# 14. Evaluate Sedimentation and Littoral Processes

Sedimentation is a primary concern when designing a harbor. If the basin or entrance channel traps sediment, there can be significant maintenance costs. It is equally important that the project not interrupt the natural long shore sediment processes. Sediment trapped or diverted to deep water may cause erosion of the structure or adjacent shorelines. For structures in shallow water, the depth of sediment at the toe may determine the height of the design wave.

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## 14.10 Sources

Whenever selecting a site for a harbor, you must be aware of all the potential sources of sediment such as rivers, cliffs or offshore bars, or adjacent shorelines. Sediment transported from a source will eventually settle out. The low-energy environment within a marina basin can be a perfect place for this to happen.

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**SOURCE that should be considered include:**

| | | |
|---|---|---|
| **1)** | Rivers/Streams | See 14.11 |
| **2)** | Cliff Erosion | See 14.12 |
| **3)** | Offshore Bars | See 14.13 |
| **4)** | Adjacent Shorelines | |

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**Note 1.** Seldom can you avoid all these sources. The key is to evaluate and manage the sources to the advantage of the project.

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**REFERENCES:**

1. U.S. Army Corps of Engineers, Dept. of the Army. *Shore Protection Manual.* 1984. CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1. Pg.4-22,115,117.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.11 Rivers/Streams (Source)*

Rivers are one of the primary sources of sediment. Identify the sediment load in rivers and streams near a harbor. The equilibrium established between river deposition and wave erosion often define the amount of sediment remaining on the coastline.

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**Weigh RIVER deposit adding to sedimentation if:**

**1)** The proposed harbor site is downdrift, i.e. in the major direction of sediment transport, of the river mouth

**2)** Existing harbor is located near a river or a river empties into the harbor basin

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**Note 1.** High incidence of flooding from a river may contribute more sediment than assumed from normal flow conditions.

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**REFERENCES:**

1. U.S. Army Corps of Engineers, Dept. of the Army. *Shore Protection Manual.* 1984. CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1. Pg.4-22,115,117.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.12 Cliff or Beach Erosion (Source)*

Cliff erosion can be a major sediment contributor. All coastline erosion upstream of the harbor with respect to the dominant wave or current direction is a sediment source. Erosion of cliffs from an area upstream can be the source of deposits for downdrift areas.

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**Consider CLIFF or beach erosion when:**

**1)** The eroding coastline is "upstream" from the harbor site
**2)** Accounting for the whole sediment budget

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**Note 1.** An eroding coastline can be a source for many miles upstream of the project. An aerial photograph may show possible sources for sedimentation more clearly. An on-site visual inspection (fly-by) is also recommended.

**Note 2.** If the toe of a cliff has rock falls or loose sediments within the run-up zone, it is probably an active source. The toe of a cliff fronted by a berm and vegetation is probably not an active source.

**Note 3.** If the cliff face has a similar composition of materials as the beach material, it is probably a source for the littoral zone. If the material is composed of finer sands, silts, and clay, it is probably deposited offshore in deep water.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. Pg. 4-117.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.13 Offshore Bars (Source)*

On relatively flat sand or gravel beaches, it is common for sediment to move offshore during periods of high-wave energy (storms) and onshore during periods of lower wave energy. Consider the time of year and recent history of major storms when documenting beach profiles.

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**Consider OFFSHORE BARS for sedimentation when:**

**1)** Estimating the sediment budget
**2)** Offshore profile contains materials that contribute to the sediment budget

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**Note 1.** The sediment supplied by offshore bars is usually found in areas just outside the breaker zone .

**Note 2.** Any beach with a typical bar-trough profile will typically move sediment on and off shore.

**Note 3.** Any beach which typically has a lower elevation and coarser material during the winter and a higher elevation of finer sands during the summer will be moving material on and offshore.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office, Vol.1. Pg. 4-118,119.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## 14.20 Sinks

Littoral processes eventually deposit material in sediment sinks. These may consist of low-energy zones such as boat harbors, tidal lagoons, or deep water offshore, or as natural barriers such as breakwaters, jetties, or headlands. The sediment budget is calculated by accounting for the quantity of sediment moved from a source to a sink. If the harbor becomes a sediment sink, costs associated with dredging and maintaining of the harbor are increased.

