Navigation and Dredging
Navigation waterways

Channel improvement for navigation is justified on the basis of savings in commercial shipping costs.

The reduced cost of moving commodities by means of waterways instead of other modes of transportation is compared with the costs of construction, operation, and maintenance.
Navigation requirements

- General requirements for channel depth, channel width, and lock dimensions for commercial navigation are governed by a number of factors, including type and volume of probable future tonnage, types and sizes of vessels, and tows in general use on connecting waterways.

- Three barge types are common: (1) open-hopper barges for transporting coal, sand and gravel, and sulfur; (2) covered-hopper barges for grain and mixed cargo; and (3) tank barges for petroleum and chemicals (figure below).

- Barge sizes vary around a standard 35 ft (10.7 m) in width and 195 ft (60 m) in length.
Pilots navigate towboats at the stern of the tow with control of the engine thrust and direction of the rudder.

The navigation width depends on channel alignment, size of tow, and whether one-way or two-way traffic is planned.

One-way traffic may be adequate when the traffic is light if the reach is relatively straight with good visibility and if passing lanes are provided.

Two-way traffic permits heavy traffic to move faster except when tows are meeting or passing.

Figure below shows the recommended channel widths for commercial navigation in straight channels.
<table>
<thead>
<tr>
<th>Type</th>
<th>Length (ft)</th>
<th>Breadth (ft)</th>
<th>Draft (ft)</th>
<th>Capacity (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open hopper barges</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>175</td>
<td>26</td>
<td>9</td>
<td>1000</td>
</tr>
<tr>
<td>Jumbo</td>
<td>195</td>
<td>35</td>
<td>9</td>
<td>1500</td>
</tr>
<tr>
<td>Super jumbo</td>
<td>250-290</td>
<td>40-52</td>
<td>9</td>
<td>2500-3000</td>
</tr>
<tr>
<td>Covered hopper barges</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>175</td>
<td>26</td>
<td>9</td>
<td>1000</td>
</tr>
<tr>
<td>Jumbo</td>
<td>195</td>
<td>35</td>
<td>9</td>
<td>1500</td>
</tr>
<tr>
<td>Integrated chemical and petroleum barges</td>
<td>150-300</td>
<td>50-54</td>
<td>9</td>
<td>1900-3000</td>
</tr>
<tr>
<td>Towboats</td>
<td>65-160</td>
<td>24-50</td>
<td>5-9</td>
<td>300-7000 hp</td>
</tr>
</tbody>
</table>

Note: 1 m = 3.28 ft; 1 ton = 2000 lb = 8.96 kN

Figure 9.19. Barge types (after Petersen, 1986).
One-way traffic:

Two-way traffic:
Dredging

Dredging is the process of removing material from the bed or the banks of a waterway for the purpose of deepening or widening navigation channels or to obtain fill material for land development.

Dredging is a very costly operation that requires heavy equipment and long pipelines.

Dredging equipment can be classified as either mechanical or hydraulic.

Mechanical dredges lift the dredged material by means of diggers or buckets.

Hydraulic dredges pick up the dredged material by means of suction pipes and pumps.
Purposes of dredging

- To maintain the depth in existing ports, harbours and channels to provide ready and safe passage for commercial and recreational vessels.
- To create new or deeper access or berths for vessels. This may mean the deepening and widening of channels and anchorages as well as the excavation of basins and marinas from areas of previously dry land.
- To provide material for specific purposes, eg. Beaches in coastal areas subject to erosion are sometimes ‘renourished’ with sand dredged from other areas.
- To bypass an artificial structure, such as a breakwater, that is an obstacle to the normal pattern of sediment movement along the coast.
- Dredging prevents a build up of material to be deposited down stream of the obstacle to allow the natural sediment transport process to occur.
- To place a structure inside water bodies.
Dredging procedure:

Dredging procedure can be classified as: Pretreatment, Extraction and Disposal

**Pretreatment:**
- Pretreatment means treatment of the ground before the dredging operations.
- It usually consists of a separate operation carried out independently of other dredging.
- There are two basic methods of pretreatment: chemical and mechanical and both are applied to rock or cemented soil.

**Extraction:**
- The extraction process involves the movement of the spoil from its natural pretreated position into vertical transportation and its delivery to the transport system.
- Extraction processes are often a combination of at least two operations: the primary operation which disintegrates or dislodges the soil and the secondary operation which moves it.
- The first of these operations is performed either mechanically or hydraulically.

**Disposal:**
Disposal facilities are consist of bottom discharge, grab, scrapers, pipelines, land based unit, natural processes.
TYPES OF DREDGING:

Dredging can be classified as:

1. Mechanical Dredging
2. Hydraulic Dredging

**Mechanical Dredging:**

- Mechanical dredging involves removal of material by a bucket, placement of the material in a scow or on a barge, and towing that scow or barge to a disposal or transfer area.

