Appendix A
Prototype and Field Studies Group Data Collection Equipment and Laboratory Analysis Procedures

The contents of this appendix are to provide detailed information on the types of data collection and laboratory equipment used in a majority of the field investigations performed by the Prototype and Field Studies Group, Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Waterways Experiment Station (WES). The following table is provided to identify the parameters most commonly measured and the types of instruments that can provide these measurements.

Table A1
Current Velocity and Direction Measurements
Recording Velocity Meter Acoustic Doppler Current Profiler System
Suspended Sediment Sampling
Pumped Water Sample Optical Backscatterance Sensors
Water-Level Measurements
Wave-Height Measurements Electronic Water-Level Recorders
Bottom-Sediment Sampling
Push Core
Meteorological Measurements
Digital Recording Station
Laboratory Equipment and Sample Analysis
Laboratory Analysis for Suspended-Sediment Concentrations Laboratory Analysis for Total Suspended Material Density Analysis

Current Velocity and Direction Measurements

Recording velocity meters

Self-contained recording current meters are used to obtain current velocity and direction measurements for both profiling and for long-term fixed-depth deployment. The two types of equipment commonly utilized are the Environmental Devices Corporation (ENDECO) Type 174 SSM current meters as shown in Figure A1 and the InterOcean S4 electromagnetic current meter shown in Figure A2.

The ENDECO 174 SSM meter is tethered to a stationary line or structure and floats in a horizontal position at the end of the tether (as shown in Figure A3). It measures current speed with a ducted impeller and current direction with an internal compass. The ENDECO 174 SSM also measures temperature with a thermilinear thermistor and conductivity with an induction-type probe. Data are recorded on an internal solid-state memory data logger. Data are offloaded from the meter data logger by means of a communication cable connected between the meter and a computer. The threshold speed is less than 0.024 mps (0.08 fps); maximum speed of the unit used is 2.57 mps (8.44 fps) (10 knots); and stated speed accuracy is ±3 percent of full scale. The manufacturer states that direction accuracy is ±7.2 deg above 0.024 mps (0.08 fps). Time accuracy is ±4 sec per day.

The InterOcean Model S-4 electromagnetic current meter can obtain continuous recording of current velocity and direction at fixed depths or can be used to profile the water column for current velocity and directions. The S-4 meter, shown in Figure A2, is a 25.4-cm-diam (10-in.-diam) sphere that is suspended vertically in the water column with a submerged flotation device and anchored to the bottom by a heavy block and anchor arrangement. This deployment technique is illustrated in Figure A4. The S-4 meter measures the current velocity using an electromagnetic field to sense current induced by the movement of water through the field. An internal microprocessor coupled with an internal flux-gate compass computes the velocity vectors, which are then stored in the solid-state memory. The accuracy of the S-4 meter current speed is ±0.2 cm/sec.

Acoustic Doppler Current Profiler

Acoustic techniques are used to obtain current velocity and direction measurements for fast and accurate profiling in the field. The equipment used is RD instruments Acoustic Doppler Current Profiler (ADCP)-BroadBand as shown in Figure A5. These instruments use a 1,200-kHz operating frequency. The equipment is mounted over the side of boat with the acoustic transducers submerged, and data are collected while the vessel is underway as shown in Figure A6.

