10. Identify Water Level Variations

You must determine all water level variations within the harbor environment. You must consider short-term events, such as waves and tides, as well as long-term events such as sea level rise. We recommend a probability to determine which events are likely to occur simultaneously, such as storm surge and extreme wave events. You should also analyze statistically independent events such as astronomical tides and extreme waves.

10.10 Astronomical Tides

Combined high tides and large waves can damage breakwaters, revetments, and other coastal structures due to runup and overtopping. Low tides and storm conditions will usually govern the design depth of navigation channels. Performance of some protective structures, such as curtain wall wave barriers, will decrease for low tide conditions.

Use ASTRONOMICAL TIDE data when:

1) Considering the design criteria for flushing and circulation based on tidal prism.
2) Calculating the entrance channel and moorage basin depths for proposed sites.
3) Optimizing a harbor layout for minimum dredging.
4) Determining elevations for the breakwater or revetment crest and adjacent uplands.
5) Determining the lower extent of breakwater armor.

Note 1. It is critical to correctly identify the tidal datum such as Mean Lower Low Water (MLLW).

Note 2. Based on probability of occurrence, it is not usually necessary to combine the highest astronomical tides with extreme wave events. Similarly, when calculating the design wave, it may not be necessary to use the highest wave and highest tide together.

REFERENCES:

1. ASCE Manual No. 50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 103-110.
2. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 144-157.
3. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. U.S. Government Printing Office. Pg. 3-88, 3-93National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA).

10.20 Tidal Data

Design elevations are determined using tidal data. All vertical elements of a project are referenced to a specific datum, typically mean lower low water (MLLW). It is **critical** to use the same datum throughout project calculations. Tidal data can be found in references such as the *Tide Tables* published by the U.S. National Ocean Survey (NOS), National Oceanic and Atmospheric Administration (NOAA).

You may include TIDAL DATA such as:

1) Mean Lower Low Water **(MLLW)**: (U.S. Pacific coast) Average for the lower low water over a 19-year period, a.k.a. metonic cycle.
2) Mean Higher High Water **(MHHW)**: Average height of the higher high water over a 19-year period.
3) Mean High Water **(MHW)**: The average height of high water over a 19-year period.
4) Mean Low Water **(MLW)**: The average height of low water over a 19-year period.
5) Mean Sea Level **(MSL)**: Average height of the surface of the sea for all tides over a 19-year period. This may not be equal to MEAN TIDE LEVEL.
6) National Geodetic Vertical Datum **(NGVD)** 1929: A fixed reference point used for surveying elevations.
7) North American Vertical Datum **(NAVD)** 1988: A fixed reference for elevations determined by goedetic leveling. It is the latest adjustment to NGVD (1929) used as a reference point.

Note 1. You should complete hydrographic surveys at **high tide** to maximize coverage and provide overlap with upland surveys. In the survey, include rocks and reefs that are exposed at low tide.

REFERENCES:

1. ASCE Manual No. 50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 103-110.
2. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 144-157.
3. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. Vol. 1. Pg. 3-88, 3-93, Appendix A-10, A-20 & 21.
4. National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA). 1988. Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska.

10.30 Storm Surges

During storm conditions, low pressure combined with high winds can result in a phenomenon called a storm surge. Storm surge is most evident in large shallow bodies of water

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Consider STORM SURGE height when:

1) The project is in an area that has a history of storm surges.
2) Water elevation is critical to the design of the structure, primarily breakwater crest and adjacent uplands.
3) Water elevation determines the height of depth-limited design waves.

Note 1. Storm surges usually occur in the fall on coasts of the Bering Sea from Bristol Bay to the Bering Strait, and in Kotzebue Sound, the Chukchi Sea, and the Beaufort Sea.

Note 2. Unlike tides, there is a high probability that extreme storm surges and extreme waves will occur at the same time.

Note 3. Storm surge can be negative, creating low water that can ground ships. There have also been documented cases of a positive storm surge resulting from the rebound of a negative surge.