Figure: Aerial view of Mechanical Dredging
Fig: Dredged materials being transported to disposal area

Fig: Dredged materials being disposed
Hydraulic Dredging

- Hydraulic pipeline dredging involves use of a hydraulic (suction) dredge, most commonly for either beach nourishment of suitable sands, or deposit into an upland containment area (for dewatering or direct disposal).
- Hydraulic dredging provides the cleanest and least obtrusive method for sediment removal without damaging the sensitive environment.
- Typically the dredge uses a cutter head on the end of the suction arm to loosen the material while the dredge pump suctions the loosened material through the arm to the pump in a slurry of about 75 to 90 percent water and 10 to 25 percent sediment.
- The slurry is pumped through a pipeline to a disposal site or dewatering/transfer area.
- A hydraulic dredge floats on the water and excavates and pumps the material through a temporary pipeline to an offsite location, often several thousand feet away.
- This dredge acts like a floating vacuum cleaner that can remove sediment very precisely.
Fig: hydraulic dredging
Fig: Dredge is dropped into the water using a crane
Fig: Aerial view of barge with hydraulic dredging equipment removing ash from the navigation channel
Fig: Ash and water are pumped through this pipeline

Fig: Relay pump in the middle of the pipeline
Fig: Ash and water discharge into holding area. Sediment can then be de-watered and either replanted or trucked off location.
Types of Dredgers

According to dredging types, dredgers are divided mainly into two kinds:

1. Mechanical Dredgers
2. Hydraulic Dredgers

- In Mechanical Dredgers, material is conveyed by mechanical contravences, whereas, in the Hydraulic Dredgers, it is conveyed by water through pipes.
- They are further classified under various principal types, depending on their mode of operation.
Mechanical Dredgers

(i) Bucket or Grab Dredger:

- It is essentially a stiff-leg derrick on a floating platform.
- By means of a derrick arrangement it lowers an open grab bucket onto the material, fills it there and lifts it.
- The material is either deposited alongside the channel, or dumped in barges or in hoppers provided on the dredger.
- Mechanical dredgers work best in consolidated or hard packed materials and can be used to clear rocks and debris.
- The advantage of the bucket dredger lies in its ability to work in small areas inaccessible to other types of dredgers.
- It is efficient in homogeneous materials, particularly in stiff mud.
- The digging power of the bucket depends on its weight and its effect is diminished by the lifting tendency of the closing wire.
- It does not have sufficient penetration power to obtain a full load in harder material, compacted sand, gravel and clay.
- Sometimes, the bucket spins twisting the opening and closing wires; the operation is stopped till they are straightened out, resulting in much loss of time.
(b) Bucket dredge

Washing of the fines C = 1000 ppm
A Grab Dredger is a stationary dredger, moored on anchors or on spud-poles. The dredging tool is a grab normally consisting of two half-shells operated by wires or (electro)-hydraulically. The grab can be mounted on a dragline or on a hydraulic excavator of the backhoe type.
(ii) Dipper dredger:
- The dredger consists of a floating power shovel, and except for the digging equipment, it is same a bucket dredger.
- It should be used only if the material is resistant such as soft rock, boulders’ material consisting of timber etc.
- Its unit cost of dredging is higher than for other dredgers.
(a) Dipper dredge

Washing of the fines $C = 1000$ ppm
(iii) Ladder dredger:

- This consists of buckets attached at each end of the frame.
- It is suitable to excavate cohesive materials.
- These dredgers are used even with self-contained hoppers. When hoppers are not provided, scows (flat-bottom boats) are required to dispose of dredged materials.
- In river and harbors works, this dredger is suitable for digging stiff, hard and non-homogeneous materials; loose sand and soft mud tend to wash out of the buckets reducing its efficiency for these materials.
- This dredger is extensively used in Europe and in the Suez Canal.
(iv) Hopper Dredger:

(v) Rock Dredger:
HYDRAULIC DREDGERS

(i) Plain Suction Dredger:

- This is the simplest hydraulic floating dredger with a centrifugal pump and auxiliary equipment mounted in the hull.
- The size and type of the hull depends on the size of the pump used and the amount of power needed to operate the equipment.
- The size of the dredger is generally described by the diameter of the discharge pipe, which ranges from 15.2 to 76.2cm (6 to 30inch).
(ii) Cutter Head Dredger:
• It is similar to the suction dredger, except that it has a rotary cutter head which carves clay, breaks off chunks of softer rocks such as coral and shale, and stirs up gravel and sand so that pipe carries material to its capacity.
• This dredger is being suitable for channel work, cut-offs, new construction, harbor excavation and making fills.
(c) Cutterhead dredge

- Gantry
- Pump
- Hoist
- H frame
- A frame
- Discharge line
- Spud
- Suction line
- Ladder
- Cutterhead basket
- Closed-nose basket
- Open-nose basket

C ≈ 10 000 ppm
A Cutter Suction Dredger is a stationary dredger which makes use of a cutter head to loosen the material to be dredged. It pumps the dredged material via a pipeline ashore or into barges. The cutter head can be replaced by several kinds of suction heads for special purposes, such as environmental dredging.
(iii) Dust-pan Hydraulic Dredger:

