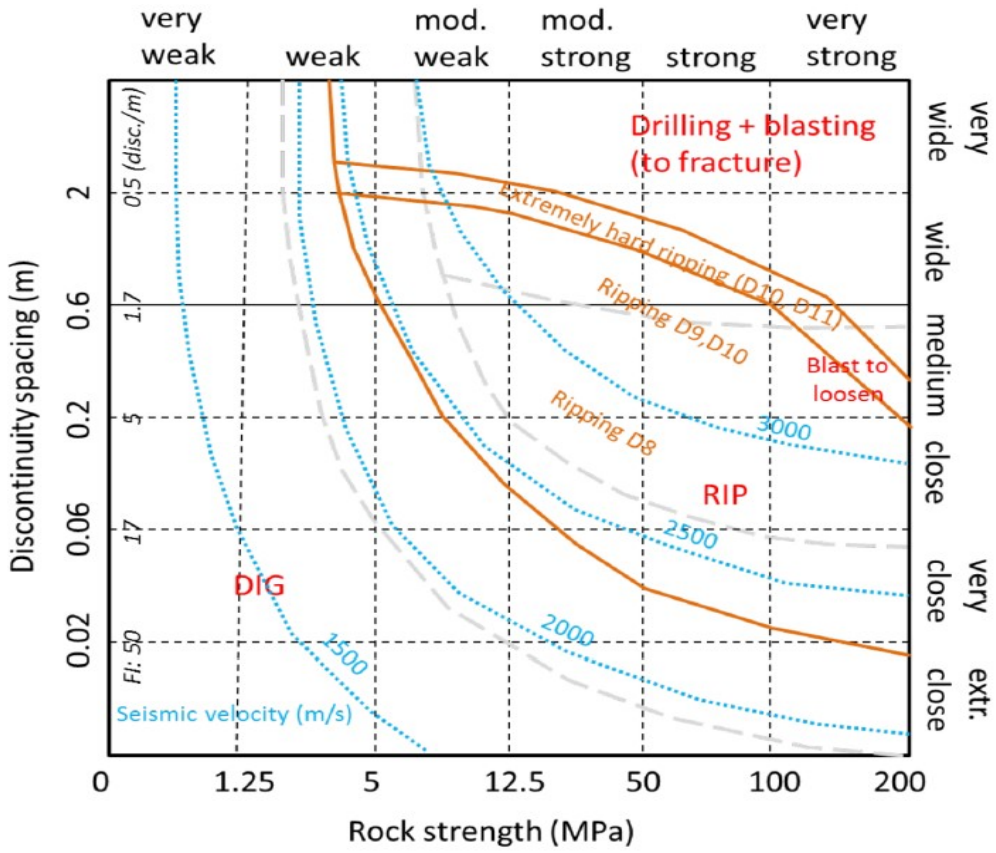


Figure B.3: The boundaries for "Dig", "Rip" and "Drilling and blasting" for Caterpillar bulldozers given by Pettifer and Fookes (1994), with the fields of the Franklin diagram in the background. In the "Extremely hard ripping" area, excavation is often assisted by hydraulic hammering.