REFERENCES:

1. Arctic Environmental Information and Data Center, University of Alaska. 1988. *Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska.* Anchorage, Alaska. Vol. 1, 2, & 3.

2. Wise, J.L. et.al. 1981. *Storm Surge Climatology and Forecasting in Alaska.* Arctic Environmental Information and Data Center. Anchorage, Alaska.

3. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. U.S. Government Printing Office. Vol. 1 & 2.

10.40 Sea Level Changes

Coastal engineers generally agree that there is a global sea level rise of about one foot every one hundred years. This prediction is uncertain, but a prudent design of structures with a long design life will address this issue.

Consider SEA LEVEL changes when:

1) High water and potential overtopping have a potential for causing damage.
2) The structure has a design life that may extend over 100 years. This would include most major rubble mound breakwaters.

Note 1. In Alaska, you should check surveys done before 1964 for accuracy. You must verify the survey elevations, including survey markers.

10.50 Wave Setup

A rise of the water surface can occur near shore in the breaker zone due to onshore mass transport of water. You should factor wave setup into the design in a manner similar to surge.

Consider WAVE SETUP when:

1) Designing a structure parallel to a shoreline, fronted by a mildly sloping beach, and exposed to depth-limited breaking waves.
2) The harbor entrance is exposed to breaking waves (usually in remote, exposed locations). This condition, if the wave setup is unsteady, may result in a phenomenon known as surf beat.
3) The offshore profile includes bars and troughs.

Note 1. Wave setup can result in longshore currents and offshore rip currents. These can be a factor in balancing the project sediment budget (Sect 14.00).

REFERENCES:

1. CIRIA Special Publication 83. CUR Report 154. 1991. *Manual on the Use of Rock in Coastal and Shoreline Engineering.* Balkema, A.A.: Rotterdam/Brookfield. Pg. 190-191.

2. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. Vol. 1 Pg. 3-88 to 89, 3-99 to 109.

3. ASCE Manual No. 50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 105.

10.60 Seiches

A seiche is the oscillation of a standing wave in an enclosed body of water. In large basins such as lakes or bays, atmospheric pressure, wind stress, or seismic events can initiate seiches. In small basins such as boat harbors, a long-period ocean swell usually initiates a seich.

Consider SEICHES when:

1) Designing a small boat harbor exposed to long period swell.
2) Designing basins that have steep reflective sides, parallel boundaries, and uniform bottom depths. We would consider a 1.5 to 1 rubble slope to be steep for long period waves.

Note 1. **We often use** “seiche” and “resonance” interchangeably when referring to small boat harbor basins (Sect. 16.5).

REFERENCES:

1. ASCE Manual No. 50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 101, 105.

2. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 165-166.

3. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. Vol. 1 Pg. 3-88 to 89, 3-93 to 99.

10.70 Tsunamis

Earthquakes, underwater landslides, and volcanoes can generate long period waves. We measure a tsunami wave period in minutes up to an hour, unlike those of wind-generated waves, which we measure in seconds. Sometimes a tsunami will seem like a very high tide and may overtop piles or other harbor structures. Generally, design considerations will not account for tsunamis, as the probability of occurrence is rare.

Consider TSUNAMIS when:

1) There is a history of tsunamis near the proposed site.
2) The cost of damage due to the tsunami exceeds the cost of prevention.

Note 1. Underwater landslide generated tsunamis were triggered in the 1964 Good Friday earthquake in Alaska.

REFERENCS:

1. ASCE Manual No. 50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 105.

2. Tobiasson, B.O. & Kollmeyer, R.C. 1991. *Marinas and Small Craft Harbors.* New York: Van Nostrand Reinhold. Pg. 144.

3. U.S. Army Corps of Engineers, Dept. of the Army. 1984. *Shore Protection Manual.* CERC. Vicksburg, Mississippi. Vol. 1 Pg. 3-88 to 89, 3-93 to 99.