- These dredgers are similar to the cutter head pipe line dredge except that in the former horizontally spread suction heads, similar to a dust-pan or a vacuum cleaner nozzle, are employed.
- Instead of a rotary cutter, high velocity water jets are mounted in the suction head to loosen the material.
- The suction head may be as wide as 9.7 m. (32 ft.) and is provided with nozzles, through which water is pumped at 1.8 kg./sq. cm. (25 lb./sq. in.) to agitate the material so that it can be more easily picked up.
- This dredger is commonly used on the Mississippi River for the maintenance of navigation channels.
(iv) Hopper Dredger Hydraulic Type:

- It is equipped to operate as an anchorless hydraulic dredger for transporting and dumping the excavated material without the assistance of auxiliary plant such as tugs, barges, etc.
- This dredger is capable of operating in rough water where pipe line dredgers are unsatisfactory because of the breaking of the pipe line.
- It is particularly suitable in busy and crowded harbors, whereas pipe line dredgers, with their long anchor cables and pipe lines, occupy much space and are slow, impeding harbor traffic.
- The principal elements of the hopper dredger are the pump, the drag hoist and hopper bins.
A Trailing Suction Hopper Dredger is a self-propelled ship which fills its hold or hopper during dredging, while following a pre-set track.
The hopper can be emptied by opening bottom doors, offloading by pumping its load off ashore.
This kind of dredger is mainly used in open water: rivers, canals, and the open sea.
Trailing suction hopper dredgers, commonly known simply as ‘hoppers’ or ‘trailers’.
IMPACTS OF DREDGING

☐ Dredging activities have the potential to change the environment.

☐ At the sites of dredging and disposal the seabed and associated communities are disturbed and for some distance, suspended sediment may cause turbidity in water and increased sedimentation on the bottom.

☐ Depending upon the nature of the dredged material, its disturbance from the sea bed may lead to changes in the chemical composition of the water.

☐ As well as toxicants, the nutrient elements, particularly nitrogen and phosphorus, which control the rate of marine plant growth, can also be released from sediments during dredging, with a risk of triggering algal blooms.

☐ Another biological risk from dredging involves the transport of species in dredgers from one port (or even country) to another.
The activity of dredging can create the following principal impacts to the environment:

1. Collection of heavy metals lead left by fishing, bullets, 98% mercury reclaimed [natural occurring and left over from gold rush era].
2. Short term increases in turbidity, which can affect aquatic species metabolism and interfere with spawning. Suction dredging activity is allowed only during non-spawning time frames set by fish and game (in-water work periods).
3. Secondary impacts to marsh productivity from sedimentation.
4. Tertiary impacts to avifauna which may prey upon contaminated aquatic organisms.
5. Secondary impacts to aquatic and benthic organisms' metabolism and mortality.
6. Possible contamination of dredge spoils sites.
7. Changes to the topography by the creation of "spoil islands" from the accumulated spoil.
8. Releases toxic compound Tributyltin, a popular biocide used in anti-fouling paint banned in 2008, back into the water.
Some Impacts of Dredging

1. Dredge boat
2. Erosive wave action
3. Contaminants
4. Resuspension
5. Mangrove seedling

- Changes in tidal area and height
- Nutrient cycling
- Food web
- Potential loss
MORPHOLOGICAL AND HYDRAULIC RESPONSE DUE TO DREDGING

- Dredging affects the morphological and hydraulic behavior of a channel section.
- Due to initial deepening or capital dredging of a channel, the river bed is degraded until the balance between the sediment load supplied to the river reach and the sediment transport capacity of the flow is restored.
- In the long term the result will be degradation to a more gentler slope and a greater depth downstream of the point of dredging.
- Degradation will also occur in upstream which leads to lowering of river bed with initial slope.
Dredging in Bangladesh

Two types of dredging are conducted in Bangladesh:

- Capital Dredging (Example: Gorai River Project by BWDB)
- Maintenance Dredging (Example: Paturia and Daulatdia Ferry Ghats by BIWTA)
Fig: aerial view of the cutter suction dredger at work in Gorai river project
According to a Rabobank outlook report in 2013, the largest dredging companies in the world are in order of size-

1. **China Harbors Engineering (China).**
2. Jan De Null (Belgium).
3. DEME (Belgium).
5. Van Ord Dredging and Marine Contractors (Netherlands).
6. **Dredging Corporation of India Limited** (Vishakapatnam, India).
Monitoring the **Performance of Capital Dredging** and Assessment of **Effectiveness of Dredging** in the Pussur River from **Mongla Port** to **Rampal Power Plant**
Multi beam echo sounder was used to obtain the depth data under study. One of the greatest benefits of using multi beam echo sounder is that it gives full bottom coverage of the water body, thereby providing a much accurate knowledge of the seafloor making it possible to detect all objects beneath the water and area not to be dredged will be clearly identified.