Appendix A Simplified Methods For Estimating Wave Height

Introduction

Wave height estimates are based on wave characteristics that may be derived from an analysis of the following data:

- wave gauge records,
- visual observations,
- published wave hindcasts,
- wave forecasts and
- maximum breaking wave at the site.

It should be noted that deepwater ocean wave characteristics derived from offshore data analysis may also need to be transformed to the project site using refraction and diffraction techniques described in the Army Corp of Engineer's "Shore Protection Manual."

Predicting Wind Generated Waves

The height of wind generated waves is a function of:

- fetch length,
- windspeed,
- wind duration and
- the depth of water.

Hindcasting

Wave hindcast information, based on historical weather records and observations, is available from the Army Corps of Engineer's Waterway Experiment Station (WES) in Vicksburg, Mississippi. Hindcasting methods should be used to determine the design wave height for coastal revetments.

Forecasting

Simplified wind wave prediction techniques may be used to establish probable wave conditions for the design of highway protection on bays, lakes and other inland bodies of water. Wind data for use in determining design wind velocities and durations is usually available from weather stations, airports and major dams and reservoirs.

The following assumptions pertain to these simplified methods.

- The fetch is short, 120 km (75 mi) or less.
- The wind is uniform and constant over the fetch.

It should be recognized that these conditions are rarely met and wind fields are not usually estimated accurately. The designer should therefore not assume that the results are more accurate than warranted by the accuracy of the input and the simplicity of the method. Good, unbiased estimates of all wind generated wave parameters should be sought and the cumulative results conservatively interpreted. The individual input parameter should not each be estimated conservatively, since this may bias the result.

The applicability of a wave forecasting method depends on the available wind data, water depth and overland topography. Water depth affects wave generation and for a given set of wind and fetch conditions, wave heights will be smaller and wave periods shorter if the wave generation takes place in a transitional or shallow water rather than in deep water. The height of wind generated waves may also be fetch-limited or duration-limited. Selection of an appropriate design wave may require a maximization procedure considering depth of water, wind direction, wind duration, windspeed and fetch length.

There is no single theory for the forecasting of wind generated waves for relatively shallow water. Until further research results are available the interim method for predicting shallow-water waves presented in the Corp's "Shore Protection Manual" (SPM) are to be used. It uses deepwater forecasting relationships and is based on successive approximations in which wave energy is added due to wind stress and subtracted due to bottom friction and percolation. An initial estimate of wind generated significant wave heights can be made by using Figure 7-A-1. If the estimated wave height from the nomograph is greater than 0.6 m (2 ft) it is recommended that the Army Corps of Engineers procedures be used to refine the input parameters.

Breaking Waves

Waves generated in deeper water and shoaling as they approach the embankment will be a maximum size wave that will reach it still in possession of most of its deep-water energy. Wave heights derived from hindcasts or any forecasting method should be checked against the maximum breaking wave that the design stillwater level depth and near-shore bottom slope can support. The design height will be the smaller of either the maximum breaker height or the forecasted or hindcasted wave height. The relationship of the maximum height of breaker which will expend its energy upon the protection, H_b, and depth of water at the slope protection, d_s, which the wave must pass over are illustrated in Figure 7-A-2.

Prediction Procedure

Following is an outline of a wave prediction procedure.