				EXCAVATION and associated subprocesses					HYDRAULIC TRANSPORT and associated subprocesses				DEPOSITION and associated subprocesses			
type of material (main particle size in terms of mass)	**material behavior**	**particle size (ranges)**	**parameter**	(pure) hydraulic excavation	hydraulic/mechanical excavation	slurry density and clayballs	mixture formation while excavating	wear+tear	critical velocity	pipeline resistance	slurry density and clayballs	wear+tear	bulking	overflow losses	(relative) density upon deposition	unloading hopper
rock		**varies**	classification and mineralogy		x			x				x				
			size and shape of grains and lumps		x		x		x	x		x	x	x	x	x
			unit weight of particles and lumps		x		x		x	x		x	x	x	x	x
			Unconfined Compressive Strength		x			x							x	
			tensile strength		x			x					x			
			seismic velocity		x			x								
			Discontinuity spacing		x			x					x			
			Carbonate content					x						x	x	
(silt) sand gravel	**cohesionless soil**	**silt (2 to 60 mu) sand (60 mu to 2 mm) gravel (2 to 60 mm)**	particle size distribution	x	x	x		x	x	x		x	x	x	x	x
			particle shape/angularity	x	x			x	x	x		x	x	x	x	x
			particle density				x	x	x	x		x	x	x	x	x
			min. and max. density, relative density	x	x		x						x		x	
			permeability	x	x		x									
			internal angle of friction	x	x		x									
			mineralogy					x				x				
			carbonate content	x	x	x		x						x	x	
(silt) clay	**cohesive soil**	**silt (2 to 60 µm) clay (< 2 µm)**	particle size distribution	x		x	x		x	x	x	x	x	x	x	x
			unit weight and water content		x	x	x		x	x	x	x	x	x	x	x
			Atterberg limits	x	x	x	x		x	x	x		x	x		x
			rheology	x		x	x		x	x	x		x	x		x
			undrained shear strength		x	x	x				x					x
			mineralogy					x				x	x	x		
peat and organic soils	**may be firm to spongy to plastic in nature**	**varies**	non-organic content	x	x	x	x		x	x	x		x	x		x
			particle size distribution	x		x	x		x	x	x	x	x	x	x	x
			unit weight and water content	x	x	x	x		x	x	x	x	x	x	x	x
			decomposition		x	x	x				x		x			
			undrained shear strength		x	x	x				x					x
			mineralogy					x				x	x	x	x	

Table 6.1: Material properties of importance for various dredging processes

The choice of a particular equipment could be identified with the help of Fig. C.1 below. The figure suggests, for extremely hard strata (RGD >60 and FI less than 5), the requirement of pre-treatment arises. However, for lesser RQD and more FI, there requirement of pre-treatment is not there. The users shall use Fig. C.1 in association with Figs. 7.1 to & 7.3.

Important: ***Finally, it is important that EIC identifies the type of material and equipment to be used for preparing a reasonable estimate of the work. For this, the most common classification to be used are weathered rock, strong rock and soil. Take off quantities shall be prepared for such rock qualities separately. This is because, strong rock will need pre-treatment also be done prior to excavation.***