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**Consider SINKS that include:**

| | | |
|---|---|---|
| **1)** | Inlets/lagoons | See 14.21 |
| **2)** | Headlands | See 14.22 |
| **3)** | Offshore slopes | See 14.23 |
| **4)** | Spits | See 14.24 |
| **5)** | Submarine canyons | |
| **6)** | Mining and dredging | |

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**Note 1.** In channels where shoaling is substantial, you may consider over-dredging for extending the interval for maintenance dredging

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-120,124.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.54,57 & 63-85, 78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.21 Inlets/Lagoons (Sink)*

Tidal flow and wave action into lagoons or inlets can move sediments from a high-energy coastal environment to a lower-energy environment. Small boat harbors have similar characteristics as natural tidal lagoons and, if not properly designed, may trap large quantities of sediments.

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**INLETS AND LAGOONS may be a factor for sediment if:**

**1)** They're adjacent and upstream of the project, in which case, they may trap sediment that may otherwise be transported into the basin

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**Note 1.** A sediment "cell" is defined as the zone of sediment movement between sources and sinks. Constructing a harbor within a sediment cell, if necessary, is done with caution and careful attention to details that affect the sediment budget.

**Note 2.** Compare aerial photographs, taken over time, for changes in quantity of trapped sediment.

**Note 3.** It is always best to situate harbors downstream from sediment sinks and upstream from sediment sources.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-120,124.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 51,54,57.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.22 Headlands (Sink)*

Eroding headlands are generally a source of sediments. They can also become sinks when they trap sediment, or divert it to deep waters. Sediments are eroded or deposited depending on the currents, wave conditions, and depths around the headland. The rate of deposition may be difficult to quantify and may account for a small percentage of the sediment budget.

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**HEADLANDS may be a concern as a sink for sediment when:**

**1)** The proposed harbor site is adjacent to a headland that actively traps sediments between a source and a sink.

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**Note 1.** Aerial photographs and charts can be useful tools in determining whether a headland is source or sink.

**Note 2.** Headlands may provide natural wave protection when designing a harbor. If the same headland is a sediment sink, it will be necessary to construct a jetty to trap the sediment with the harbor entrance between the jetty and headland.

**Note 3.** Jetties, as artificial headlands (sinks), trap sediment before it can enter a harbor basin. These may tend to fill, requiring periodic bypassing.

**Note 4.** Whenever a project creates a sediment sink, it is important to be aware of potential erosion to downstream shorelines.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-120,129.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 51,54,57.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.23 Offshore Slopes (Sink)*

Sediments deposited offshore may be an important factor in the littoral process. Storm activity, gravity, and mixing of the surf zone and water offshore are the main transport mechanisms. Surveys to calculate the amount of sediment lost can be costly and difficult to attain.

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**OFFSHORE SLOPES may be a concern as a sink for harbor site when:**

**1)** The proposed site is downstream of a steep offshore slope or canyon. This will usually be beneficial for reducing the amount of available sediment that may enter the basin

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**Note 1.** Deep-water spits that form in the longshore direction may indicate an offshore loss of sediment.

**Note 2.** Recent theories have identified steep offshore slopes created as sediment sinks as sources of potential sub-marine slides, which may result in tsunamis.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-120,129.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 51,54,57.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.24 Spits (Sink)*

Spits form by the longshore transportation and deposition of sediments. When sediments reach the end of the spit, they are deposited into deep water. Spits will continue to grow until the source of sediments is cut off or they restrict the opening to an inland water body. When a spit begins to close an inner body of water, the tidal velocities will adjust the opening to an equilibrium cross section. A proposed site can use natural littoral processes by locating the harbor entrance on the leeward side.

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**SPITS may be a source of concern for sedimentation if:**

**1)** The proposed harbor entrance channel is on the dynamic side of the spit

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**Note 1.** Aerial photographs can be useful in defining sediment sources that feed a spit.

