EVALUATION OF A PROPOSED CHANNEL ON CIRCULATION AND MORPHOLOGY CHANGE AT KAWAIHAE HARBOR AND PELEKANE BAY, ISLAND OF HAWAII, HI, USA

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ABSTRACT

Kawaihae Deep Draft Harbor (KDDH) and Pelekane Bay (PB) are located on the northwest coast of the Island of Hawaii, HI. KDDH is protected by a long breakwater, outside of which extends a rich coral reef. Tissot (1998) noted a major decline in the abundance of the marine biota in PB, and associated this change with long-term sedimentation by terrestrial runoff and reduced bay circulation caused by the construction of KDDH.

In an effort to improve the water quality and restore marine habitats in PB, installation of a circulation channel was proposed with the intent of enhancing water circulation in PB through KDDH and flushing accumulated sediment out of PB. This study was conducted to investigate the hydraulics and sediment transport consequences of dredging such a channel. Considering the near-shore harbor is located in an environment dominated by wave-driven coastal processes, the coupled wave, flow, and sediment transport Coastal Modeling System (CMS), developed by the Coastal Inlets Research Program at the Coastal and Hydraulics Laboratory, U.S. Army Corps of Engineers, was applied as the main analysis tool for the study. The CMS is a coupled hydrodynamic and wave model consisting of CMS-Flow and CMS-Wave. Physical processes calculated by CMS-Flow are circulation, sediment transport, and morphology change (Buttolph et al. 2006). CMS-Wave is a two-dimensional wave spectral transformation model that contains approximations for wave diffraction, reflection, wave transmission, wave run-up, and wave-current interaction (Lin et al. 2008).

Relative to the local mean low lower water, two channel depths, 1.0 and 1.5 m were specified as alternative designs such that channels would be kept wet under various tidal conditions. A dry channel was considered undesirable because potential circulation would be reduced and periodic wetting and drying might tend to promote erosion or deposition. Two different channel widths, 30 and 50 m, were selected referring to the scale of a “notched” area on the southeast side of KDDH. The length of the channel extends about 470 m from the bottom of the notch to PB. Four alternatives were configured (Alts 1 to 4) for the study.

A 15-day and a 6-month simulation were conducted to represent a non-storm and a typical winter (storms) time interval, respectively. CMS results were analyzed and compared between existing condition and channel alternatives. In addition to forcing the CMS with the time series of offshore waves, three steady-state incident wave conditions were specified to examine cause and effect, and channel hydraulic performance in a systematic manner.

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It was found that upon reaching PB, incident waves breaking induces higher water level from wave setup, whereas the breakwater at KDDH inhibits depth-limited breaking and setup, creating a differential in water surface elevation (WSE). The water level rise along the channel was calculated to be 0.01-0.03 m, with WSE in PB being higher (Figure 1).

The differential wave setup, found for almost all wave conditions, produces water flow from PB to KDDH in the proposed channel. Without consideration of channel and bay infilling, the temporally averaged along-channel current speed is calculated from 0.07 to 0.2 m/sec for the non-storm and storm conditions, respectively. Persistent bay-to-harbor flows will move sediment into the channel, most of which is deposited within 120 m from PB. Storms are a major cause in contributing to sand transport and accumulation (blockage of the channel). For the 6-month storm conditions, the maximum deposition in the channel was calculated to be approximately between 0.7 and 2.0 m among the different alternatives. More sand is deposited under the deeper channel alternatives (Alts 2 and 4). The channel or bay blockage appears under all channel alternatives before reaching the end of the simulation.

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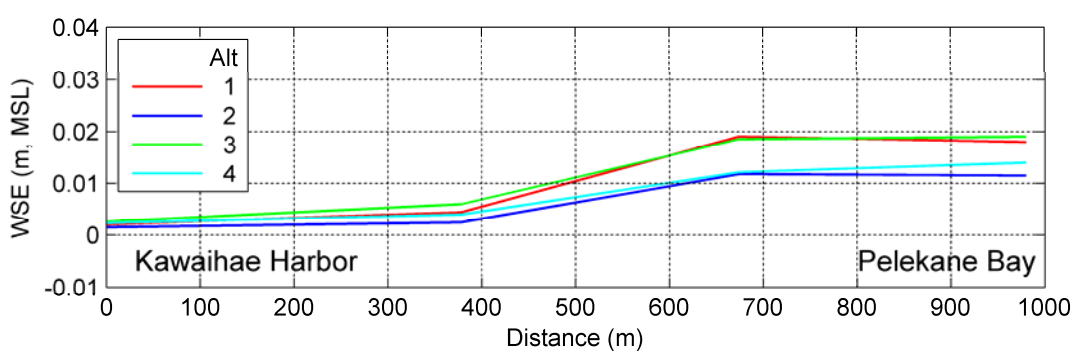

Figure 1. Temporally averaged water surface elevation (WSE) (October-December 1992) along section composed of four stations from Kawaihae Harbor to Pelekane Bay.