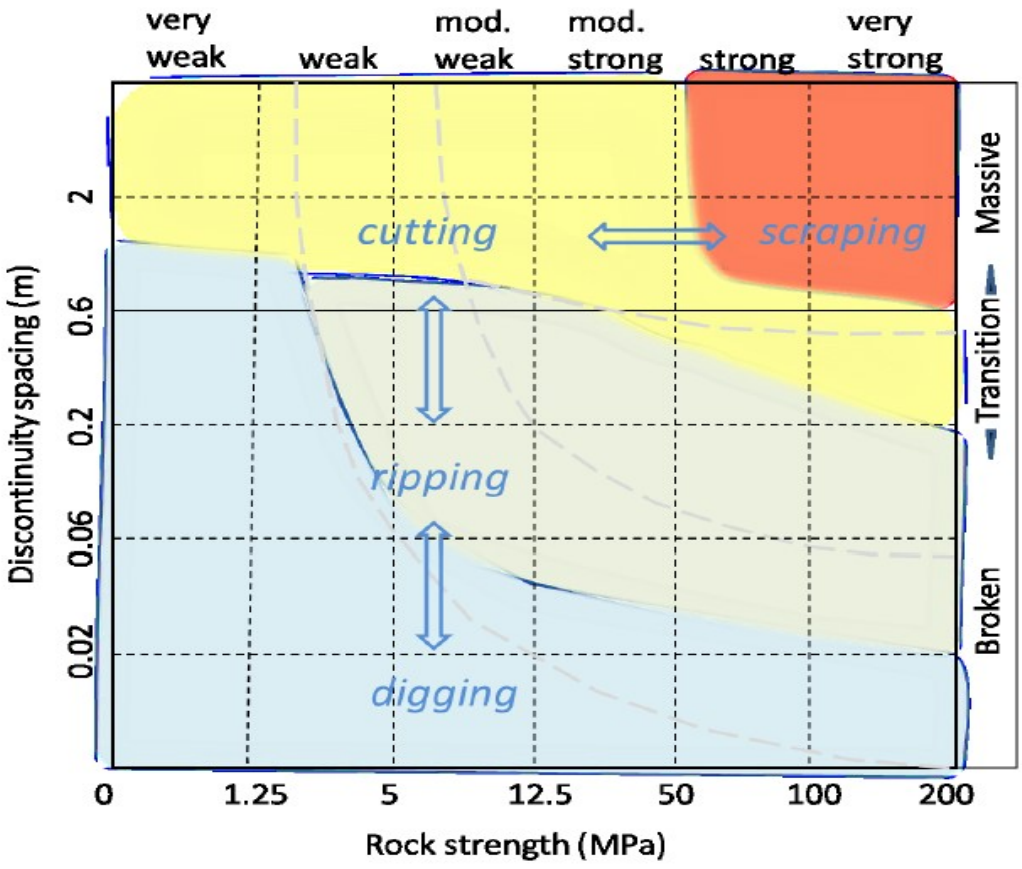


Figure B.4: Rock excavation mechanism fields plotted on excavatability chart. The coloured fields for digging, ripping, cutting and scraping are machine dependent, and will be unique for each type of rock cutting dredger

