A sediment tracer study is a method to evaluate the in-situ dispersal patterns affecting a specific sediment type within a targeted area of interest. Successful execution of a (properly designed) tracer study can significantly improve holistic understanding of sediment transport pathways within a given area of interest, be it a river, lake, estuary, or coastal setting. Sediment tracer studies can be particularly useful where sediment transport and morphological response is non-symmetric in space and non-stationary in time. The objective for tracer studies is two-fold: A) Obtain the stand-alone results from each tracer study to conceptually demonstrate sediment transport dispersion pathways to stakeholders and resource agencies, and B) Integrate the tracer study results with other types of data or analyses to improve methods of sediment transport estimation.

The total cost for executing a tracer study adjacent to an energetic coastal inlet (high sediment dispersion) can approach $500,000. Executing a similar scope sediment tracer study within a LOW sediment dispersion study area can be less than $200,000. Although these costs represent a sizable investment, results from a successful tracer study can be very effective for describing sediment transport pathways within a complex or contentious area. Note that results from sediment tracer are based on prototype observed (real) data. Sediment tracer results can be fused with other information such as computer model results, morphology changes, in-situ process measurements, etc. This type of data fusion can help motivate or justify beneficial placement of dredged sediment, or other project specific actions based on regional sediment management principles (http://www.wes.army.mil/rsm/pubs/pdfs/rsmprimer.pdf). Depending upon site conditions and accrued benefits, the tracer investment could be quickly recouped after operational changes are implemented (ie. beneficial use of dredged material).

For a given sediment tracer study, a mass of tracer particles is manufactured to mimic characteristics of the specific sediment targeted for evaluating at a given study area; in terms of the sediment size gradation, density, hardness, shape, and fall speed within the water column. The sediment tracer is deployed at a defined drop zone (DZ) and repeated sediment in-situ sampling is performed at the DZ and surrounding area to “track” the dispersal of the released tracer material. For a tracer study to be successful, it is necessary to be able to detect the tracer very low levels in each collected sediment sample (1 part per billion). This detection capability enables tracking of the tracer after significant dispersion by waves and/or currents. Analysis of the spatial and temporal distribution of recovered tracer indicates the spatial extent of tracer sediment transport during the data collection time-frame.

Tracer studies rely exclusively on field data obtained from periodic sediment sampling, within a real world setting driven by Lagrangian processes. Results are based on the integrated effect of sediment transport affecting the sampled area, during the interval between sediment sampling events. Because tracer studies do not derive results from sediment transport theories or methods of mechanistic estimation, tracer studies can be perceived as unscientific endeavors that produce ambiguous results. This unsatisfactory endpoint will be realized if three important considerations are not fully addressed: 1) The sediment tracer must properly emulate the sediment physics of interest, 2) A sufficient mass of tracer must be deployed to allow detection to far-field dispersion points, and 3) Proper post-deployment sampling must be performed to capture the dispersion of trace over time. Each of these elements has a direct bearing on study cost and performance (success vs. failure). Successful tracer studies address the above considerations though detailed experimental design and execution protocols. Considerable effort should be given to optimizing tracer study design prior to execution. Adaptive management is essential to realize study success during the post-tracer deployment phase. A description of completed tracer studies is available in (ETS-EHI 2011 and Moritz et al 2011).

Tracer Procedure

Sediment tracer studies are executed in 2 planning phases and 4 operational phases. First, the physical properties of the sediment of interest are identified. This data defines the specifications to create the sediment tracer. Second, the areal aspects of the site of interest, environmental forces that affect sediment transport at the site, and expected far-field sediment dispersion aspects are estimated. This data is used to define the location and method for tracer deployment, areal extent for post-deployment tracer sampling, the frequency of sampling events needed and sampling density for each event, and mass of tracer needed to be manufactured & deployed to satisfy detection limits over the expected dispersal area. Third, the tracer is manufactured according to the gradation, shape, & density of target sediment and shipped to the project site. Fourth, the tracer is prepped for deployment and placed at pre-determined release points within the drop zone (DZ). Fifth, a series of position-controlled sediment sampling events is performed periodically within and beyond the DZ to capture tracer as it is progressively dispersed within the project area. Tracer dispersal results from each sampling event describe the spatial aspects of the sediment tracer at a given point in time, integrated from the date of tracer deployment. The sixth and final step of the tracer study procedure is to test each sediment sample for tracer content. Sample testing is performed subsequent to each sampling event, and results are used to inform the following sampling event.

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