Figure A1. ENDECO 174SSM recording current meter

Figure A2. InterOcean S-4 current meter

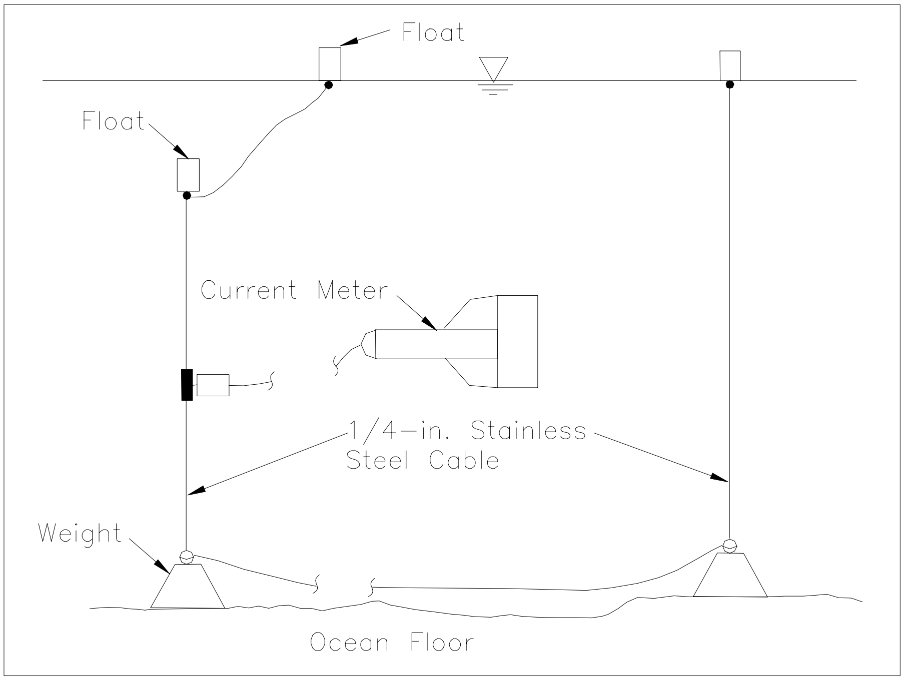

Figure A3. Typical deployment technique for fixed-depth velocity meter

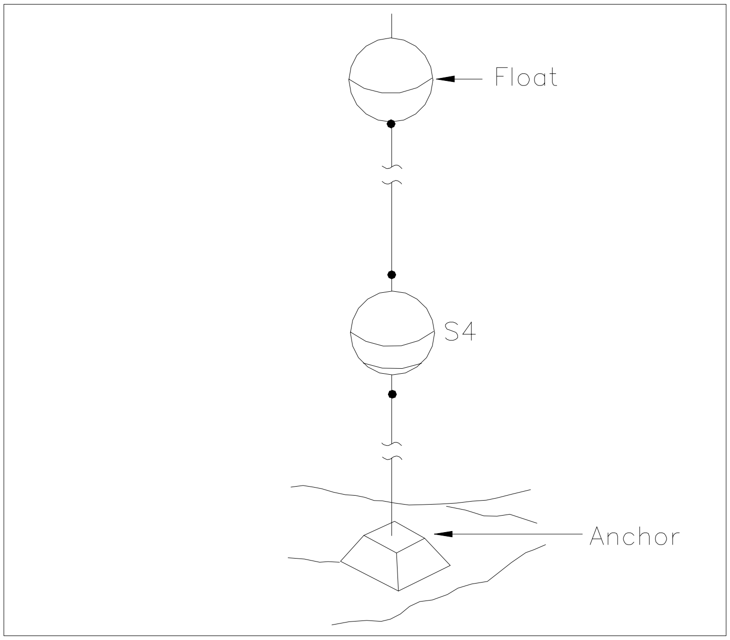

Figure A4. S-4 current meter deployment method

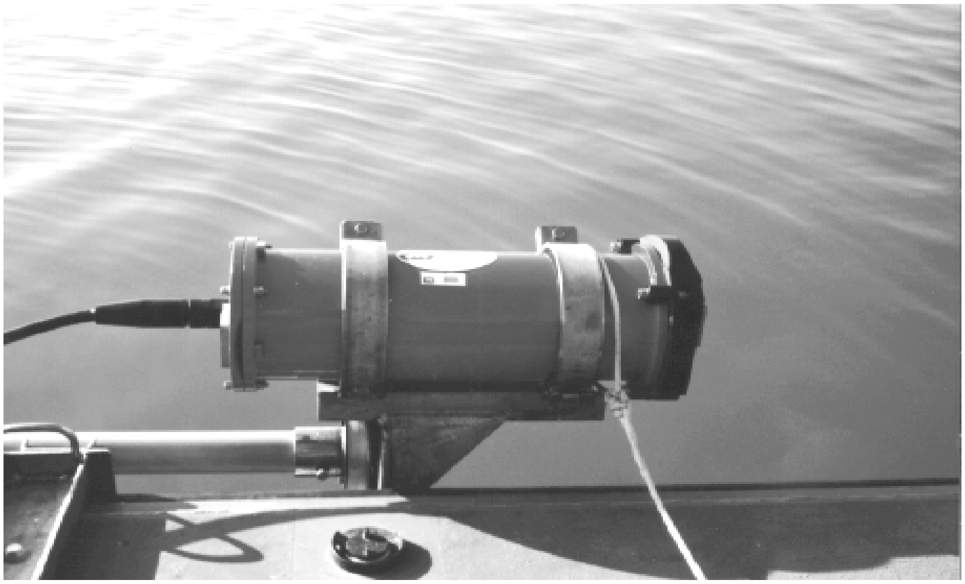

Figure A5. Acoustic Doppler Current Profiler (ADCP)

Figure A6. Vessel-mounted ADCP

The ADCP transmits sound bursts into the water column that are scattered back to the instrument by particulate matter suspended in the flowing water. The ADCP listens for the returning signal and assigns depths and velocity to the received signal based on the change in the frequency caused by the moving particles. This change in frequency is referred to as a Doppler shift. The ADCP is also capable of measuring vessel direction, current direction, water temperature, and bottom depth. Communication with the instrument for setup and data recording are performed with a portable computer using manufacturer-supplied software, hardware, and communication cables. The manufacturer stated accuracies for current speed measurement ±0.2 cm/sec; for vessel direction ±2 deg; and temperature ±5 °C.