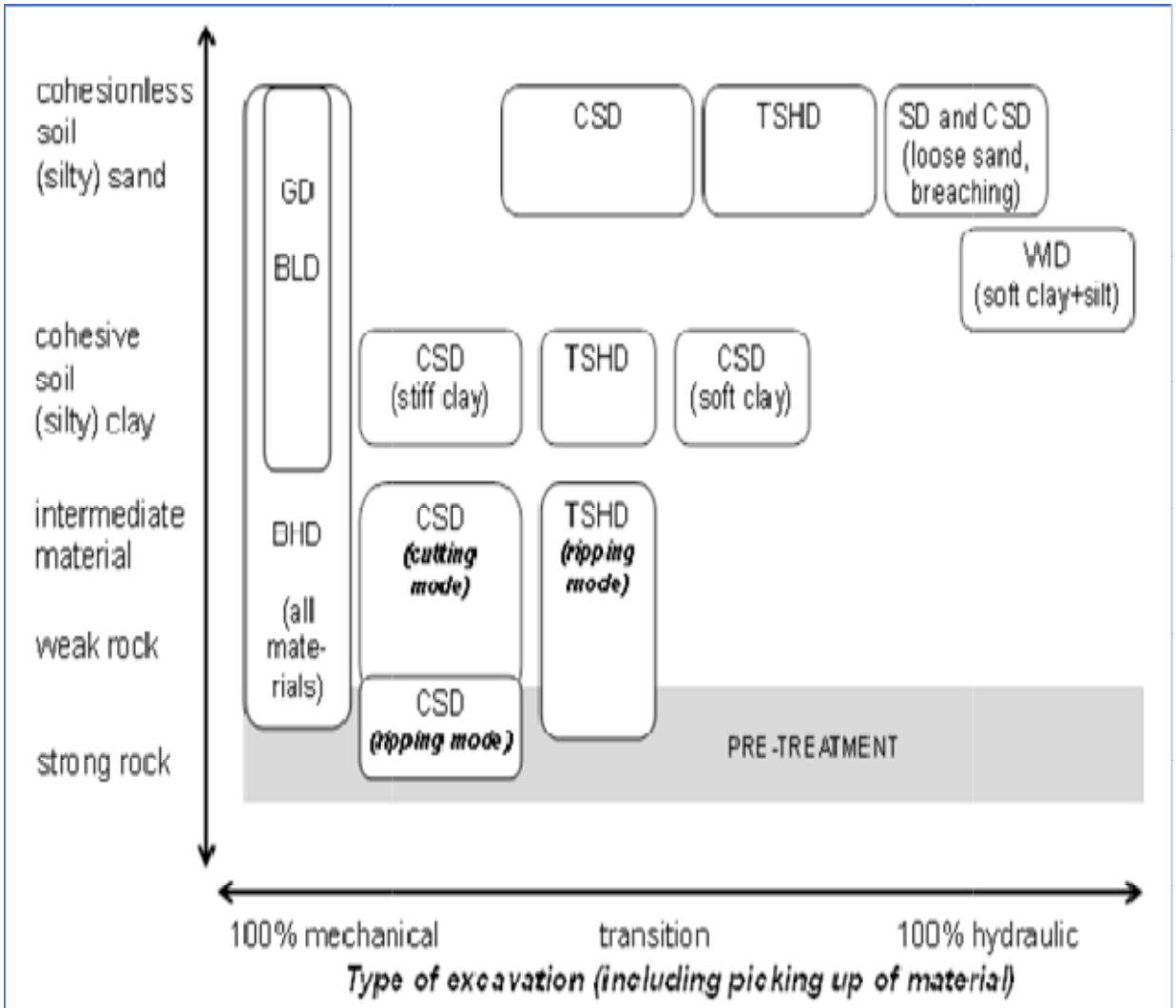


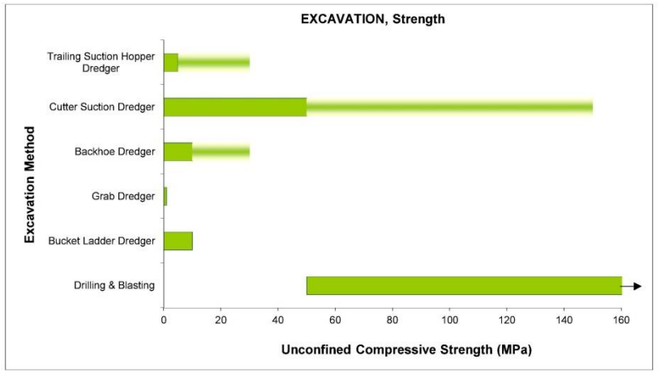
Figure C.1: Qualitative relationship between the nature of the dredging process (including the type of equipment) and the material to be dredged.

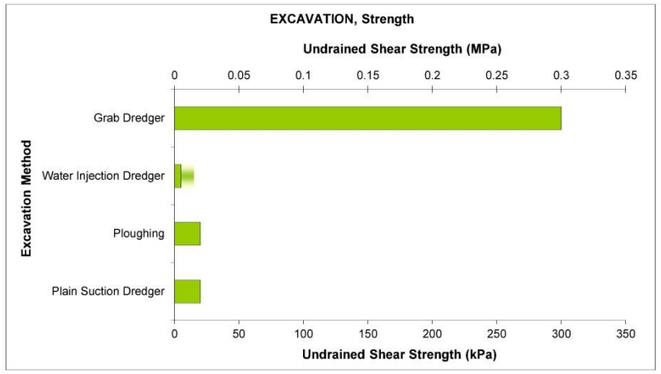
Figure 7.1 Guidance on Application of the Classification: Excavation

Excavation Method	Strength[o] (MPa) UCS* & c_u**		Comments
	General Practice	Less Frequently Used	
Trailing Suction Hopper Dredger	0 to 5 UCS	0 to 30 UCS	Values entered into the 'General Practice' column tend to apply to the cutting of 'massive rock' whilst those identified as 'Less Frequently Used' tend to apply to rock which is fractured or layered, with layer or block sizes smaller than the effective size of the cutting tool.
Cutter Suction Dredger	0 to 50 UCS	0 to 150 UCS	
Backhoe Dredger	0 to 10 UCS	0 to 30 UCS	
Grab Dredger	0 to 0.3 c_u & 0 to 1 UCS		
Water Injection Dredger	0 to 0.005 c_u	0.005 to 0.015 c_u	
Ploughing	0 to 0.02 c_u		
Plain Suction Dredger	0 to 0.02 c_u		
Bucket Ladder Dredger	0 to 10 UCS		
Drilling & Blasting	>50 UCS		

NB: Weathering can result in strength changes, thus the effects of weathering are incorporated when strength is considered here.

