Report for 2002PA2B: Resuspension of Bottom Sediments by Recreational Watercraft

- Other Publications:
  - Hill, D.F., M.M. Beachler, 2003, Wakes on Lakes, Research Penn State, p.11.
  - Hill, D.F., M.M. Beachler, Recreational boating impacts, a case study, in preparation.
  - Hill, D.F., M.M. Beachler, P.A. Johnson, 2002, Hydrodynamic impacts of commercial jet boating on the Chilkat River, Alaska, final report, 120 pp.

Report Follows:

Problem and Research Objectives

Our nation's lakes, rivers, estuaries, and harbors serve important environmental, economic, and recreational roles. From a management point of view, balancing the numerous pressures on an individual water resource in such a way that the long-term health of that resource will be preserved is a serious challenge. The operation of watercraft has numerous potential impacts that deserve consideration, from noise pollution to fuel emissions, to erosion caused by wakes and turbulent prop wash. An understanding of (i) under what conditions these impacts occur and (ii) the consequences of these impacts are clearly of high management value.

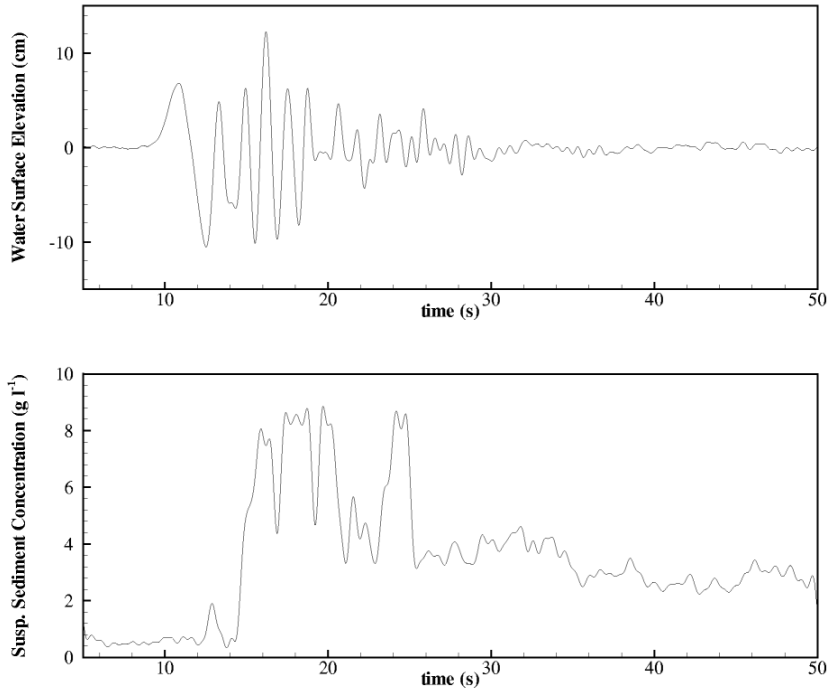
This research extended the work conducted by PI Hill during the period of 3/1/01 – 2/28/02. The specific objectives were to:

1. Refine our understanding of the conditions under which a recreational boat is capable of disturbing a sediment bed.
2. Conduct a study to determine how wake heights vary with operational parameters such as boat speed, size, and distance from shore.
3. Conduct a study to determine how much sediment is dislodged from a shoreline in response to boat passage.

Methodology

In order to answer these questions, a field study was conducted during the summer of 2002 in Haines, Alaska. A wide variety of measurements were made with an equally wide variety of instrumentation. In order to measure fluid velocity induced beneath passing boats, a Sontek Field Acoustic Doppler Velocimeter (ADV) was used. This instrument is capable of measuring all three components of fluid velocity at sampling rates up to 25 hertz. Next, a Downing & Associates Optical Backscatter Sensor (OBS) was used to measure the turbidity of the water in a variety of configurations. This device relies upon reflected infrared radiation and gives a measure of the 'cloudiness' of the water. By performing a laboratory calibration with local sediment samples, it is also possible to determine suspended sediment concentration values. Finally, wake heights were measured with capacitance wave staffs from Richard Brancker, Ltd., and Ocean Sensor Systems, Inc. In both cases, analog voltage output signals are directly proportional to the water surface elevation.

The experiments included both controlled and uncontrolled studies. The controlled studies were conducted by the investigators while the uncontrolled studies involved other boats passing by the study area. The advantage of the controlled studies is that the parameters, such as speed, etc. can be systematically varied. Nevertheless, the uncontrolled studies were of value in that they reflected the actual usage characteristics of the river. An individual experiment consisted of a single boat pass, with transient velocity, turbidity, and wake height data all being collected. Sample wave height and suspended sediment concentration (derived from turbidity) data are shown in the figure below.



Principal Findings and Significance

The present study yielded numerous interesting findings. First of all, it clearly demonstrated that boat wakes have the potential to dislodge significant amounts of sediment from the shoreline. In numerous trials, the turbidity meter 'pegged out' at its maximum value of 500 NTUs (nephelometric turbidity units). This is of concern from an erosion point of view as well as from a biological point of view as many plant and animal species are sensitive to turbidity levels. The measurements also demonstrated the conflict that exists in trying to simultaneously minimize impacts to the bottom and the shoreline of a water body. For example, erosive effects at the shoreline are minimized by reducing wake heights, which is achieved by requiring boats to travel at extremely slow speeds. However, this operation of a boat in so-called 'displacement' (i.e. non-planing) mode maximizes disruption to the bottom of the water body. Management decisions must therefore consider both of these effects carefully.

Next, the collected data were used to establish a predictive equation for expected maximum wave height (H_{max}) at shore. Based upon boat length (L) and distance from shore (x), it was found that

$$\frac{H_{\max}}{L} = 0.033\left(\frac{x}{L}\right)^{-0.43}.$$

Thus, if it is desired to keep wake heights below some threshold value, the minimum operating distance can readily be computed.

Finally, numerous calculations and estimates of hydrodynamic parameters, such as energy, power, and shear stress were made in an effort to compare the impacts of recreational watercraft use to the impacts associated with the ambient flow of a river. It was found that the conclusions varied widely depending upon the chosen parameter and upon the specific conditions of the site. Most interestingly, it was found that even seemingly low levels of boating activity can produce hydrodynamic impacts that exceed those of the background flow. It is still not clear which parameter is the most effective and accurate measure of shoreline impact. It is hoped that future research will resolve this lingering question.

Student Support

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