Suspended-Sediment Sampling

Pumped water samples

In combination with the over-the-side velocity measuring equipment, water samples for analyses of suspended-sediment concentrations and total suspended solids are obtained by pumping the sample from the desired depth to the surface collection point. The pumping system consists of a 0.64-cm (0.25-in.) ID plastic tubing attached to the current meter signal cables for support. The opening of the sampling tubing is attached to the solid suspension bar at the same elevation as the current meter and is pointed into the flow. A 12 Vdc pump is used to pump the water through 15.24 m (50 ft) of the tubing to the deck of the boat where each sample is then collected in individual 226.80-g (8-oz) plastic bottles. The pump and tubing are flushed for approximately 1 min at each depth before collecting the sample.

Optical backscatterance (OBS) sensors

The OBS sensor, a product of D&A Instruments and Engineering, is a type of nephelometer for measuring turbidity and solids concentrations by detecting scattered radiation from suspended matter. It consists of a high-intensity infrared emitting diode (IRED), a series of silicon photodiodes as detector, and a linear solid-state temperature transducer. The IRED emits a beam at angles 50 deg in the axial plane and 30 deg in the radial plane to detect suspended particles by sensing the radiation they scatter, as shown in Figure A7. Scattering by particles is a strong function of the angle between the path of radiation from the sensors through the water and the signal return to the detector. OBS sensors detect only radiation scattered at angles greater than 140 deg. As with other optical turbidity sensors, the response of the OBS sensor depends on the size distribution, composition, and shape of particles suspended in the medium being monitored. For this reason, sensors must be calibrated with suspended solids from the waters being monitored. The OBS sensor can be interfaced with “smart” data loggers that are capable of powering the sensor during sampling intervals.