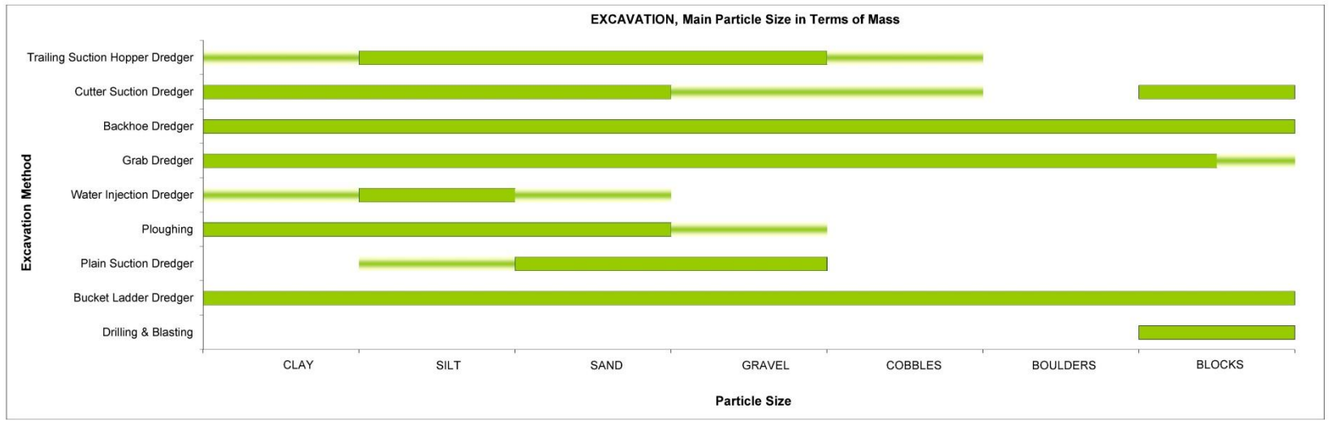
[o] Strength - The indicative strengths quoted are based on the ranges identified during the site investigation. The strength of material it is possible to dredge is dependent on the size of the plant, the reader is referred to the appendix of Chapter 4.
* UCS - Unconfined Compressive Strength
** c_u - Undrained Shear Strength





Excavation Method	Main Particle Size in Terms of Mass		Comments
	General Practice	Less Frequently Used	
Trailing Suction Hopper Dredger	Silt to Gravel	Clay & Cobbles	Maximum particle size that can be dredged will be influenced by suction pipe diameter and the apertures through the draghead and pump unless the dredging process breaks the particle down.
Cutter Suction Dredger	Clay to Sand & Blocks	Gravel & Cobbles	Caution - clay balls are problematic for pumping. Mixtures of particle sizes containing cobbles can be difficult to dredge.
Backhoe Dredger	Clay to Blocks		Ability to excavate large particle sizes can be limited by the size of the bucket and the lifting power of the machine.
Grab Dredger	Clay to Blocks	Blocks	Dependant on block size.
Water Injection Dredger	Silt	Clay & Sand	Only effective for clays close to their liquid limit and very fine or fine sands.
Ploughing	Clay to Sand	Gravel	
Plain Suction Dredger	Sand & Gravel	Silt	
Bucket Ladder Dredger	Clay to Blocks		
Drilling & Blasting	Blocks		

NB: Weathering, discontinuities and fractures can result in particle size changes, thus the effects of these factors are incorporated when particle size is considered here.