Windspeed Estimation

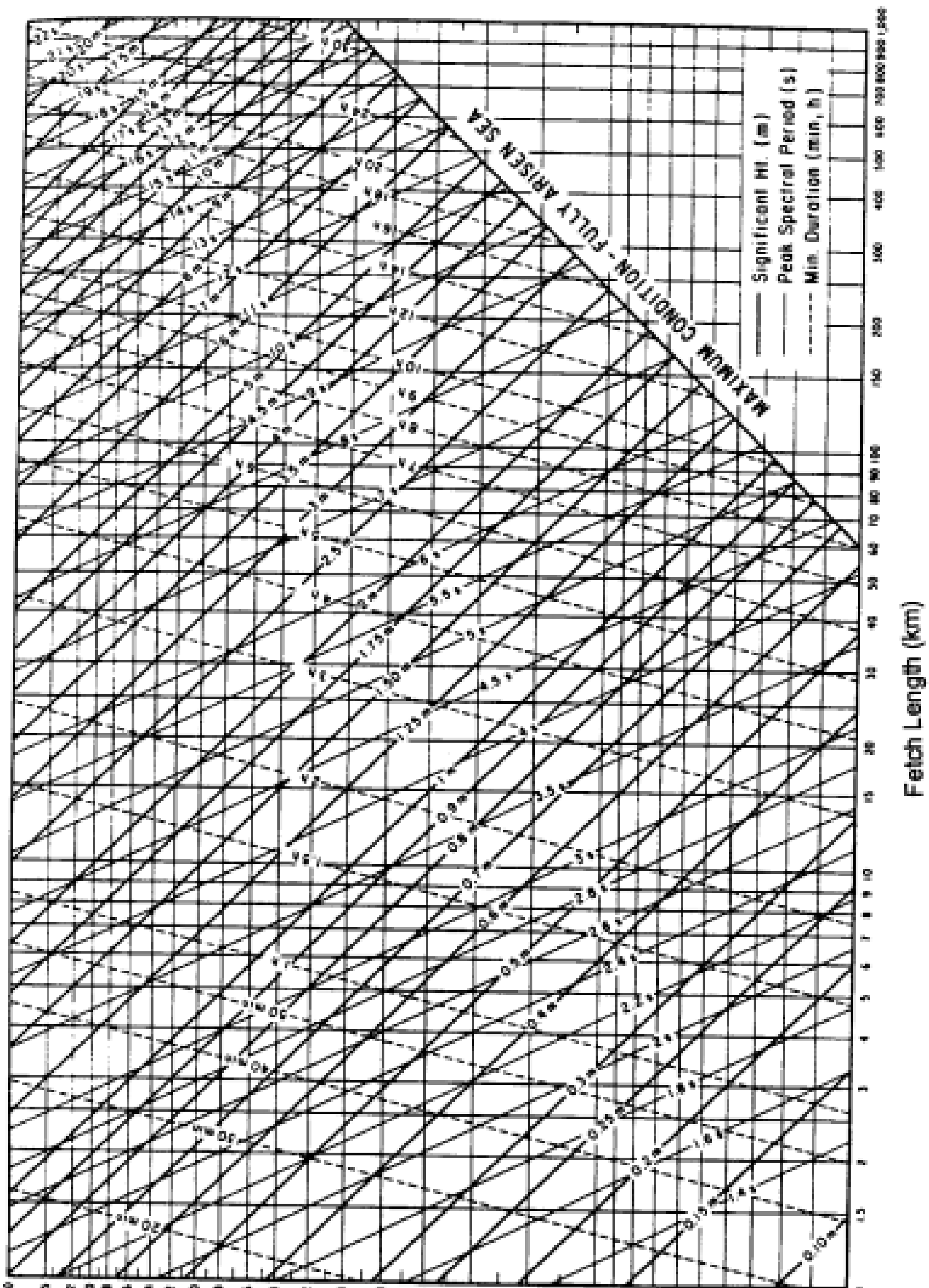
To estimate windspeed the following information is needed:

- actual wind records from the site,
- general wind statistics and
- best alternative source of wind information.

Site Maximization Procedure

Using the method presented in the Army Corp of Engineer's "Shore Protection Manual," (SPM) the site maximization procedure consists of the following steps.

- Adjust wind information to 10 m (33 ft) above water surface.
- Determine fetch limitations.
- Adjust wind information for over water conditions.
- Develop and plot a windspeed-duration curve.
- When applicable, develop and plot a wind speed-duration curve for limited fetch.
- Select design wind.
- Forecast deepwater wave characteristics from deepwater significant wave prediction curves (Figures 7-A-1 or 7-A-1.1).
- Determine if deepwater or shallow-water conditions are present.
- For shallow-water conditions, forecast shallow-water significant wave height and period (SPM Figures 3-27 through 3-36).
- For deepwater conditions, refract and shoal the deepwater wave to the project site, if needed.
- Compute wave run-up and wind set-up.