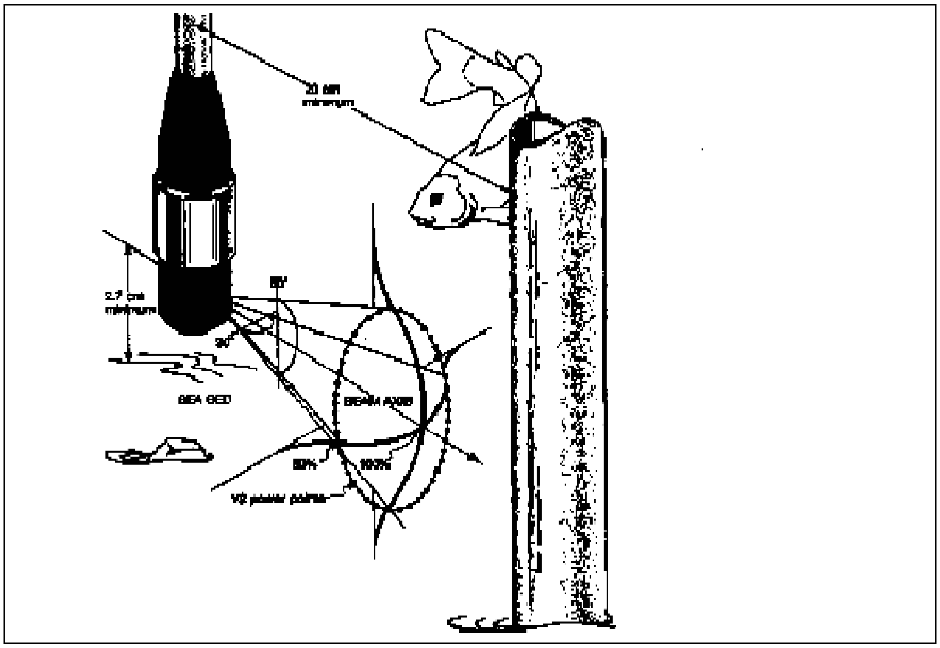

Figure A7. OBS sensor beam pattern

Wave-Height Measurements–Electronic Wave-Height Recorders

The Microtide water-level recorders, shown in Figure A8, contain a strain-gauge-type pressure transducer in a subsurface case that records the absolute pressure of the column of water above the case. The pressure transducer is not vented to the atmosphere; therefore, an extra unit is positioned in the study area to record atmospheric pressure changes. Water pressure is measured for the desired sample interval, and an average value is computed and stored on the internal RAM data logger. The stated accuracy is ±0.006 m (±0.02 ft). The sampling time interval can be set from 1 min to 24 hr. The Microtide also measures temperature by means of a YSI thermilinear thermistor built into the water-level recorder. The thermistor has a range of -5 to +45 °C, with a stated accuracy of ±0.1 °C. The data from each recorder are stored on an accessible RAM located in the waterproof subsurface unit that also contains the DC power supply.

Wave-Level Measurements–Electronic Water-Level Recorders

Water-level elevation measurements can also be recorded using solid-state electronic recorders, such as Microtide and ENDECO water-level recorders.

Figure A8. Microtide electronic wave-height recorder

Water-level elevations, temperature, conductivity, and suspended-sediment concentration measurements are recorded using ENDECO models 1152 SSM and 1029 (solid-state measurement) water-level recorders shown in Figure A9. The ENDECO model 1152 SSM and 1029 recorders contain a strain-gauge-type pressure transducer located in a subsurface case that records the absolute pressure of the column of water above the case. The pressure transducer is vented to the atmosphere by a small tube in the signal cable to compensate for atmospheric pressure. The pressure is measured for 49 sec of each minute of the recording interval with a frequency of 5-55 kHz to filter out surface waves, therefore eliminating the need for a stilling well. The accuracy is ($\pm$0.15 m) ($\pm$0.05 ft). The sampling time interval can be set from 1 min to 1 hr. The 1152 and 1029 also measure temperatures by means of a thermilinear thermistor built into the recorders. The thermistor has a range of -5° to +45° C, with an accuracy of $\pm$0.2 C. The 1152 measures conductivity by an inductively coupled probe installed on the meter. These measurements and the measurements of temperature are used to calculate water-suspended sediment concentrations in units of parts per thousand. The water-suspended sediment concentrations are computed with an accuracy of $\pm$0.2 ppt.

The sampling time interval for conductivity and temperature cannot be set independently from the water-level measurements. The data from each recorder are stored on a removable EPROM solid-state memory cartridge located in a waterproof surface unit that also contains the DC power supply.

Figure A9. Water-level recorder

Bottom-Sediment Sampling–Push Core Sampler

Bottom sediment is obtained using a push-core-type sampler. The sampler consists of a 3.81-cm-diam (1.5-in.-diam) PVC pipe, 45.72 cm (18 in.) in length. Attached to this is a smaller section of pipe with a valve attached at the upper end. The purpose of the valve is to create a reduced pressure holding the sample in the larger diameter pipe. The samples are then brought to the surface and classified by visual inspection or transported back to WES for more detailed analysis.

Meteorological Measurements–Digital Data Acquisition of Meteorological Data

Continuous wind speed and direction measurements are recorded using a HANDAR Model No. 540-A Data Acquisition system (see Figure A10). The data collection platform is typically located at some central location in the study area and mounted approximately 10 m above the water. The data acquisition system is a battery-powered microcomputer with a real-time clock, a serial data interface, and programmable analog-to-digital converter. The battery is constantly charged using a solar panel charging system located near the system.

Various programming options are available for setting the sampling interval of the system for the input signals from the wind speed and direction sensors. The system can be programmed to sample the input signals each second over a set period of time to determine the mean wind speed, mean direction, maximum