Excavation Method	Plasticity		Comments
	General Practice	Less Frequently Used	
Trailing Suction Hopper Dredger	Non Plastic	Plastic	Caution - Clay balls can block dragheads (stiff clays) and adherence of clay to metal surfaces of the dredger may cause problems during excavation.
Cutter Suction Dredger	Non Plastic & Plastic		Caution - Clay balls can cause blockages (stiff clays) and adherence of clay to metal surfaces of the dredger may cause problems during excavation.
Backhoe Dredger	Non Plastic & Plastic		The Adherence Potential of clays is related to Plasticity, a high Adherence Potential may result in clay sticking in buckets influencing their ability to be excavated.
Grab Dredger	Non Plastic & Plastic		The Adherence Potential of clays is related to Plasticity, a high Adherence Potential may result in clay sticking in grabs influencing their ability to be excavated.
Water Injection Dredger	Non Plastic	Plastic	Sediments with a small degree of plasticity can sometimes be dredged in this way.
Ploughing	Non Plastic	Plastic	The Adherence Potential of clays is related to Plasticity, a high Adherence Potential may result in clay sticking to ploughs influencing their ability to be excavated in this way.
Plain Suction Dredger	Non Plastic		
Bucket Ladder Dredger	Non Plastic & Plastic		The Adherence Potential of clays is related to Plasticity, a high Adherence Potential may result in clay sticking in buckets influencing their ability to be excavated.
Drilling & Blasting	N/A		Drilling and blasting is not appropriate for sediments.

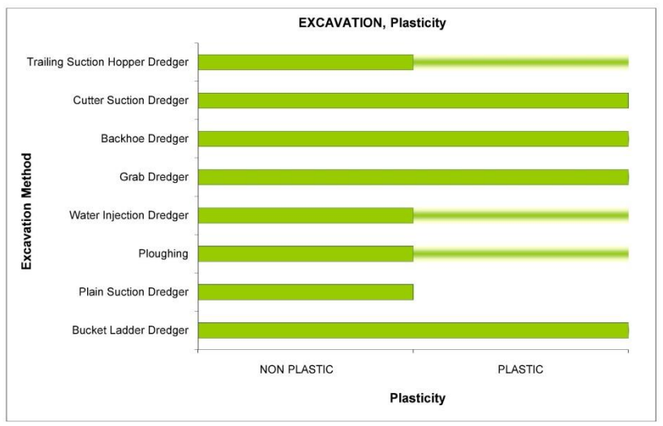
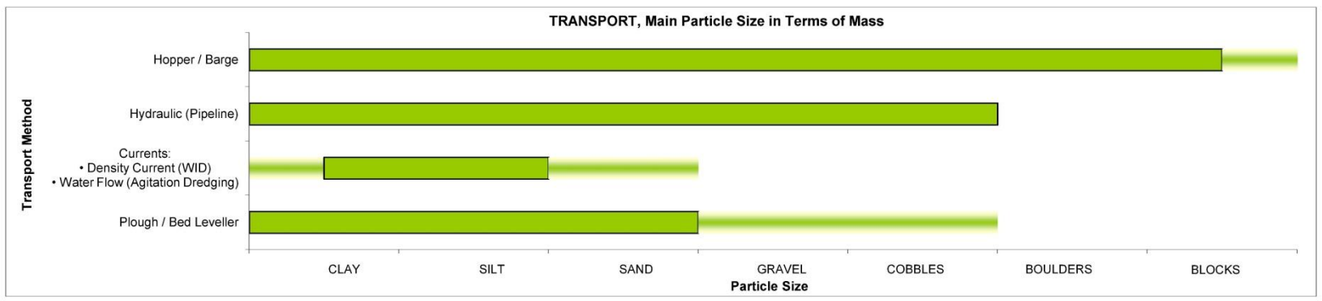


Figure 7.2 Guidance on Application of the Classification: Transport

Transport Method	Main Particle Size in Terms of Mass		Comments
	General Practice	Less Frequently Used	
Hopper / Barge	Clay to Blocks	Blocks	
Hydraulic (Pipeline)	Clay to Cobbles		The diameter of the pipeline can limit the maximum particle size unless the particles may be subject to breakage as a consequence of the dredging process.
Currents: • Density Current (WID) • Water Flow (Agitation Dredging)	Clay & Silt	Clay & Sand	Only effective for very fine and fine sands. Soft clay is general practice, while the technique is infrequently used for stiff clay. The method is best suited to use in soft cohesive silts.
Plough / Bed Leveller	Clay to Sand	Gravel & Cobbles	



Transport Method	Plasticity		Comments
	General Practice	Less Frequently Used	
Hopper / Barge	Non Plastic & Plastic		
Hydraulic (Pipeline)	Non Plastic & Plastic		Plastic material may form clay balls and may cause pipe blockages - tends to be stiff clays, plasticity may affect the power needed for pumping.
Currents: • Density Current (WID) • Water Flow (Agitation Dredging)	Non Plastic	Plastic	Sediments with a small degree of plasticity can sometimes be transported in this way.
Plough / Bed Leveller	Non Plastic	Plastic	Sediments with a small degree of plasticity can sometimes be transported in this way.