Wind-Stress Factor, U_A (m/s)

Figure 7-A-1 Nomographs Of Significant Wave Height Prediction Curves As Functions Of Windspeed, Fetch Length and Wind Duration (Metric units)

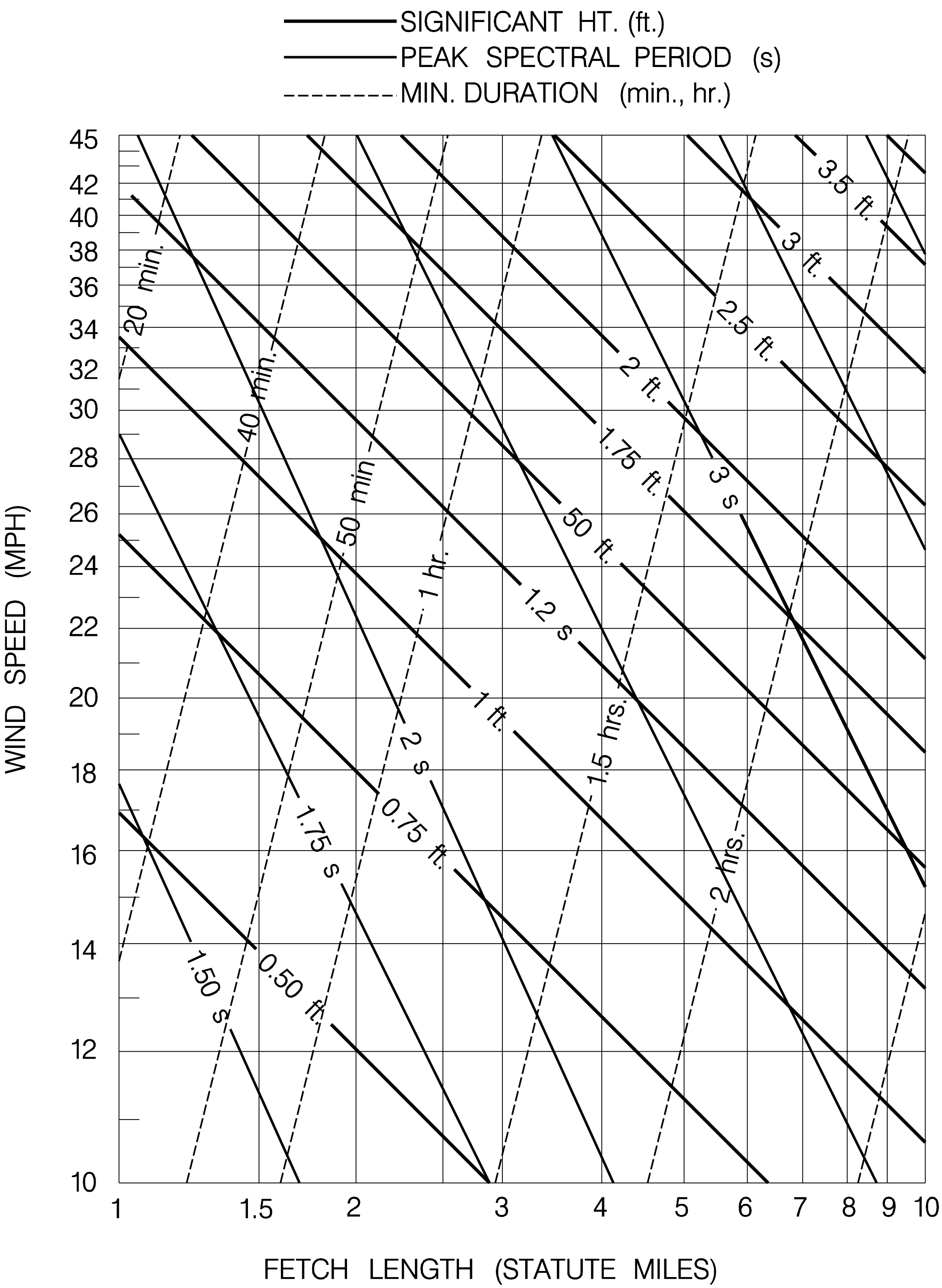


Figure 7-A-1.1 Nomograph of deep water significant wave height prediction curves (English units)