**Note 2.** A channel constructed through an active spit will require a jetty to trap sediments or divert them to deep water. Material between the entrance and terminal end of the spit will be subject to erosion.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-120,129.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 51,54,57.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## 14.30 Transport Mechanisms

### *14.31 Waves (Transport Mechanism)*

Waves are the primary energy source moving sediments along exposed shorelines. Most movement of finer materials is just inside the breaker zone. Coarser beach material is moved in the swash, or wave run-up zone. The direction of transport will depend on the waves longshore component of the angle of incidence. Waves perpendicular to the shoreline will move sediments on and offshore.

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**Always consider WAVES for sediment transport:**

**1)** Some waves deposit and erode coastline sediments at the same rate, resulting in no net change.

**2)** The quantity of material transported depends mostly on beach composition, wave height and angle of incidence to the shoreline.

**3)** Sedimentation will be significant if a project is adjacent to mildly sloping sandy beaches. Sediment transport will be negligible if steep rocky materials border the project. Or the project is downstream from a sediment sink.

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**Note 1.** The direction of transport by waves may be seasonal, with one direction during the summer and another during the winter.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol.1. 4-89,107.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.54, 57.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.32 Currents (Transport Mechanism)*

Currents are the primary source of sediment transport in rivers. They may also be a strong factor in shallow estuaries exposed to high tidal ranges. Wave-induced currents also contribute to sediment transport.

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**CURRENTS may be a factor for sediment transport if:**

**1)** The proposed harbor site is downdrift, i.e. in the major direction of sediment transport, or within direct influence of a river

**2)** Coastline is irregular, and the harbor site is near the mouth of an inlet or a shallow estuary

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**Note 1.** Currents mainly carry suspended sediments. They rarely have enough force to lift bedload (large particles that move along the bottom).

**Note 2.** Include accounting for tide-induced currents and all other mechanisms in the calculation of longshore sediment transport, where applicable.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1. Chapter 4. Pg. 126-129.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## *14.33 Winds (Transport Mechanism)*

The transport of sediments in areas that have long expanses of beach and are susceptible to high winds can be significant. Often , winds carry sand in the longshore direction and deposit it in the water offshore. With onshore winds the sand may be carried inland and deposited in dunes. Contributions of sediment from winds need to be determined for the sediment budget.

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**Consider WINDS as a transport mechanism if:**

**1)** The proposed harbor site is in an area with wide sandy beaches and strong winds.

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**Note 1.** Wind is seldom a significant contributor to the sediment budget.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1. Chapter 4. Pg. 126-129.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.78-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.

## 14.40 Estimate Sediment Budget

The sediment budget is a valuable tool for estimating potential problems from sedimentation. Using a nautical chart, aerial photographs, and other similar references, draw a boundary around the project area. Then, draw arrows pointing in or out of the circle depending on the expected flow of sediment based on existing reports, observations, bathymetry, etc. Vary the size of the arrow to reflect the significance of a source or sink, i.e. the larger the arrow, the greater its contribution of sediment.

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**Analyze SEDIMENT BUDGET when:**

**1)** There are more or larger arrows pointing into the control area than pointing out; your project has become a sediment sink and you may have a maintenance-dredging problem

**2)** There are more or larger arrows pointing out of the control area than pointing in; your project has become a sediment source and you may have an erosion problem

**3)** There are large arrows pointing in and out of the control area; this implies a dynamic situation that will require special attention

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**Note 1.** All sources, sinks and convective processes contribute to sedimentation. Examples of sources are erosion of cliffs, beaches, and river sediments. Sinks may include inlets, lagoons, deep-water depressions, and headlands. Convective processes are waves, tidal flows, wave-induced currents, and winds.

**Note 2.** A sediment budget may be difficult to quantify, however, it can still be a valuable tool for simply identifying all the potential sources and sinks with an "order of magnitude" approximation of quantities.

**Note 3.** Develop before-and-after sediment budgets for a proposed project. If they are significantly different, it may identify a problem of erosion or deposition.

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**REFERENCES:**

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* CERC, Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1 Pg. 4-128.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.76-85.
3. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 173-199, 219-225, 359-360.