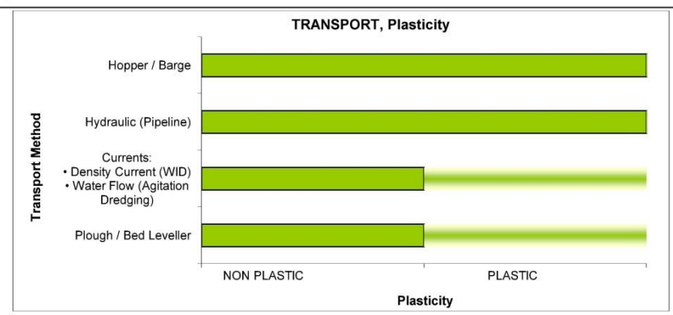
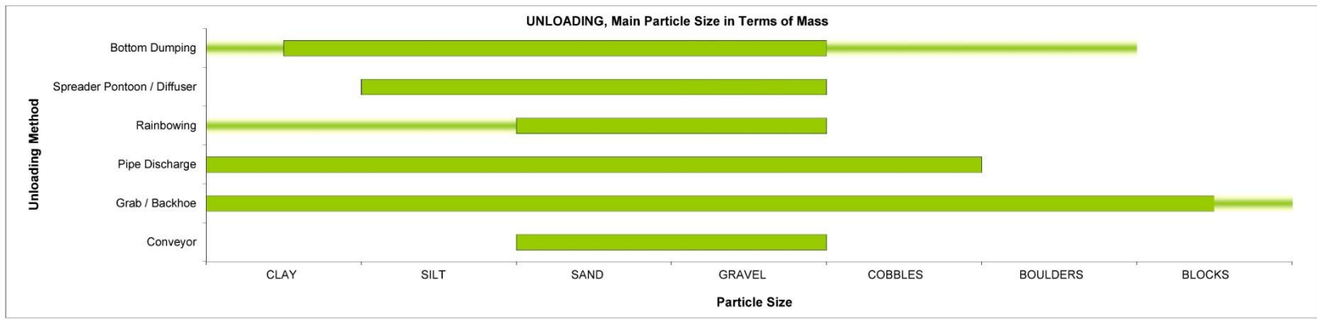


Figure 7.3 Guidance on Application of the Classification: Unloading

Unloading Method	Main Particle Size in Terms of Mass		Comments
	General Practice	Less Frequently Used	
Bottom Dumping	Clay to Gravel	Clay, Cobbles & Boulders	Materials lighter than water cannot be bottom dumped (e.g. some peats and organic soils). Soft clay is general practice whereas stiff clay is less frequent and can be problematic.
Spreader Pontoon / Diffuser	Silt to Gravel		
Rainbowing	Sand & Gravel	Clay & Silt	
Pipe Discharge	Clay to Cobbles		
Grab / Backhoe	Clay to Blocks	Blocks	
Conveyor	Sand & Gravel		



Unloading Method	Plasticity		Comments
	General Practice	Less Frequently Used	
Bottom Dumping	Non Plastic	Plastic	Caution - Adherence Potential of clay is related to Plasticity and may be of considerable importance when considering unloading material, the clay may for example stick to hopper surfaces.
Spreader Pontoon / Diffuser	Non Plastic		
Rainbowing	Non Plastic		
Pipe Discharge	Non Plastic & Plastic		
Grab / Backhoe	Non Plastic & Plastic		Caution - Adherence Potential of clay is related to Plasticity and may be of considerable importance when considering unloading material, the clay may stick to surfaces of buckets / grabs.
Conveyor	Non Plastic