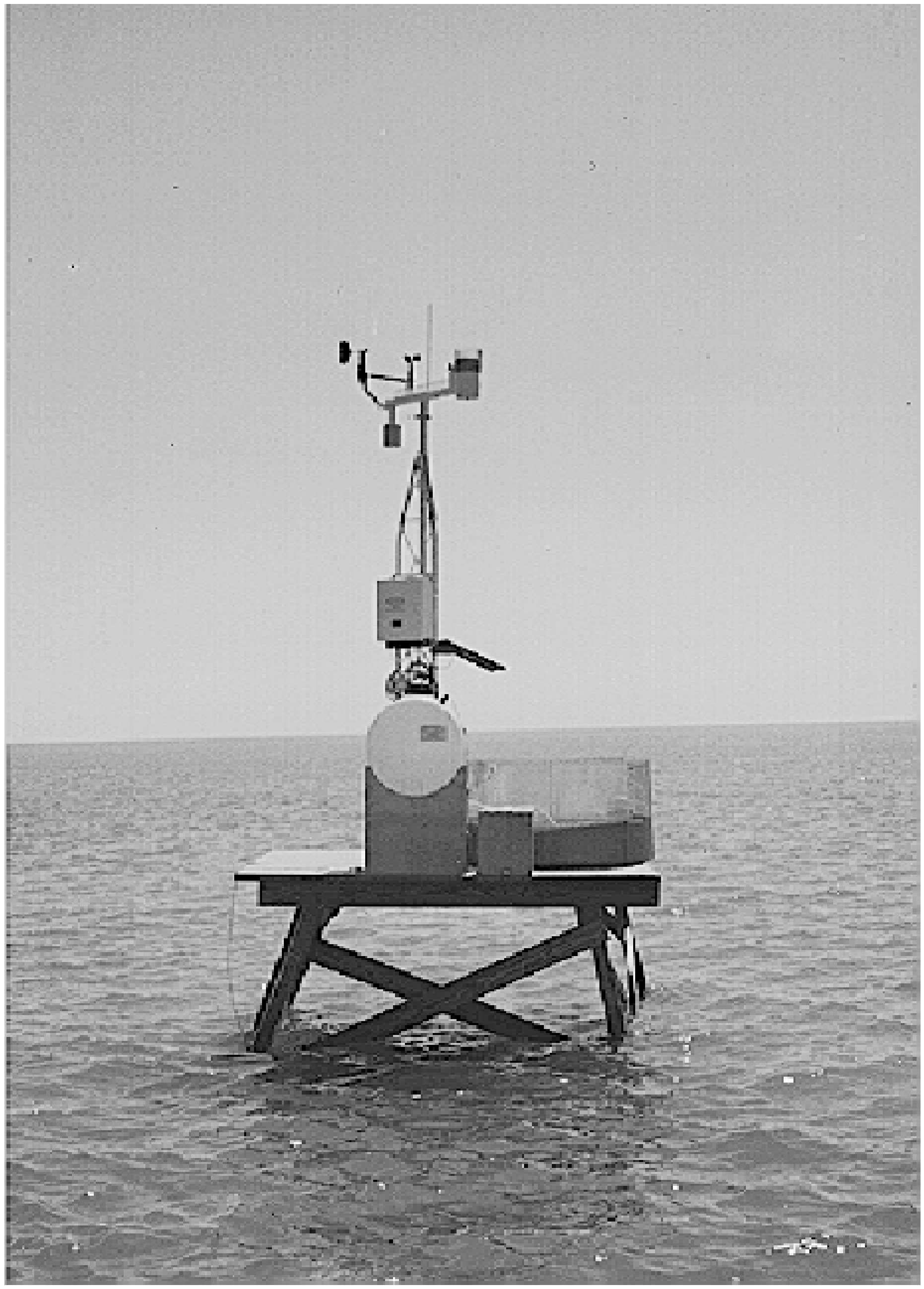

Figure A10. HANDAR meteorological data-acquisition system

wind-gust speed, and maximum wind-gust direction. The data are processed internally and stored in formats specified in a user-entered output table. The accuracy of the analog input of the wind speed and direction sensors are ±1.0 mph and ±3.0 deg, respectively.

Laboratory Equipment and Sample Analysis

Total suspended materials (TSM) are determined by filtration of samples. Nuclepore (Registered Trademark) polycarbonate filters with 0.40-μm pore size are used. They are desiccated and preweighed, then a vacuum system (8-lb vacuum maximum) is used to draw the sample through the filter. After the filters and holders are washed with distilled water, the filters are dried at 105 °C for 1 hr and reweighed. The TSM are calculated based on the weight of the filter and the volume of the filtered sample.

Density Analysis

A density analysis is done using wide-mouth, 25-cm, constant-volume pycnometers. They are calibrated for tare weight and volume. A pycnometer is partially filled with sediment and weighed, then topped off with distilled water. Care is taken to remove any bubbles before the pycnometer is reweighed. The bulk density (BSG) of the sediment is then calculated by the equation:

$$BSG = \frac{(p)(sedwt - tarewt)}{(p)(volpyc) + (sedwt) - (sed + waterwt)}$$

where

p =density of water at temperature of analysis

$sedwt$ = weight of pycnometer with sediment

$tarewt$ = tare weight of pycnometer

$volpyc$ = volume of pycnometer

$sed + waterwt$ = weight of pycnometer with sediment and water