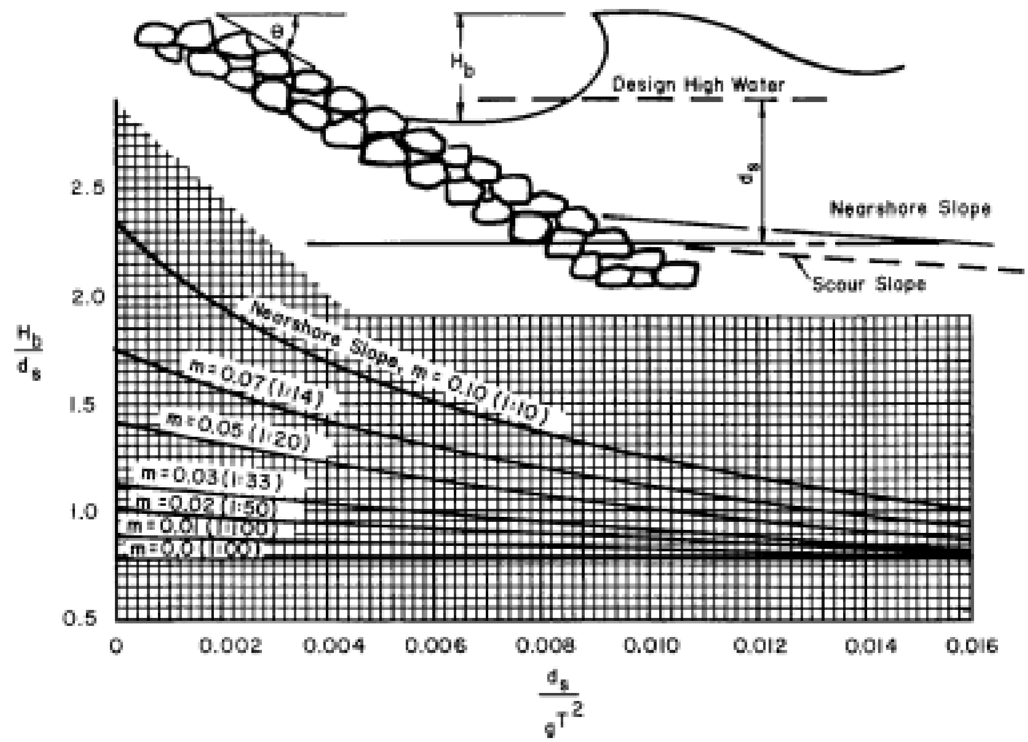


Figure 7-A-2 Design Breaker Wave

Design Breaker Wave

The following example illustrates how to use Figure 7-A-2 to estimate the maximum breaker wave height.

Example

By using hindcast methods, the significant wave height (H_s) has been estimated at 1.2 m (4 ft) with a 3-s period. Find the design wave height (H_b) for the slope protection if the depth of water (d_s) is only 0.6 m (2 ft)and the near-shore slope m (ft) is 1V:10H.

Solution

$(d_s/gT^2) = 0.6 \text{ m}/[(9.81 \text{ m/s}^2)*(3 \text{ s})^2] = 0.007$

From Figure 7-A-2, $H_b/d_s = 1.4$, and $H_b = 0.84$ m

Answer

Since the maximum breaker wave height, H_b, is smaller than the significant deepwater wave height, H_s the design wave height is 0.84 m.